

Effects of Sea Water Salinity on the Growth of Vetiver Grass (*Chrysopogon Zizanioides* L.)

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Abstract: Vetiver grass (*Chrysopogon zizanioides* L.) has an ability to adapt and develop in many different environments and to recover quickly from the disadvantage conditions of the environment. It can absorb large amounts of nitrogen, phosphorus and dissolved heavy metals in the environment. Studies to date on salt tolerance of vetiver grass have been conducted mainly in the soil environment and much less so 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 humans as well as those of industrial and 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 to 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 [1]. Estuarine ecosystems play a very important role for human activities, ranging from 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 from pollution. Despite its ecological and economic importance to the region, estuarine ecosystems have suffered considerable degradation due to intensive and continuous industrial activities, domestic contamination, pesticides from runoff of agriculture, and transportation activities [2].

Until now, there are several methods used to treat contaminated water and phytoremediation is one of the techniques that make use of plants and associated soil microbes to reduce the concentrations of contaminants in the environment. It is a novel treatment, cost effective, efficient, environmentally friendly and in situ applicable. The study results of Huaiman (1999) [3], Weiguo (1999) [4], Truong (1999) [5], Koyro (2008) [6] showed that vetiver grass (*Chrysopogon zizanioides* L.) has many pre-eminent properties for phytoremediation technology. It can be used for the removal of contaminants such as heavy metals and radionuclides as well as organic pollutants, with ability for broad adaptation to different environmental conditions. In particular, according to Truong (1994) [7], vetiver grass can grow in a relatively highly saline soil environment.

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

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2. Materials and Methods

2.1 Preparation of Test Plants

Seedlings of vetiver grass were collected from experimental plots 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 planting slips with roots (7 cm long) and shoots (40 cm high) and transplanted to containers (20 cm high and 18cm in diameter) with various salinity levels.

2.2 Experimental Design

The study was performed as a glasshouse experiment; the vetiver grass (*Chrysopogon zizanioides* L.) was used to investigate the level of salt tolerance. Water samples taken from Da Nang Bay and Phu Loc River, were combined according to the following 11 treatments (Table 1). The symbol ‰ shows per mille (per thousand).

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).

Table 1 Dilution Proportion and Salinity Levels of 11 Treatments

Formula	Ratio		Salinity	
	Water taken from Da Nang Bay (‰)	Water taken from PhuLocRiver (‰)	‰	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	25.00
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

2.3 Statistical Analysis

Data was analyzed with a one-way ANOVA. Comparison among means was done using Duncan's test. All tests 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.

Results after 15-day 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 decreased from 5.33 to 2.67; root length from 11.33 to 8.00 to cm, respectively ($p \leq 0.05$).

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

Meanwhile, the number of new shoots increased in the range of 35.72 to 0 dS/m, decreased gradually in the range of 46.43-35.72 dS/m and died at 46.43 dS/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 0-30.33 dS/m salinity and completely died at 46.43 dS/m.

According to Truong and Baker (1996) [8], when planting *Chrysopogon zizanioides*, *Chloris gayana* 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 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 → +++



Fig. 1 Vetiver Grass after 15-Day treatments 1(L)-11(R)

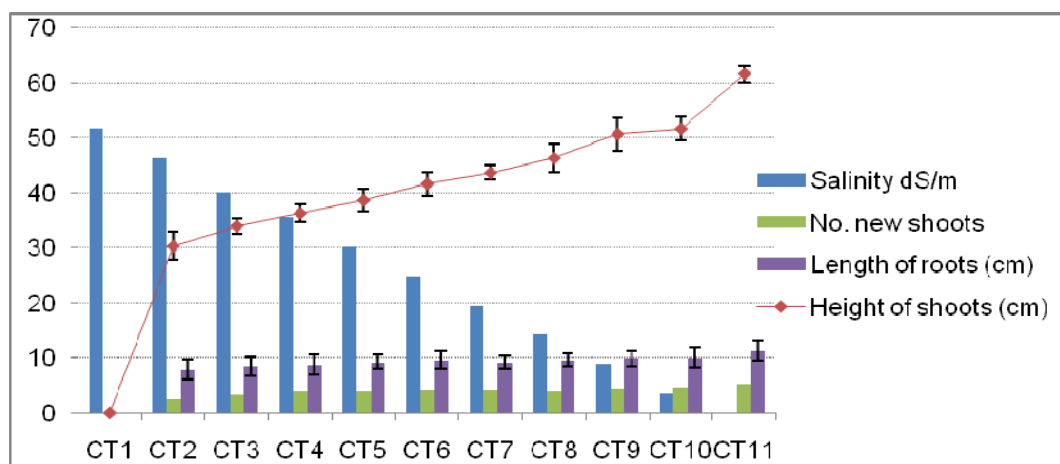


Fig. 2 Effect of Salinity on the Growth of Vetiver

Table 3 Salt Tolerance of Some Grass Species

Species	Soil salinity (dS/m)	
	0-5 cm	10-20 cm
<i>Chloris gayana</i>	4.83	9.59
<i>Paspalum vaginatum</i>	9.73	11.51
<i>Chrysopogon zizanioides</i>	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 possess long and dense root systems and potentially reaching deeper horizons to obtain more nutrients and possibly less saline water.

In a pilot study for saline land rehabilitation due to mining activities, Radloff et al. (1995) [9] 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 fertilization. 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 shown 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	9.00±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	++++	+++
<i>Changes in height of shoots (cm):</i> < 0 → -; 0 - 5 → +; 6 - 15 → ++; 16 - 30 → +++; and > 30 → ++++				<i>Changes in length of roots (cm):</i> ≤ 2 → +; 3 - 7 → ++; and > 7 → +++			

After 30 days the results revealed that vetiver grass can only grow at the salinity lower than 35.72 dS/m, with shoot height reaching 16.67 to 80.17 cm; the number of new shoots range 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 is reduced from 35.72 to 25 dS/m, but increases sharply as salinity is reduced from 25 to 0 dS/m, and that vetiver died at a salinity level higher than 35.72 dS/m.

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 (1999) [5] and Truong

et al. (2002) [10] reported that, the saline threshold of Monto vetiver is $EC_{se} = 8 \text{ dS/m}$ and soil EC_{se} values of 10 and 20 dS/m would reduce yield by 10% and 50%, respectively (Figs. 5, 6).



Fig. 3 Vetiver Grass after 30 Days, Treatments 1(L)-11(R)

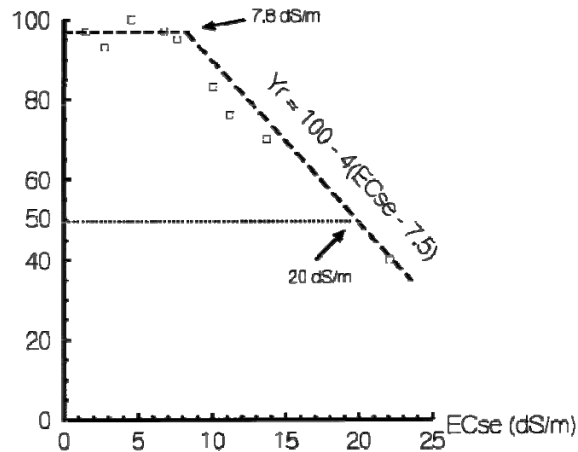


Fig. 4 Saline Threshold Level of Vetiver Grass [7]

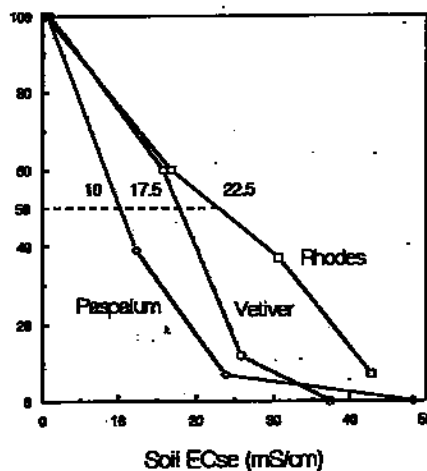


Fig. 5 Saline Threshold Level of Vetiver Grass, Rhodes Grass (*Chloris gayana*) and Paspalum (*Paspalum dilatatum*) [7]

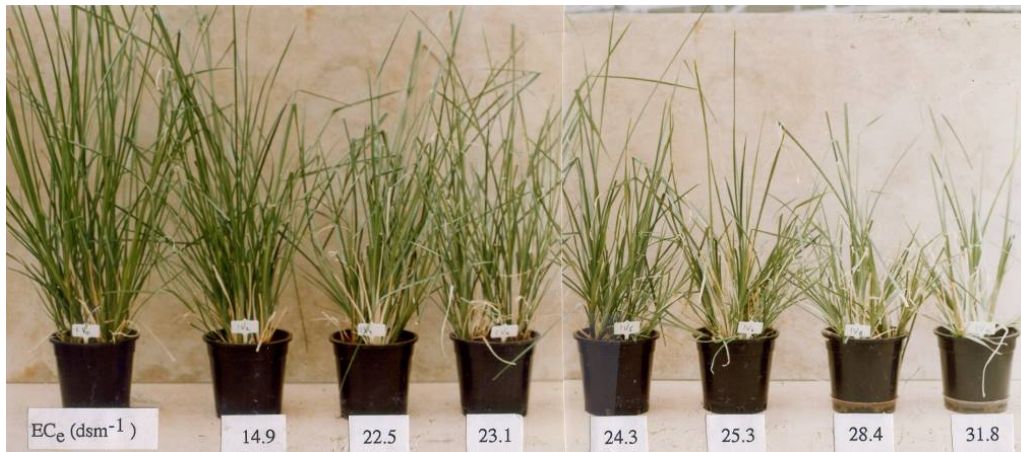


Fig. 6 Salt Tolerance Level of Vetiver Grass Grown in Australia [7]

Pongvichian et al. (2005) [11] 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 20 dS/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, has shown that vetiver grass continues to grow in water salinity ranging from 0-19.64 dS/m, and at salinity levels greater than 19.64 dS/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.

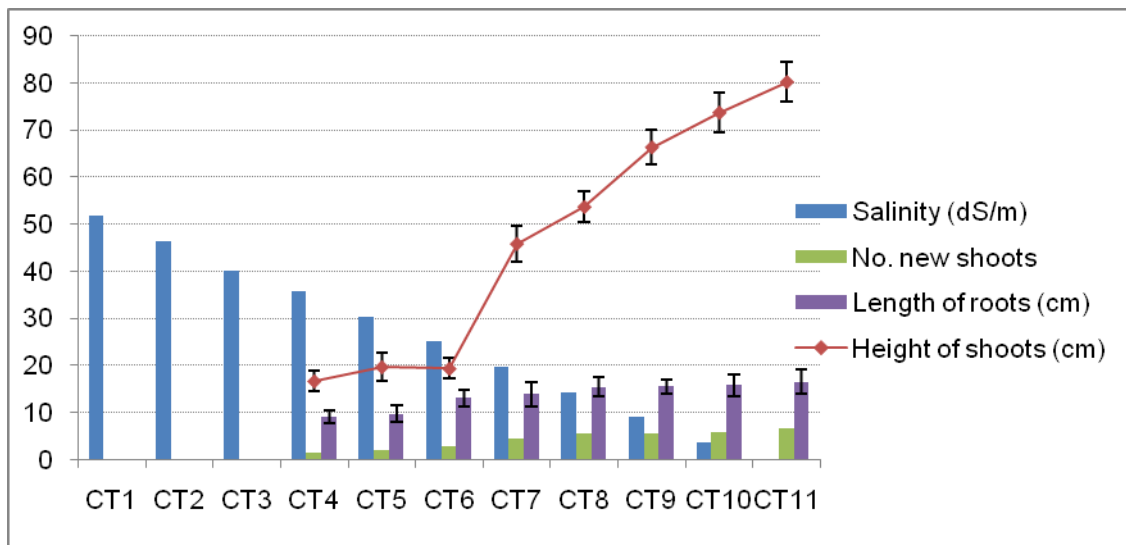


Fig. 7 Effects of Salinity on the Growth of Vetiver Grass after 30 Days

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 do treatment of saline wastewater

at coastal estuaries, a full understanding of the chemical properties of the pollutants requiring treatment is needed for best results.

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