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A NOTE ON SALT ACCUMULATION WITH ECOPHYSIOLOGICAL COMMENTS

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ABSTRACT

Increased industrialization and urbanization has resulted in conversion of arable land into marginal land. A few grasses in particular *Vetiveria zizanioides* L and *Sporobolus ioclados* L can withstand adverse environmental conditions because of their higher tolerance level. Present study was aimed to assess the uptake and partitioning of different ions by these two grasses i.e. *Vetiveria zizanioides* L and *Sporobolus ioclados* L. Accumulation of different ions has been noticed and the content of ion accumulated increased with the developmental stage without having too much impact on their growth and morphology.

Keywords : *Vetiveria zizanioides* L, *Sporobolus ioclados* L, sodium, potassium, calcium and chloride.

Introduction

Vetiveria zizanioides and *Sporobolus ioclados* are grasses belonging to family Poaceae and are commonly known as "Khus" and "Sawarri" respectively. *Vetiveria zizanioides* is characteristised by having short rhizomes, deep, extensive and penetrating root system. Stem of *Vetiveria zizanioides* L. is tall and leaves are long, thin and rigid (Erslkine, 1992; Troung, 1999; Hellin and Haigh, 2002; Ke *et al.,* 2003). These plants have a strong adaptability to adverse conditions, which make them ideal for soil, water conservation and erosion control in arid and semi arid regions. Their greater adaptability is attributed to fast growth, easy planting, high survival rate, also never turn into a kind of weed (Lavania, 2000).

Vetiveria zizanioides and *Sporobolus ioclados* have been reported to withstand drought, long periods of inundation, extreme temperatures, soil acidity and alkalinity (pH from 3.3 to 10.5) (Erskine, 1992; Dalton *et al.,* 1996; Truong and Loch, 2004; Zhou and Yu, 2009). Unique morphological, physiological and ecological characteristics render these plant species capable of growing in harsh environmental and soil conditions. *Vetiveria zizanioides* and *Sporobolus ioclados* accumulate toxic heavy metals mainly in roots and least in shoots (Yang *et al.,* 2003). *Vetiveria zizanioides* and *Sporobolus ioclados* have been reported to possess high tolerance to metals like Al, Mn and heavy metals like Cd, Cr, N, Pb, Hg, Se, Zn and metalloids such as arsenic present in the soils (Troung, 2000; Cheng *et al.,* 2004; Chiu *et al.,* 2005). This tolerance to the heavy metals by grasses is often attributed to their capability to accumulate metals in above ground tissues without affecting the root and shoot growth. Moreover, mycorrhizal association within the roots of *Vetiveria zizanioides* make it sturdy enough to withstand high metal concentration in the soil (Roongtanakiat and Chairoj, 2002; Cheng *et al.,* 2004). Salinity is one of the most deleterious abiotic stresses, which adversely influences plant growth, development and crop productivity in both irrigated and non-irrigated areas of the world (Jungklang *et al.,* 2003; Ashraf *et al.,* 2008; Zhu, 2008). Growth of plants is generally reduced due to osmotic stress induced by the accumulation of sodium and chloride (Munns and Termaat, 1986; Zhou and Yu, 2009).

High concentration of salts in the soil solution also interferes with balanced absorption of essential nutritional ions by plants (Tester and Devenport, 2003). Salt tolerant plants provide good material for investigating the adaptation mechanisms (Ashraf, 2003). Soil salinity is an important feature of landscape of arid countries especially where artificial irrigation is practiced (Flower, 2004). Halophytic plants have the capability to minimize the detrimental effects by morphological means and physiological or biochemical processes such as osmotic adjustment achieved by accumulating osmolytes like K^+ and proline (Jacoby, 1999). Focus has been on using tolerant plant species for conservation of soil and water along with phytoremediation of heavy metals and other pollutants from contaminated fields (Pang *et al*. 2003; Lai and Chen 2004).

Height of most grasses is adversely affected at the higher levels of salinity which might be due to less availability of water and toxicity of sodium chloride (Munns, 2002). However, seeds of *Sporobolus ioclados* germinated in NaCl upto 500mM (Gulzar *et al.*, 2003) and shoot length of *Vetiveria zizanioides* was increased by 18.60% at 200 mM NaCl concentration but was adversely affected at higher (300mM) NaCl concentration. So it appears that the grass species exhibit salinity tolerance upto 200 mM NaCl as far as growth in terms of shoot length is concerned (Mane *et al.,* 2011). *Vetiveria zizanioides* has been reported to function as an effective adsorbent for the removal of fluoride from aqueous solution (Puthenveedu *et al.,* 2012). It was with this viewpoint that accumulation of salts in different parts of *Vetiveria zizanioides* and *Sporobolus ioclados* at different developmental stages was evaluated for the present work.

Material and Methods

Young plants of *Vetiveria zizanioides* and *Sporobolus ioclados* were collected from Malanpur (Bhind) and Jiwaji University campus and planted in pots at Botanical Garden of Jiwaji University, Gwalior. Different plant parts were collected at two different stages after plantation i.e. 20 and 40 days after plantation. These parts were washed with distilled water and dried in oven at 60^0C for 2 days. Dried plant parts were used for analysis.

Estimation of K, Na and Ca.

Estimation of K, Na and Ca was done flame photometrically as adopted by Tomar and Agarwal (2013). One gram of dried plant material was digested using triacid mixture (H_2SO_4 + HNO_3 + $HClO_4$ in 9:3:1 ratio). After digestion final volume was made up to 100 ml using distilled water and filtered. Colourless filtrate was directly read on flame photometer for estimation of Na, K and Ca using separate filters and calculations were done using standard curves.

Estimation of chloride.

Estimation of chloride was done following method of Eaton *et al.* (2005). One gram dry plant sample was boiled in 100 ml distilled water on a water bath for 30 minutes. After cooling the extract was filtered and 25 ml of this filtrate was used for analysis. Few drops (5-6) of 5% potassium chromate (indicator) were added and titrated against 0.1 N $AgNO_3$ solution till a permanent brick red precipitate appears.

Results and Discussion

An increase in uptake and accumulation of Potassium, sodium, calcium and chloride contents was found at later stage of plantation. Leaves of both *Sporobolus ioclados* L and *Vetiveria zizanioides* L partitioned greater amounts of potassium and calcium than roots. However, sodium accumulated to a greater degree in roots than leaves indicating greater tolerance of roots to sodium (Tables 1 and 2). Salt tolerance is a complex process which involves adaptations at physiological and genetic levels in both more tolerant (halophytes) and less tolerant plants (Flower, 2004). Synthesis and accumulation of compatible organic osmolytes such as polyamines, glycine betaine, proline and free sugars is an important adaptation of plants to mitigate stress (Bartels and Sunkar, 2005). Salinity affects plant growth through the osmotic and ionic effects thereby disrupting the integrity of cellular membranes, uptake of essential nutrients, function of photosynthetic apparatus and many other physiological and biochemical processes (Zhu, 2008).

Osmotic adjustment is considered to be an important component of salt tolerance mechanisms in plants and is usually defined as a decrease in the cell sap osmotic potential resulting due to net increase in intracellular osmolytes to prevent the loss of cell water. Intracellular osmolytes include inorganic ions normally absorbed from medium and organic solutes which are synthesized and transported within the plant (Carvajal, *et al*., 1999; Bajji *et al.,* 2001; Annick *et al*., 2004; Navarro *et al.,* 2007). Inorganic ions, mainly include K^+, Na^+, Ca^{2+}, Mg^{2+}, $Cl^–$, $NO_3^–$, SO_4^{2-}, $H_2PO_3^–$ which however, can cause ionic toxicity when accumulated in higher concentrations, particularly Na^+ and $Cl^–$ (Martínez *et al*., 2003; Ottow *et al.,* 2005; Touchette, 2007; Yang *et al.,* 2007).

Potassium is an important macro element which improves plant growth and resistance against environmental stresses. Potassium is involved in several physiological processes like stomatal regulation, osmoregulation, enzyme activation, maintaining energy status, charge balance, photosynthesis, protein synthesis and translocation (Beringer and Trolldenier 1978; Marschner 1995). Excess rain or irrigation can cause leaching of potassium through the soil. Potassium deficiency results in reduced growth, short internodes, scorched leaf margins, necrosis, reduced lateral breaks and increases susceptibility to wilting. Studies have shown that the application of K fertilizer mitigates the adverse effects of drought on plant growth (Andersen *et al.,* 1992; Studer, 1993; Sangakkara *et al.,* 2001).

Sodium can substitute for potassium and K deficiency symptoms of many plants are reduced by Na (Hylton *et al.,* 1967; Amin and Joham, 1968). Na has been shown to be an essential element for Bermuda grassland for certain C_4 plants (Brownell and Crossland, 1972). Sodium requirement was first demonstrated for the bladder slat-bush, a perennial pasture species of arid inland areas of Australia have since then surveyed 32 species of plants for their sodium requirement. The metabolic basis for the sodium requirement may be related to the transport of pyruvate, a critical intermediate in the C_4 pathway between the bundle-sheath and mesophyll cells (Brownell and Wood, 1957; Brownell and Crossland, 1972).

Sodium has specific function in concentration of CO_2 in C_4 plants. Many halophytic plants are able to take advantage of similarity between sodium and potassium and have adapted to grow in areas of high salt whereas growth of other less adapted plants is limited due to high salinity (Greenway and Munns, 1980; Glenn *et al.,* 1999). Uptake and movement under natural conditions is possible to increase the cycling of sodium through plants by suitable nutrient management practices and at times sodium containing wastes could be used to

Table 1: Percent potassium, sodium, calcium and chloride in *Sporobolus ioclados* L.

Plant part	Potassium		Sodium		Calcium		Chloride	
	20 days after plantation	40 days after plantation	20 days after plantation	40 days after plantation	20 days after plantation	40 days after plantation	20 days after plantation	40 days after plantation
Roots	0.043±0.003	0.1652±0.015	0.0250±0.002	0.1381±0.027	0.025±0.013	0.250±0.00	0.0011±0.00	0.0142±0.00
Stem	0.085±0.006	0.4415±0.002	0.0378±0.002	0.0846±0.001	0.2175±0.017	0.410±0.021	0.0017±0.00	0.0237±0.001
Leaves	0.122±0.002	0.5417±0.007	0.0463±0.001	0.0985±0.009	0.254±0.013	0.571±0.00	0.0042±0.00	0.0385±0.004
Flower	0.0729±0.008	0.3164±0.002	0.0306±0.003	0.0829±0.001	0.2785±0.005	0.431±0.021	0.0025±0.00	0.0397±0.004

Table 2: Percent potassium, sodium, calcium and chloride in *Vetiveria zizanioides* L.

Plant part	Potassium		Sodium		Calcium		Chloride	
	20 days after plantation	40 days after plantation	20 days after plantation	40 days after plantation	20 days after plantation	40 days after plantation	20 days after plantation	40 days after plantation
Leaves	0.870±0.0012	0.605±0.0029	0.165±0.0078	0.108±0.008	0.146±0.0020	1.053±0.001	0.025±0.0000	0.038±0.0028
Roots	0.279±0.0023	0.657±0.0202	0.221±0.0640	0.234±0.0053	0.120±0.0500	1.169±0.010	0.009±0.0012	0.034±0.0000

grow plants, which could then provide food, O_2 and clean water for the crew (Wheeler *et al.,* 2002).

Present study reveals greater uptake and accumulation of ions with the time of plantation and their partitioning is more in the upper plant parts i.e. leaves and stem. Increase in content of ions with the developmental stage reflects about the enhanced potential of *Sporobolus ioclados* L. and *Vetiveria zizanioides* L. to accumulate salts which can be quite useful in conversion of marginal land into arable land. Obviously, further studies should be rewarding.

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