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EFFECT OF INCREASING SODIUM CHLORIDE CONCENTRATIONS ON THE GROWTH AND ION UPTAKE OF *HONCKENYA PEPLOIDES* (L) EHRH

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Effect of increasing NaCl concentrations was observed on *Honckenya peploides* (L) Ehrh. Increasing concentrations of NaCl increased fresh and dry matter, decreased the root and shoot lengths and internal water content of *H.peploides*. The reduced root and shoot lengths (growth) is possibly due to the adverse effect of NaCl mainly on root growth consequently shoot growth is also affected. The Na and Fe content increased with NaCl treatments while K, Ca, and Mg decreased. The Zn content were variale. The mechanism of salt tolerance in *H.peploides* is possibly through accumulation of Na and/or organic solutes and that Na substitute K.

Key words : Salt tolerance, Growth, Ion uptake, Dry matter, Osmotic pressure and Turgor pressure.

Introduction

Sodium and chloride are the common ions that occur in saline sodic soils. Salt tolerance of a plant is commonly measured in terms of tolerance to sodium chloride. Many investigators [1–3] have used NaCl and other sodium salts to investigate initial salt tolerance of seeds on germination and on seedling growth e.g. *Atriplex nummularia* [4] and *Salicornia bigelovi* [5]. Nevertheless, plant response to high salt concentrations varies from species to species. An earlier investigator Steiner, 1934-39 in Albert [6] classified halophytes into two groups: (a). Salt regulating (b). Salt accumulating. The former group was considered to be regulating because of their physiological behaviour in restricting internal salt concentration. The restriction occur either by desalination through salt glands or by reduced uptake of salts. The latter group which cannot prevent increase in internal salt concentration accumulate salts.

Honckenya peploides (L) Ehrh. (Carryophyllaceae) commonly occur in the circumboreal maritime environment, where the amount of soluble salts in sea spray is considerable. Very little information is available on this species except for a few reprots on its germination [7] and seed dormancy [8-9].

The present study was conducted because of the paucity of information about the salt tolerance of *H.peploides*.

Materials and Methods

The seeds of *H. peploides* were collected from Gibralter, Poit, Lincolnshire U.K. in the year 1982. Culture experiments were performed at 20± 1°temperature and 1076.25 lux light intensity. The photo period was adjusted to 16 hr. a day.

After germinating the seeds in petridishes in distilled water the seedlings were transfered to culture vessels. The culture vessels were supplied with nutrient solution every day in order to keep the nutrient level as constant as possible. Appropriate quantity of NaCl in the concentrations of 25, 50 and 100 mM was added to the nutrient solution. The vessels were not aerated on the assumption that the surface area of the vessel was large enough (3 litre container) to allow resolution of sufficient oxygen from the atmosphere. The nutrient solution was based on Long Ashton medium [10] and was prepared in de-ionized distilled water. The pH of the nutrient solution was maintained at 6.0.

There were five replicates of each treatment. Two week old seedlings (five in each replicate) were transplanted and harvested after eight weeks. After harvesting roots and shoots were rinsed in tap water for 30 sec. to remove salts from the outer surface of the plants and the wet seedlings were immediately dried with tissue paper in order to protect seedlings from contamination or deplation of salts. The following analyses were carried out: (a). Fresh and dry weight of root and shoot (b). Root and shoot lengths (c) Root : shoot ratio (length and dry weight ratio) and chemical analysis for inorganic cations. For dry weight seedlings were dried in an oven at 80° and chemical analyses were carried out following acid digestion method [11] using an atomic absorption spectrophotometer.

Analysis of variance was carried out following Bishop [12]. Since the calculated probability values were greater than the tabulated probabilities, the sign (>) is used for mentioning the level of significance.

Results and Discussions

Fresh weight. The average fresh weight of the root increased significantly (p 0.001 and $p > 0.05$) at all treatment levels of NaCl relative to the control. The average fresh weight of the shoot did not increase significantly at 25mM but did so at 50 and 100 mM ($p > 0.001$ and $p > 0.01$) NaCl treatments compared the control (Table 1).

TABLE 1. FRESH WEIGHT, DRY WEIGHT, WATER CONTENT, ROOT, SHOOT LENGTHS AND ROOT TO SHOOT RATIO OF *HONCKENYA PEPLOIDES* GROWN IN DIFFERENT SODIUM CHLORIDE TREATMENTS.

Treat-ments in mM NaCl	Fresh weight in g		Dry weight in g				Percent water content		Root length in cm	Shoot length in cm	Root to Shoot length ratio	Root to shoot D.W. ratio
	Root	Shoot	Root	%D.W.R	Shoot	%D.W.S	Root	Shoot				
Control	0.056^{a} ±0.006	0.395^{a} ±0.01	0.0062^{a} ±0.001	11.07	0.039^{a} ±0.002	9.87	88.93	90.13	11.6^{a} ±1.57	27.4^{a} ±5.23	2.36	6.29
25	0.095^{b} ±0.002	0.397^{a} ±0.006	0.011^{b} ±0.002	11.58	0.04^{a} ±0.004	10.07	88.42	89.93	5.7^{b} ±0.92	17.00^{b} ±4.69	2.98	3.64
50	0.090^{c} ±0.003	0.46^{b} ±0.008	0.012^{bc} ±0.003	13.34	0.049^{b} ±0.005	13.34	86.66	89.35	4.4^{c} ±0.50	13.34^{bc} ±2.44	3.03	4.08
100	0.092^{bc} ±0.004	0.47^{bc} ±0.009	0.013^{bc} ±0.002	14.13	0.054^{bc} ±0.008	14.13	85.87	85.87	4.4^{bcd} ±0.90	15.00^{bcd} ±3.94	2.96	4.15

The similar letters (a,b,c) at two or more than two treatments indicate that non-significant differences occurred between them. However they are significant with others having different letters (mean ± SD).

Dry weight: The average and percentage dry weight of the roots significantly increased ($p > 0.001$) at all treatment levels of NaCl relative to the control. However, the increment was insignificant within treatment levels of 25, 50 and 100 mM NaCl. The average and percentage dry weights of the shoots did not increase significantly at 25 mM but did so at 50 and 100 mM NaCl ($p > 0.001$ and $p > 0.05$) respectively compared with the control (Table 1).

Percent water content. The percentage water content of the root and shoot slightly decreased at 25 mM and prominently at 50 and 100 mM NaCl treatments relative to the control (Table 1).

Root/shoot lengths. The root and shoot lengths significantly decreased at all treatment levels of NaCl (25, 50 and 100 mM) compared with the control ($p > 0.001$, $p > 0.01$ and $p > 0.05$). However at 50 and 100 mM NaCl treatments the root length differences were insignificant, whereas shoot length differences were insignificant within all NaCl treatments (Table 1).

Root, shoot, length and dry weight ratio. The root to shoot ratio slightly increased at all treatments relative to the control. However, it was insignificant within treatment levels of NaCl.

The root to shoot dry weight ratio was lower at all treatment levels of NaCl relative to the control. The results demonstrate that increasing NaCl concentrations reduced both root and shoot growth.

Chemical Content

Sodium. The sodium content of leaves increased significantly ($p > 0.001$) with increasing NaCl concentrations of the culture medium compared with the control (Table 2).

Potassium. The potassium content of leaves decreased significantly ($p > 0.001$) at all treatment levels of NaCl relative to the control (Table 2). The K : Na ratio also increased.

Calcium. The calcium content of the leaves increased significantly at 25mM NaCl ($p > 0.001$) and decreased at 50 and 100 mM ($p > 0.01$ and $p > 0.001$ respectively) relative to the control (Table 2).

TABLE 2. INORGANIC CHEMICAL CONTENT OF LEAVES AT DIFFERENT NaCl TREATMENTS (MEAN VALUES ± SD)

Treatments of NaCl in mM	Concentrations of ions in g. 100 g. dm^{3}						
	Na	K	Ca	Mg	Fe	Zn	Na: K ratio
Control	0.62^{a} ±0.044	5.01^{a} ±0.106	0.79^{a} ±0.03	1.13^{a} ±0.06	0.07^{a} ±0.026	0.07^{a} ±0.01	0.124
25	3.1^{b} ±0.02	3.41^{b} ±0.102	0.99^{b} ±0.1	1.10^{a} ±0.1	0.11^{b} ±0.026	0.10^{b} ±0.036	0.909
50	3.56^{c} ±0.053	2.35^{c} ±0.132	0.64^{c} ±0.06	0.6^{b} ±0.027	0.10^{bc} ±0.005	0.074^{ab} ±0.019	1.52
100	5.32^{d} +0.13	2.1^{d} +0.02	0.56^{c} +0.04	0.63^{bc} +0.02	0.15^{d} +0.03	0.08^{ab} +0.01	2.54

Magnesium. The magnesium content of the leaves did not change significantly at 25 mM and significantly decreased ($p > 0.001$) at 50 and 100 mM NaCl compared with the control (Table 2).

Iron. The iron content of leaves increased significantly at all treatments of NaCl ($p > 0.01$, $p > 0.05$ and $p > 0.001$ respectively) compared with the control (Table 2).

Zinc. The zinc content of the leaves showed significant increase at 25 mM NaCl ($p > 0.05$) while at other treatments (50 and 100 mM) the zinc content did not differ significantly from the control (Table 2).

Discussion

The present results obtained in *Honckenya peploides* demonstrate that increasing NaCl concentrations increased fresh and dry matter (average and percentage) slightly decreased internal water content at 25 and 50 mM and prominently at 100mM of both root and shoot. There have been similar reports on dry matter production of plants in salinized media. Ashby and Beadle [13] have reported increased dry matter production of *Atriplex* species *(A. inflata* and *A. nummularia*) and *(Lycopersicum esculatum)* on addition of NaCl, Na_2SO_4 and KCl. Moreover they have mentioned that water use was less in the salt bushes receiving sodium treatments. A similar report mentioned by Dumberoff and Cooper [14] also concurs with the present findings. They reported that tomato plants showed decreased water content and succulence under stressed conditions. However, some other halophytes produced a different response to salinity. For instance, Black [15] has reported that *Atriplex hastata* showed increased water content and succulence when grown in saline solution.

Although, dry matter increased, the overall growth of *H. peploides* is affected on salinization with NaCl solutions in terms of low root and shoot growth (Table 1). The low root and shoot growth appears to be the effect of NaCl mainly on root growth, consequently shoot growth is also affected. A recent report of Munns and Termaat [16] is in agreement with this view. They suggested that NaCl affects shoot growth through the adverse effects on root growth.

The increased dry matter could possibly be the result of solute accumulation. Nonetheless, the chemical analysis of internal cations concentration (Na, K, Ca, Mg, Fe and Zn) did not show any prominent feature except the significant increase in Na and Fe content of leaves. In contrast other cations (K, Ca and Mg) were found decreased with increasing NaCl concentration and Zn content did not differ significantly other than at 25mM. The reasons for the decrease in internal water content and increase in dry matter is obscure. At least the present data do not provide any firm answer for this. However, it could be infered that at increasing NaCl concentration the uptake of water is reduced (water deficit) and the accumulation of Na and possibly organic solute occurred in order to maintain the turgor, especially when the K absorption was restricted (Table 2). Reduced K absorption in the presence of high Na concentration is a common feature of certain halophytes[17,18]. The assumption gets support from the views of Greenway and Munns [19] and Munns *et.al* [20]. Greenway and Munns mentioned that halophytes generate turgor by high internal Na and Cl concentrations. Munns *et.al* suggested that lowering of turgor pressure potential of the growth zone can be accomplished by accumulation of organic solutes (proline, glycinebetamine etc.) This may be passive process by temporarily lowering of growth or an active process by uptake of inorganic solutes from the xylem or phloem. However, in the present study we do not have practical evidence for either Cl or organic solute accumulation.

On the basis of present findings it may be deduced that the mechanism of salt tolerance in *Honckenya peploides* is possibly through accumulation of Na and / or organic solutes and that Na substitute K.

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