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Effect of Seawater on *Salvadora persica* Linn.

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Abstract Twenty nine per cent seeds of *Salvadora persica* germinated in pure seawater (56 dS m^{-1}) although maximum germination was recorded in distilled water. In isotonic solutions of 12 atmospheres, maximum germination was observed in NaCl followed by mannitol and Na_2SO_4. Reduction of about 6 % in soluble proteins in various parts of 21 day old seedlings grown in 24 dS m^{-1} seawater was observed. Salinity induced an increase in accumulation of glutamic acid, glycine, isoleucine, leucine, methionine, phenylalanine, proline, serine, threonine and valine in different parts, whereas reverse effect was noted for arginine, alanine, aspartic acid and asparagine. Accumulation of total, reducing and major sugars in three of four parts of the seedlings was adversely affected under salinity stress. Increased uptake of cations and Cl was observed in seedlings grown in seawater.

Key words Salinity, Germination, Seedlings, *Salvadora*, Sugars, Amino acids, Minerals

Salvadora persica Linn. grown widely in the semi-arid saline waste-lands of Bhal area in Gujarat for fodder and fuel (Krishna Kumar 1986). The seeds contain a high quantity of lauric acid which can be used in cosmetic industry. Successful germination and establishment of seedlings under saline environment is a vital and a pre-requisite condition for the selection of any species for reclamation of saline soils. Similarly, Ungar (1978) suggested that quite limited information was available on accumulation of inorganic ions and organic metabolites in seedlings of halophytes grown in saline condition. In this paper we describe the germinability of *S. persica* in seawater dilutions and effects of 24 dS m^{-1} seawater salinity on accumulation of soluble proteins, free amino acid, sugars and minerals in various parts of 21 day old seedlings.

Materials and Methods

Seeds were collected from plants growing in a marshy habitat near Bhavnagar (21° 45' N 72° 14' E). Fifty seeds of uniform size, shape and colour were kept for germination in distilled water and in natural seawater having electrical conductivity of 8 to 56 dS m^{-1} in Petri dishes lined with Whatman No.1 filter paper at room temperature (31°-39°C). Natural Seawater was diluted with distilled water for preparation of waters having different EC levels. Five replicates were maintained. Seedlings were grown in distilled water and 24 dSm^{-1} seawater for 21 days.

Na and K were estimated by flame photometry; Ca and Mg by EDTA titration (Vogel 1978); Cl on chloride meter (Elicomodel EE-34). For estimation of proteins method of Lowry *et al.* (1951) and for free amino acids paper chromatographic analysis described by Joshi (1986) were followed. Total sugars and the reducing sugars were estimated respectively by anthrone reagent and by the method of Folin and Malmros (1929) modified by Umbriet *et al.* (1959).

Results and Discussion

Seed germination was significantly inhibited in seawater compared to distilled water (Table 1). The initial delay as well as a decrease in germination in higher salinity levels were noticed. Germination in isotonic solutions indicated the least inhibitory effect of NaCl followed by mannitol and Na_2SO_4.

Epicotyls, cotyledons and hypocotyls of treated and non treated contained alkali soluble proteins between 20 to 25.2% of the dry weight (Fig.1A). Amounts of ethanol and water soluble proteins in these parts varied between 11 to 18%. Reduction upto 6% in protein in seawater grown seedlings indicated the marginal effects of salinity on their metabolism. It was observed that total

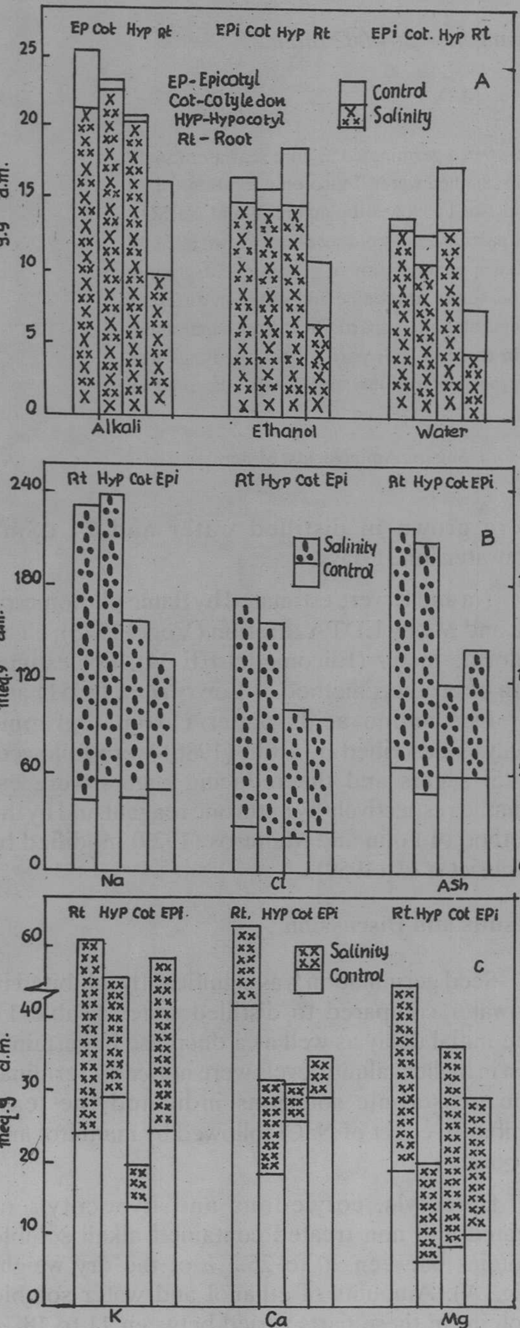

Fig 1 Protein content (A) and mineral composition (B & C) of different parts of 21 day old seedlings of *S. persica.*

Table 1 *Effect of seawater dilutions on germination of S. persica. (mean ± SE of five replications)*

Treatments	% germination
Distilled water	85±3
Seawater of	
8 ds m^{-1}	76±2
16 ds m^{-1}	75±1
24 ds m^{-1}	73±1
32 ds m^{-1}	59±2
40 ds m^{-1}	53±1
48 ds m^{-1}	48±5
56 ds m^{-1}	29±1
Isotonic Solutions	
(12 atmosphere)	
NaCl	65±4
Na_2SO_4	55±4
Mannitol	63±4

amino acids in roots of the treated seedlings was severely affected by salinity (Table 2). A slight decrease in their concentrations was noted in case of epicotyl also. Nevertheless the amino acids content increased in the hypocotyl. Accumulation of glutamic acid, glycine, isoleucine, leucine, methionine, phenylalanine, proline, serine, threonine and valine in the above ground parts of the seedlings grown in was observed. While the amounts of seawater aspartic acid and glutamine in roots were decreased under salt stress. Proline occurred in traces in roots. Similarly, salinity induced a decline in the accumulation of arginine in the seedlings and that of alanine and aspartic acid except in hypocotyl.

Total and reducing sugars in control plants varied from 29.6 to 69.1 and 17.8 to 48.1 mg g^{-1} respectively (Table 2). Glucose and galactose occurred in higher concentrations than arabinose. Decrease in the total, reducing and individual sugars was observed under saline condition except in the epicotyl.

The mineral composition of 21 day old seedings of *S. persica* grown in diluted seawater (Fig 1 B,C) showed accumulation of salts. Similarly Na, K, Ca, Mg and Cl content in the seedlings was more under salt stressed condition. These findings indicated

Table 2 *Effect of seawater salinity on free amino acids and sugars in 21 day old seedlings of S. persica*

Components	Roots		Hypocotyl		Epicotyl		Cotyledone	
	a	b	a	b	a	b	a	b
Amino acids (μ g^{-1})								
Alanine	96	69	315	375	303	66	138	30
r-aminobutypric acid.	–	–	–	–	–	–	22	75
Arginine	715	–	2854	1272	817	668	256	193
Asparagine	1050	1154	5931	10001	7111	6300	1981	1554
Asparatic acid	15732	663	6266	15304	11096	7244	1157	864
Glutamic acid	98	134	34	439	66	102	76	101
Glutamine	1783	96	884	568	718	324	30	102
Glycine	124	172	50	220	58	245	45	145
Histidine	863	–	2355	3881	3136	1254	967	1483
Iso-leucine	66	177	106	276	69	246	53	50
Leucine	92	134	121	328	77	292	61	85
Methionine	311	Tr	202	403	92	98	172	251
Phenylalanine	268	777	3319	4441	1295	3948	122	458
Proline	Tr	Tr	Tr	212	Tr	188	Tr	64
Serine	124	150	184	783	395	696	206	149
Threonine	49	275	559	688	364	153	284	179
Tyrosine	–	–	–	–	–	–	280	218
Valine	166	Tr	123	220	47	62	108	143
Total	21537	3741	23303	39411	26244	21886	5961	6107
Sugars (mg g^{-1})								
Total	29.6	21.3	52.5	36.5	52.5	65.4	69.4	55.5
Reducing	17.8	13.4	48.1	30.4	35.8	61.4	46.6	35.8
Arabinose	0.6	1.6	6.8	0.5	0.7	3.1	3.3	Tr
Galactose	5.3	1.1	15.8	5.8	7.6	17.4	7.8	3.8
Glucose	11.0	2.0	25.9	11.9	15.1	38.7	15.5	7.9

a. distilled water b. seawater. Tr- traces.

retention of inorganic ions in roots of young seedlings.

Twenty nine per cent seeds of *S. persica* germinated in pure seawater although maximum germination was observed in distilled water (Table 1). Sen and Chawan (1969) had reported 90 to 94% germination of *S. persica* and *S. oleoides* in distilled water. Seeds of many halophytes germinate best both under fresh water conditions and salinity levels below 0.5% NaCl. Neverthelss, 29% germination of *S. persica* in seawater itself indicates its ability to germinate in extremely saline conditions like other euhalophytes (Williams & Ungar 1972, Joshi & Iyengar 1982). Thus, the seeds endowed with high degree of salt tolerance can be used for propagation of the species in barren saline wastelands. Germination in isotonic solutions of 12 atmospheres indicated promoting and inhibitory effects of NaCl and Na_2SO_4 respectively than inert solution of mannitol. It is clear, therefore, that inhibition of germination of *S. persica* in higher salinities due to a combination of osmotic and specific ionic effects of seawater.

The present investigation showed that the seedlings yielded proteins equilvalent to amounts recorded for mature plants (Krishna Kumar 1986). Moreover, their concentration was slightly affected at 24 dS m^{-1}. This indicates that the young seedlings are well adapted to salinity stress as far as the availability of proteins is concerned.

Results of free amino acids indicated their enhanced metabolism during seedlings stage. Koller *et al.* (1962) had suggested that number and the contents of amino acids increased during germination of seeds. Significant increase in the concentration of proline in the epigeal parts shows that *S. persica* accumulates proline under salt stressed condition like other halophytes (Stewart *et al.* 1979, Flowers 1985). Enhanced synthesis of alanine, arginine, aspartic acid, glutamic acid, glycine, serine and threonine may be of help to seedlings as some of them have been known to have protective effects on membranes (Tyankova 1970).

Our results of the total and reducing sugars in the seedlings of *S. persica* are quite comparable to those noted for mangrove species (Joshi *et al.* 1972). However, our study shows the adverse effects of salinity on accumulation of sugars in the seedlings except in the epicotyl region.

The seedlings grown in 24 dS m^{-1} seawater showed markedly high uptake of Na, Cl, K and to a lesser extent that of Ca and Mg. Preferential uptake of Na and Cl by seedlings and young plants of halophytes is well known (Flowers 1985). About 2 fold increase in the K content under salt stress is striking and it may be due to the existence of 'dual carrier mechanism' operating for uptake of K from Na rich environment (Epstein 1972).

The present investigation suggests that seeds of *S. persica* can germinate in highly saline condition and that the seedlings possess well adapted mechanisms of proteins, amino acids and mineral ions which help to avoid adverse effects of salinity during their early establishment.

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