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NaCl induced changes in organic constituents of *Acanthus ilicifolius* a salt marsh halophyte

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Abstract : The present study pertains to the effect of exogenous addition of different concentration of NaCl ranging from 100 to 500 mM, to the one month old seedlings of *Acanthus ilicifolius*. Accumulaiton of organic constituents like amino acids and total sugars decreased with increasing concentration upto200 mM. Beyond 200 mM, they gradually increased. The proline content increased with increasing salinity upto the extreme level of 500 mM NaCI. The protein, starch and chloropyll content also increased with increasing concentration upto 200 mM and thereafter they gradually declined. (*Key Words : Acanthus ilicifolius, Amino acid, Halophyte, Sugar).*

Soil salinity is one of the principle factors responsible for deterioration of soils, with consequent reduction of their agricultural potential. Saline-sodic soils in semi-arid regions pose difficulties in land use because of economic and climatic constraints related to ameliorative measures. Although leaching of salts by good quality irrigation water and replacement of exchangeable sodium by chemical amendments might improve such soils, these measures are confined and in practice being expensive, are not readily feasible. The halophytes are able to maintain the water potential gradient (osmoregulation) by accumulation of inorganic ions and low molecular mass organic compounds in their tissues (Weretilnyk *et al.* 1989).

Accumulation of free amino acids occurred in many plants in response to changing osmotic adjustment of their cellular contents. Proline is the stable and less toxic for cell growth among all the amino acids. It is also more resistant to acid hydrolysis in plant under stress. The free proline content in the leaves and roots increased significantly with stress intensity, duration and is similar to the reports of several investigators (Ramanjulu *et al.*, 1993). Leaf chlorophyll has been reported to increase with optimal level of 200 mM NaCL in *Ipomoea pescaprae* (Venkatesan *et al.*, 1995).

Materials and Methods

One month old seedlings of *Acanthus ilicifolius*, a halophytic dicotyledonous shrub were collected from the salt marsh of Pichavaram on the north east coast of Tamil Nadu (11°24'N and 79°44'E) and the saline treatments were carried out in the Botanic garden of Annamali University. The seedlings were subjected to NaCl salinity ranging from 100-150 mM, besides a control. The salt treatment continued for 10 days, until the plants received the required concentration of salt. The seedlings could not survive beyond 500 mM concentration, a week after salt treatment. After completion of salt treatment, the seedlings were maintained irrigated with tap water. Samples were collected on 60th and 90the day after salt treatment and washed thoroughly with tap water followed by distilled water to analyse the biochemical studies. The data were statistically analysed by critical difference method.

Free amino acid contents were quantitatively determined using the method of Moore & Stein (1948). Proline was determined by the method of Bates *et al.* (1973). The total sugar content was determined according to the method of Nelson (1944). Protein was extracted and estimated following the method of Lowry *et al.* (1951). Chlorophyll content was estimated according to the method of Arnon (1949).

Results and Discussion

Amino acids

Total free amino acid contents of *A. ilicifolius* significantly decreased with increasing concentrations of NACI upto 200mM. Beyond this concentration, an increase in amino acid was observed (Table 1). Rao & Rao (1981) reported that certain halophytes under moderate salinity accumulated free amino acids due to degration of proteins and it was believed to be important an osmotic adjustment of cells.

Proline

The results on the effect of NaCI stress on the proline content of all the three tissues are presented in Table 1. There was two-fold increase in proline content in the tissues at 500 mM when compared to those of control plants. Salt tolerance has been associated with the capacity of a speices to accumulate proline when acts as an intracellular osmoticum (Zidan, 1995).

Protein

The data on the effect of NaCl on the protein content of leaf, stem and root are presented in Table 2. Maximum accumulation of protein content increased with incrasing salinity upto 200 mM and thereafter gradually declined. The leaf had more protein than stem and root.

The progressive decrease in protein and increase in the total free amino acids under NaCl salinity were either due to the conversion of protein into amino acids or inhibition of amino acid incorporation into protein. Increase in protein was assiciated with the decrease in the amino acid content under moderate salinity and a reverse trend was noticed at higher salinity ranges. Protein synthesis responded dramatically to environmental stress such as heat shock and anaerobiosis and salt stress (Erickson & Alfinito, 1984).

Carbohydrates

Sodium chloride treatment decreased the total sugar content of the leaf, stem and root (Table 2). The sugar content decreased with increasing concentration upto 200 mM NaCl salinity and beyond 200 mM, gradual increase was observed. The results on the effect of NaCl on the starch content of the leaf, stem and root are presented in Table 5. There was an increase in the starch content with increasing salinity upto 200 mM and thereafter the starch content gradually decreased.

Under salinity stress, the decrease in carbohydrate could be either due to high respiration or a decrease in photosynthetic activity. An increase in sugar content and corresponding decrease in the starch at higher salinities have been reported in a few halophytes (Venkatesan & Chellappan, 1998).

Chlorophyll

The total chlorophyll content increased with increasing salinity upto 200 mM and at higher salinity the content gradually declined (Table 2). Positive effect of NaCl salinity on the chlorophyll synthesis has been reported in halophyte, *Ipomoea pes-caprae* (Venkatesan *et al.* 1995).

It was concluded that NaCl stimulate the growth and organic components upto 200 mM. Salinity

Table 1. Effect of NaCl on the aminoacid and proline content [mg.g^{-1} (d.m)] in leaves, stems and roots of *A.ilicifolius* measured at 60, 90 days after salt treatment (mean ± SE, N=3)

NaCl (mM)	Days after salt treatment											
	Aminoacid						Proline					
	60th day			90th day			60th day			90th day		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
0	2.56 ±0.150	1.12 ±0.060	0.665 ±0.039	3.03 ±0.070	1.27 ±0.24	1.18 ±0.187	4.00 ±0.171	3.13 ±0.271	2.86 ±0.211	4.53 ±0.182	3.53	3.04
100	2.04 ±0.120	0.89 ±0.050	0.430 ±0.025	2.20 ±0.132	1.07 ±0.064	0.903 ±0.054	4.82 ±0.289	3.53 ±0.212	3.04 ±0.182	5.36 ±0.321	4.23 ±0.253	3.67 ±0.220
200	1.30 ±0.070	0.53 ±0.030	0.276 ±0.016	1.59 ±0.095	0.87 ±0.052	0.571 ±0.034	5.92 ±0.355	4.69 ±0.281	3.98 ±0.238	6.64 ±0.398	4.84 ±0.290	4.24 ±0.254
300	2.92 ±0.180	1.86 ±0.116	1.67 ±0.100	3.50 ±0.210	2.23 ±0.133	2.06 ±0.123	6.13 ±0.367	5.50 ±0.330	4.55 ±0.273	7.22 ±0.433	6.08 ±0.364	4.97 ±0.296
400	4.60 ±0.270	3.24 ±0.194	3.06 ±0.183	5.35 ±0.321	3.93 ±0.235	3.24 ±0.194	6.89 ±0.413	6.26 ±0.370	5.14 ±0.308	7.98 ±0.478	7.09 ±0.425	5.88 ±0.352
500	4.95 ±0.290	4.30 ±0.258	4.68 ±0.280	6.23 ±0.373	4.83 ±0.289	4.76 ±0.285	8.24 ±0.494	7.55 ±0.453	6.07 ±0.364	9.07 ±0.544	7.90 ±0.474	6.77 ±0.406
CD= P(0.05)	0.623	0.408	0.370	0.755	0.488	0.436	1.243	1.058	0.886	1.409	1.164	0.987

Table 2. Effect of NaCl on the protein and total sugars content [mg.g^{-1} (d.m)] in leaves, stems and roots of *A.ilicifolius* measured at 60, 90 days after salt treatment (mean ± SE, n=3)

NaCl (*m*M)	Days after salt treatment											
	Protein						Total Sugars					
	60th day			90th day			60th day			90th day		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
0	8.49	7.56	6.97	10.18	9.37	8.74	11.64	7.69	6.75	12.47	10.16	7.64
	±0.506	±0.453	±0.418	±0.610	±0.562	±0.524	±0.698	±0.461	±0.405	±0.748	±0.609	±0.458
100	9.97	8.41	7.55	10.99	9.84	9.06	9.72	6.08	5.89	10.687	9.60	7.23
	±0.598	±0.504	±0.453	±0.659	±0.590	±0.543	±0.583	±0.364	±0.353	±0.640	±0.576	±0.433
200	10.41	8.99	8.06	12.71	11.41	10.69	7.83	5.82	4.67	8.67	6.94	4.82
	±0.624	±0.539	±0.483	±0.762	±0.684	±0.641	±0.469	±0.349	±0.280	±0.520	±0.416	±0.289
300	9.67	8.04	7.86	11.07	10.63	9.73	10.92	6.70	5.57	11.04	7.09	5.98
	±0.580	±0.482	±0.471	±0.664	±0.637	±0.583	±0.655	±0.402	±0.334	±0.662	±0.425	±0.358
400	9.26	7.66	6.41	9.46	8.53	6.56	12.05	9.72	7.85	12.96	10.45	6.93
	±0.555	±0.459	±0.384	±0.567	±0.517	±0.393	±0.723	±0.583	±0.471	±0.777	±0.627	±0.415
500	8.13	6.32	4.66	8.72	7.34	5.43	14.14	10.35	8.04	15.32	11.87	9.11
	±0.487	±0.379	±0.279	±0.523	±0.440	±0.325	±0.848	±0.621	±0.482	±0.919	±0.712	±0.546
CD=P(0.05)	1.933	1.624	1.434	2.182	1.974	1.735	2.293	1.603	1.340	2.463	1.940	1.441

Table 3. Effect of NaCl on the starch, chlorophyll 'a', chlorophyll 'b' and chlorophyll a/b content [mg.g^{-1} (d.m)] in leaves, stems and roots of *A.ilicifolius* measured 60, 90 days after salt treatment (mean ± SE, n=3)

NaCl (*m*M)	Days after salt treatment													
	Starch						Chlorophyll							
	60th day			90th day			60th day				90th day			
	Leaf	Stem	Root	Leaf	Stem	Root	'a'	'b'	Total	a / b	'a'	'b'	Total	a / b
0	7.052	5.236	4.281	7.906	6.253	4.645	1.370	1.079	2.449	1.269	1.589	1.152	2.741	1.379
	±0.423	0.314	0.256	0.474	0.375	0.278	0.082	0.064	0.146	0.076	0.095	0.069	0.164	0.082
100	8.750	5.403	4.970	9.323	8.643	6.895	1.477	1.194	2.671	1.237	1.617	1.274	2.945	1.311
	±0.525	0.324	0.298	0.559	0.518	0.413	0.088	0.071	0.160	0.160	0.100	0.076	0.176	0.078
200	12.468	9.313	7.118	14.944	10.685	8.513	2.306	1.627	3.933	3.933	2.358	1.988	4.346	1.186
	±0.748	0.558	0.427	0.898	0.641	0.510	0.138	0.097	0.235	0.235	0.141	0.119	0.260	0.071
300	10.326	8.073	6.051	12.846	9.879	7.187	1.753	1.315	3.068	3.068	2.137	1.645	3.782	1.299
	±0.619	0.484	0.363	0.770	0.592	0.431	0.105	0.078	0.184	0.184	0.128	0.098	0.226	0.077
400	9.826	6.036	5.114	10.142	6.377	5.065	1.490	1.071	2.561	2.561	1.893	1.435	3.328	1.319
	±0.589	0.362	0.306	0.608	0.382	0.303	0.089	0.064	0.153	0.153	0.133	0.086	0.199	0.071
500	5.822	3.209	2.533	7.006	4.891	4.602	1.367	0.997	2.364	2.364	1.519	1.129	2.648	1.345
	±0.349	0.192	0.151	0.420	0.293	0.276	0.082	0.059	0.141	0.141	0.091	0.067	0.158	0.080
CD= P(0.05)	1.877	1.288	1.039	2.151	1.614	1.274	0.337	0.250	0.588	0.276	0.385	0.297	0.683	0.265

possess a major problem in the cultivation of crop plants. Halophytes offer a possibility of alternative crop, an understanding of their physisology of salt tolerance offers a possible route to increase salt resitance in existing crop species.

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Trends in rice area, production and productivity in the different agro-climatic zones of Tamil Nadu

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Abstract : Rice grain production in Tamil Nadu had ranged from 3.33 million tonnes to 7.56 million tonnes during 1959-60 to 1996-97. The overall trend on rice production and productivity increased but the area under rice showed a decreasing trend. Rice area in the state was declining at an average rate of 22,900 ha yr^{-1} and the total rice grain production increased at an average of 84,600 t yr^{-1}. The North Eastern Zone, Cauvery Delta Zone and Southern Zone contributed to 87% of total rice production in the state with a standard deviation of 1.64%. The Western Zone, North Western Zone and High Rainfall Zone contributed to 12.8% Rice productivity (kg grain ha^{-1}) in Tamil Nadu had shown an increasing trend at an average of 82 kg ha^{-1} yr^{-1}. The overall mean of rice productivity was highest in the Western Zone (4.2 t ha^{-1}). *(Key Words : Rice, Agro-climatic zones, Yield trend).*

Rice is the staple food in Tamil Nadu and hence rice production has been given top priority. Average rice grain yields in Tamil Nadu have increased considerably with the introduction of high yielding varieties and improved crop management technologies. But, there is still quite a gap between the potential yields in the different agro-climatic regions of Tamil Nadu and the actual yields