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Impact of NaCl on growth, photosynthetic characteristics of *Bruguiera conjugata* Merr and *Ceriops roxburghiana.* Arn

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Abstract
A present study deals with the effect of exogenous addition of sodium chloride ranging from 0-800mM NaCl on growth and photosynthetic characteristics of *Bruguiera conjugata* and *Ceriops roxburghiana*. The growth parameters such as shoot length, root length, fresh weight, dry weight increased upto optimum level of 400mM NaCl in *B. conjugata* and 300mM NaCl in *C. roxburghiana*. The chlorophyll content and net photosynthetic rate increased upto optimum level, beyond this level drastically reduced the net photosynthetic rate. The increase in the net photosynthetic rate was associate with the increasing chlorophyll content of both species.

Keywords: growth, chlorophyll, mangroves, salinity, net photosynthetic rate

1. Introduction
A variety of mechanism contributes to the salt tolerance of halophytes. It is suggested that compartmentation of ions in the vacuole and accumulation of compatible solutes in the cytoplasm as well as presence of gene for salt tolerance [1]. An adverse effect of salinity in chlorophyll synthesis in the leaves of *Avicennia marina* and *Avicennia officinalis* was reported by [2]. In contrast of the above observation, an increase in the chlorophyll content with increasing external salining upto optimum level was noticed *Ipomoea pes-caprae* [3], *Arthrocnemum indicum* [4] and *Ipomoea pes-caprae and Cleodendron inerma* [5]. The ions involved in osmotic adjustment were largely attributed to the vacuoles and osmotic potential of the cytoplasm being adjusted with organic compatible solutes [6].
The net photosynthesis of many plant species declined with increasing rhizosphere salinity. Inhibition of photosynthesis and plant growth at high salinity has been observed in many mangrove species. On the other hand, the net photosynthesis, PSI, PSII are whole chain electron transport have been reported to increase with increasing salinity upto optimum concentrations of NaCl in *Ipomoea pes-caprae* [3], *Bruguirea parviflora* [7], *Rhizosphora mangle* [8]. The photosynthetic rate and stomatal resistance and inter cellular CO_2 level were greatly reduced and the biomass was increased by the treatment [9]. The knowledge of the mechanism of salt tolerance by halophyte in general and mangrove in particular and their photosynthetic responses to salinity would be of immense use in agriculture and silviculture in saline environment. The objective of the present study was to examine the effect of NaCl on the growth and net photosynthesis in the leaves of *Bruguiera conjugata* and *Ceriops roxburghiana* commonly occurring coastal land plants.

2. Materials and Methods
Identical one-month old seedlings of each of *Bruguiera conjugata* and *Ceriops roxburghiana* were collected from the tidal forest of mangrove belt of Pichavaram on the north east coast of Tamil Nadu, India (11°24'N and 79°44'E). The seedlings were planted in the polythene sleeves filled with homogenous mixture of garden soil it comprising sand, red earth and farm yard mannure in the ratio of 1:2:1 and were irrigated with tap water. The entire experimental site were maintained in the botanical garden, Annamalai University with normal sunlight. After one month fully established seedlings were selected, kept in nine plots each consisting of 30 plants and treated with 0 to 1000 mM NaCl. The seedlings treated, beyond 800 mM NaCl in *Bruguiera conjugata* and 600 mM NaCl in *Ceriops roxburghiana* could not survive a weak after salt treatment. The salt treatment continued for 10 days, after receiving the required millimolar concentrations of salt treatment, the seedlings were irrigated with tap water.
The shoot and root length were measured by scale on 120th day after salt treatment. The fresh weight and dry weight of the plant organs weighing with electronic balance and dry weight the plant organs are kept it in 80°C for 24hrs after that the plant organs are weighed.
The photosynthetic responses of the two species measured by 120th day after salt treatment was studied. The net photosynthetic rate (P_N) was measured at 28±2°C, CO_2 concentration of 350gm^{-3}, irradiance of 450±25 Wm^{-2} and relative humidity of 50±10% Li-6000(Li-Cor USA). The chlorophyll (chl) content was determined spectrophotometrically (Hitachi 200-20, Japan) followed by the method of [10]. The sampling data were statistically analysed by anova two-way method. Chlorophyll and net photosynthetic rate data analysed by correlation (r). Both

data were analysed statistically siginificant at both 1% and 5% level.

Table 1: Effect of NaCl on shoot and root length, fresh and dry weight of *Bruguiera conjugata* and *Ceriops roxburghiana* on the 120th day after salt treatment (mean ± SE; n = 5)

Plant Species	NaCl (mM)	Shoot Length (cm Plant^{-1})	Root length (cm Plant^{-1})	Fresh weight (g Plant^{-1})			Dry weight (g Plant^{-1})			F values
				Leaf	Stem	Root	Leaf	Stem	Root	
B. Conjugata	0	20.50±1.23	17.40±1.04	6.86±0.49	6.00±0.36	5.50±0.33	2.59±0.15	2.30±0.13	1.95±0.11	Shoot length F1=43.26*
	100	26.45±1.58	21.35±1.28	10.10±0.60	7.61±0.45	6.20±0.37	3.54±0.21	2.45±0.14	2.20±0.13	
	200	28.40±1.7	23.60±1.41	11.90±0.71	8.00±0.48	6.82±0.40	3.70±0.22	2.65±0.15	2.53±0.15	Root length F2=69.45*
	300	29.60±1.77	25.90±1.53	12.45±0.74	9.52±0.57	8.14±0.48	4.15±0.24	3.22±0.19	2.87±0.17	
	400	32.50±1.95	28.60±1.71	18.60±1.11	11.74±0.70	9.40±0.56	6.52±0.39	3.80±0.22	3.09±0.18	Fresh weight (FW) F1=96.03*; F2=98.83*
	500	28.66±1.71	26.10±1.56	16.40±0.80	9.66±0.57	8.60±0.51	6.21±0.37	3.31±0.19	2.71±0.16	
	600	24.50±1.47	23.40±1.40	13.32±0.79	8.95±0.53	7.55±0.45	5.88±0.35	3.630±0.18	2.50±0.15	Dry weight (DW) F1=95.15*; F2=125.45*
	700	22.40±1.34	20.10±1.20	10.25±0.61	7.66±0.45	6.65±0.39	5.01±0.30	2.77±0.16	2.10±0.12	
	800	19.48±1.16	16.30±0.99	8.80±0.52	6.50±0.39	5.84±0.35	4.20±0.25	2.45±0.14	1.86±0.11	
C.roxburghiana	0	17.2±1.032	7.0±0.42	6.2±0.37	4.6±0.27	4.2±0.43	2.2±0.13	1.9±0.114	1.2±0.07	Shoot length & Root length F1 = 11.24* & F2 = 39.69*
	100	18.5±1.110	7.3±0.438	8.5±0.51	5.8±0.34	4.9±0.51	2.8±0.168	2.3±0.138	1.6±0.09	
	200	19.3±1.158	8.2±0.49	9.3±0.55	6.3±0.37	5.9±0.55	3.0±0.18	2.7±0.154	2.2±0.132	Fresh weight (FW) F1
	300	24.5±1.47	8.9±0.534	11.5±0.69	8.6±0.49	8.6±0.61	3.7±0.22	3.2±0.189	2.6±0.156	= 66.94*; F2 110.94*
	400	21.9±1.31	8.0±0.48	9.6±0.57	7.2±0.43	7.8±0.49	3.2±0.192	2.6±0.166	2.10±0.126	Dry Weight (DW) F1
	500	18.3±1.09	7.2±0.41	8.7±0.53	6.3±0.37	7.01±0.429	2.6±0.156	2.1±0.141	1.8±0.108	= 20.29*; F2 = 73.29*
	600	16.0±0.960	6.7±0.36	7.2±0.43	5.66±0.21	6.4±0.31	2.14±0.121	1.69±0.120	1.5±0.09	

Table 2: Effect of NaCl on Net Photosynthestic rate (P_N) and chlorophyll (a+b) content in this leaf of *Bruguiera conjugata* and *Ceriops roxburghiana* on the 120th day after salt treatment (mean ± SE; n = 5)

NaCl (mM)	*Bruguiera conjugata*		*Ceriops roxburghiana*	
	(P_N) (µmoleCO_2 m^{-2} g^{-1})	Chl (a+b) mg g^{-1} fr. wt	(P_N) (µmoleCO_2 m^{-2} g^{-1})	Chl (a+b) mg g^{-1} fr. wt
0	4.632±0.278	1.89±0.113	6.10±0.368	1.64±0.098
100	5.118±0.301	2.30±0.138	6.90±0.414	2.48±0.148
200	5.992±0.354	2.96±0.178	7.40±0.444	3.15±0.189
300	6.640±0.397	3.74±0.224	8.07±0.570	3.97±0.308
400	9.850±0.553	4.95±0.297	9.50±0.484	5.14±0.238
500	7.900±0.435	4.68±0.281	7.41±0.445	4.72±0.208
600	6.075±0.365	3.66±0.219	6.20±0.312	2.10±0.128
700	5.120±0.344	2.86±0.172	_	_
800	3.850±0.219	2.15±0.131	_	_
	r =+0.912		r =+0.887	

3. Results and Discussion

Sodium Chloride treatment enhanced the growth rate of shoot length, root length, fresh weight and dry weight upto 400mM NaCl in *Bruguiera conjugata* and 300mM NaCl in *Ceriops roxbughiana* and thereafter drastically reduced the growth (Table 1). The maximum increase was observed in shoot and root length (32.50; 28.60 cm plant^{-1}), fresh weight of leaves, stem and root (18.60; 11.74; 9.40 g plant^{-1}) and dry weight of leaves, stem and root (6.52; 3.80; 3.09 g plant^{-1}) upto 400mM in *B. conjugata*. The maximum increase was found in shoot and root length (24.5; 8.9 cm plant^{-1}), fresh weight (11.50; 8.60; 8.30 g plant^{-1}), dry weight (3.7; 3.2; 206 g plant^{-1}) upto 300mM in *Ceriops roxbhughiana*. Beyond this optimum level drastically reduced the growth rate of both species.

Growth stimulation at low moderate external salinity has been reported for many halophytes such as *Saueda fruticosa* [11]; *Atriplex nummularia* [12]; *Salicorinia brachiata,* [13]. The increase in fresh weight in the leaves was mainly due to an increase in tissue water content and can be a good reason for tissue succulence. The dry weight increase may be attributed to the accumulation of inorganic and organic constituents in the plant the similar findings observed in other species. *Suaeda attisima* [14], *Sesirium portulacastrum* [15] and *Ipomoea pes-caprae* and *Clerodendron innerma,* [5], *Rhizophore mangle* [8].

Sodium Chloride treatment enhanced the P_N rate upto 400 mM in *B. conjugata* 300mM NaCl in *Ceriops roxbughiana*, beyond this optimum level the P_N activity was reduced gradually. (Table 2); The Chl(a+b) content also increased maximum upto optimum level in both taxa (Table 2). There was a significant correlation between the Chl content and P_N. Similar trends was observed in many other halophytic species such as *Spartina alterniflora* [16], *Rhizophora mangle* [8], *Apera intermedea,* [17]. The net photosynthesis increased with increasing salinity upto the optimum level and the CO_2 uptake rate was identical in this species at various concentration. Even the extreme salinity the CO_2 uptake was comparable to that of non-saline control plants and CO_2 uptake could be correlated with the Chlorophyll content.

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