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SALINITY TOLERANCE OF RICE AS RELATED TO GROWTH AND PHYSIOLOGICAL CHARACTERISTICS

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Abstract

The effect of salinity of the physico-chemical characters of rice was studied to understand the physiology of salt tolerance. Salinity was observed to affect root length more drastically than shoot height. Higher salt tolerance indices (STI) and lower reductions of dry weight were recorded in salinity tolerant varieties, Pokkali and Nonabokra. At EC of 2.5 dS/m, except IR 20, the beneficial effect of salinity was reflected by increased dry matter accumulation in the shoot.

The salinity tolerant varieties showed higher initial chlorophyll content and a less reduction of chlorophyll with the increase of salinity. Although N increased with the increase of salinity, the total N uptake was the highest only at EC of 2.5 dS/m, correlating well with a higher dry matter production at this level. Salt tolerance index, chlorophyll and N contents are good indicators of salt tolerance in rice.

Key words: Rice, Salinity, Salt Tolerance Index (STI), Chlorophyll, Nitrogen.

Introduction

Soil salinity is a constraint to successful rice cultivation in about 0.8 m ha active saline regions of the coastal districts and off-shore islands of Bangladesh. Measures to reclaim the soil or desalinize the seawater that intrudes the rice field do not seem to be economically feasible. Expansion of rice acreage by the introduction of varieties in the saline areas offers hope of additional rice production. Development of salt tolerant varieties would require the understanding of salt tolerance mechanism and their physiological behaviour in saline condition.

Biologists have long been concentrating on studying the salinity tolerance of rice (Ehrencorn, 1965; Balasubramanian and Rao, 1977; Fageria *et al.*, 1981; Reddy and Vaidyanath, 1982; Akbar and Senadhira, 1988; Ryu *et al.*, 1988; Punyawardena and Dharmamasri, 1989) to identify and incorporate salt tolerance characters in varietal improvement programme. Salinity is known to affect the photosynthetic process by altering the chlorophyll content (Ota and Yusui, 1962) and nutrient status (Ahmed *et al.*, 1989) of the rice plant. Attempts were made to study the affect of NaCl and seawater on the physiological and chemical changes (chlorophyll and N content) of the salt tolerant and susceptible varieties of rice at the seedling stage.

Materials and Methods

Expt. 1. Five rice varieties namely, Pokkali, Nonabokra, MI-48, IR20 and ZH5 were grown in nutrient solution on styrofoam contained in trays and supplied with NaCl to give salinity of 0,7, 10 and 13 dS/m. The plants were grown in the greenhouse and replenished with nutrient solution every 3-4 days. Ten plants were sampled per replication at 21 days after sowing (DAS). Data on plant height, root length, dry weight of shoot and, chlorophyll (Yoshida *et al.,* 1971) and N content (by micro-Kjeldahl digestion) of plant shoot were determined after harvest.

Expt. 2. In this experiment, four varieties were the same as in Expt. 1, but ZH5 was substituted for BR20. The treatments consisted of nutrient solutions supplied with simulated concentrations of seawater to give ECs of 0, 2.5, 5.0, 7.5, 10.0 and 12.5 dS/m. All other experimental procedures were the same as in Expt. 1. The plants were harvested at 35 DAS. Data on dry weight accumulation and nitrogen content were collected. Salt tolerance index (STI) was determined from the ratio of dry weights of plant shoot grown in saline treatment to those of untreated control.

The experiments were set in completely randomised design in the greenhouse with three replications per treatment and ten plants per replication. The trays were placed in the greenhouse.

Results and Discussion

Plant height and root length

The increase of salinity is observed to adversely affect the plant height of all the five varieties tested (Table 1). However, in the popularly known salt tolerant varieties, Pokkali and Nonabokra, the reductions of plant height were observed to be lower. Although the root lengths due to treatment of 7, 10 and 13 dS/m resulted in a decrease compared to control (EC of 0, untreated), except MI-48, insignificant

Table 1. Effect of NaCl on the plant height (cm) at 21 DAS.

Variety	Treatment EC (dS/m)			
	0	7	10	13
Pokkali	57.47 aA	42.93 aB (25.30)	36.13 aC(37.13)	31.80 bD(44.67)
MI-48	23.09 dA	11.60 cB(49.76)	11.21 dB(51.45)	00.00 dD(100)
Nonabokra	60.49 aA	39.98 aB(33.91)	31.08 bB(48.47)	36.35 aB(39.91)
IR20	26.44 cA	14.59 bcB(44.28)	14.73 cB(44.28)	13.32 cB(49.62)
ZH5	30.87 bA	15.19 bB(50.79)	13.24 cdB(57.11)	13.24 cdB(57.11)
C.V.(15.30%)				

Means followed by same small letters denote no significant difference among varieties and those followed by same capital letters among treatments. Figures in parenthesis are percent reduction in plant height over their respective controls.

differences were observed among the treatments (Table 2). The percent reductions show that root length is more drastically affected by salinity than plant height (Tables 1 and 2). Akhar *et al.* (1972) also showed that the effect of salinity was more pronounced in root elongation than production of root dry matter. A number of investigators (Fageria *et al.*, 1981; Punyawardena and Dharmamasri, 1989) observed that both shoot and root growth were affected by salinity in rice seedlings.

Salt tolerance index (STI) and shoot dry weight

The comparative analysis of response of treated and untreated seedlings expressed as STI showed that Pokkali had the best tolerance followed by Nonabokra, IR20, ZH5 and MI-48 (Fig. 1). Krishnamurty *et al.* (1987) also observed higher indices in salt tolerant varieties. Salt tolerant varieties showed lower dry weight reductions compared to susceptible ones with increasing salinity (Fig 1 and 3). Saline tolerant varieties Pokkali and Nonabokra also showed improved dry matter content at EC of 2.5 and 5.0 dS/m, while in some susceptible ones, (MI-48 and BR20) dry matter accumulation increased only at 2.5 dS/m (Fig. 3). Our findings suggests a beneficial effect of salinity due to NaCl or seawater in dry matter production in Pokkali, Nonabokra, MI-48 and BR20 when used in low concentrations. Mondol *et al.* (1988) observed an increase of dry weight of endosperm of rice at 17 DAS in saline stress of 5, 10 and 15 dS/m.

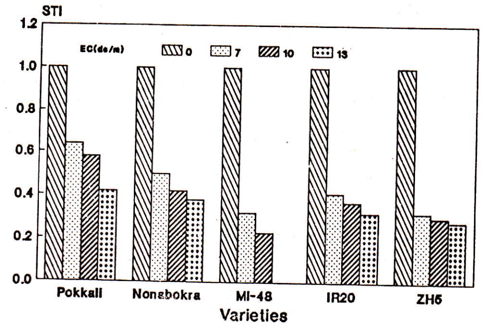

Fig. 1A. Effect of NaCl on the STI based on shoot dry wt. at 21 DAS

Table 2. Effect of NaCl on the root length (cm) at 21 DAS.

Variety	Treatment EC(dS/m)			
	0	7	10	13
Pokkali	8.66 bA	3.91 bB(54.85)	4.35 aB(49.76)	3.67 abB(57.62)
MI-48	8.08 bA	3.71 bB(54.08)	2.99 bB(62.99)	0.00 cC(100)
Nonabokra	10.05 aA	4.26 abB(20.50)	3.88 abB(26.53)	4.38 aB(43.73)
ZH5	9.16 abA	3.63 bB(60.37)	3.10 abB(66.16)	3.00 bB(67.25)
C.V. (17.9%)				

Means followed by same small letters denote no significant difference among varieties and those followed by same capital letters among treatments. Figures in parenthesis are percent reductions in root length over their respective controls.

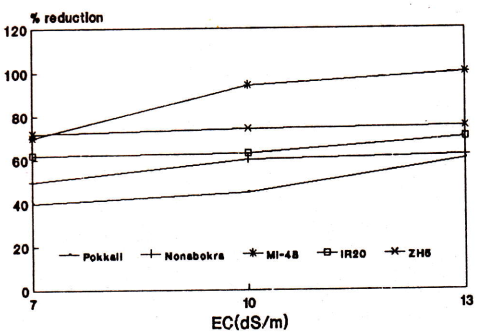

Fig. 1B. Effect of NaCl on % reduction of shoot dry wt. at 21 DAS.

Chlorophyll and nitrogen content

The chlorophyll content is an important indicator of a plant's photosynthetic functions. Salt concentrations from EC of 0-13 dS/m

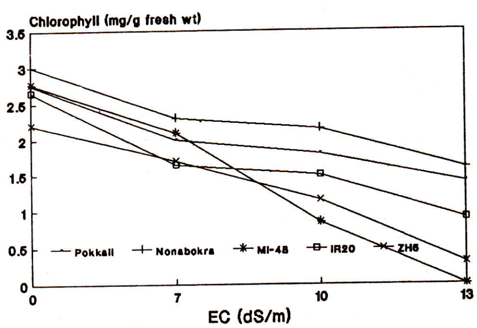

Fig. 2. Effect of NaCl on the chlorophyll (mg/g fresh wt.) of shoot at 21 DAS.

showed a linear decrease in chlorophyll content of plant top (Fig 2). However, in Pokkali and Nonabokra, the two salt tolerant cultivars maintained a higher chlorophyll content with increasing salinity. As observed by us, Baset and Arju (1989) also showed that initial chlorophyll concentration was higher in tolerant than susceptible cultivars. Some investigators (Ota and Yusui, 1962; Krishnamurty *et al.*, 1987) observed that salt stress decreases chlorophyll content in proportion to an increase in salinity but others (Pandey and Srivastava, 1987) showed an increase in chlorophyll content by 5.0 to 14.6% at 10 dS/m in rice.

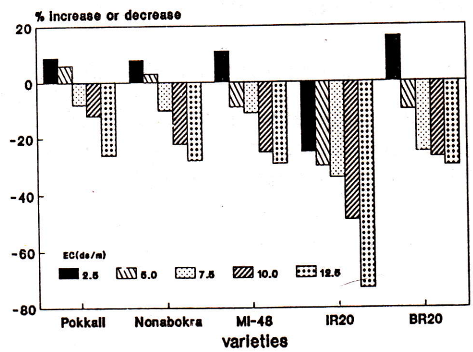

Fig. 3. Effect of salinity (sea water) on the % Increase or decrease of shoot dry wt. over control at 35 DAS.

The nitrogen content (%) of the plant top increased with the increase of salinity in salt tolerant varieties like Pokkali and Nonabokra

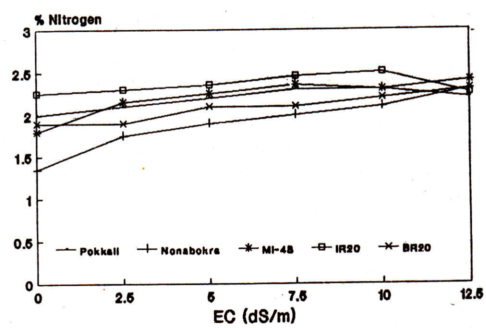

Fig.4. Effect of salinity (sea water) on the % nitrogen of shoot at 35 DAS.

while in MI-48, BR20 and IR20, the increase was little (Fig. 3 and 4). At the lowest salinity level of 2.5 dS/m, the total N uptake was higher than control (Fig. 5) indicating a positive relationship of tolerance to higher dry matter accumulation and increased N uptake at this level. The HYV's, IR20 and BR20 both had higher percent and total uptake of N in plant shoot. Low levels of salinity have shown to increase the N content of some rice plant by Girdhar (1988).

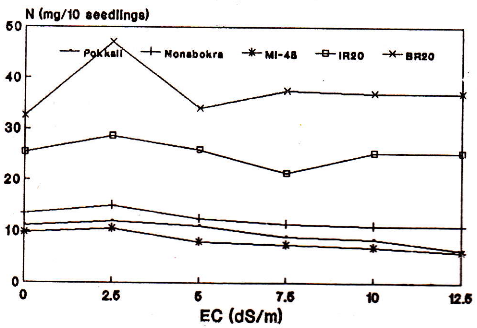

Fig. 5. Effect of salinity (sea water) on the total N uptake (mg/10 seedlings)

A salinity level of up to 5.0 dS/m for salt tolerant variety, Pokkali and a low level of 2.5 dS/m in salt susceptible variety MI-48 may safely be considered a beneficial dose for rice growth at the seedling stage. This study reflects the survivability and healthy growth of rice seedling in low saline condition, requiring continued studies on the bio-chemical changes of rice due to salinity status at the various ecological regions.

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