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Salinity Resistance of Certain Rice (*Oryza sativa* L.) Cultivars

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Abstract: A greenhouse experiment was carried out to evaluate the response of six rice (*Oryza sativa* L.) cultivars (Ribe, Tri-445, Serhat 92, Kros 424, Baldo and Rocca) to NaCl salinity. While salinity inhibited the growth of all six cultivars, Baldo, Ribe, Rocca and Kros-424 were less affected than the other cultivars. Salt treatment increased Na and Cl content of the plants, while it decreased K content. In general, the proline content and stomatal resistance of the cultivars were increased by salt treatment.

Key Words: Salinity, Rice, Proline, Stomatal resistance, Na, K, Cl.

Bazı Çeltik (*Oryza sativa* L.) Çeşitlerinin Tuzluluğa Dayanıklılıkları

Özet: Sera denemesi ile altı çeltik (*Oryza sativa* L.) çeşidinin (Ribe, Tri-445, Serhat 92, Kros-424, Baldo ve Rocca) tuzluluğa dayanıklılıkları araştırılmıştır. Tuzluluk bütün çeşitlerin gelişmelerini azaltmıştır. Bununla birlikte, Baldo, Ribe Rocca ve Kros-424 çeşitleri tuzluluktan diğer çeşitlere göre daha az etkilenmiştir. Bitkilerin Na ve Cl içerikleri tuzluluk sonucu artmış, K içerikleri ise azalmıştır. Genel olarak, çeltik çeşitlerinin prolin içerikleri ve stoma dirençleri tuz uygulamalarına bağlı olarak artış göstermiştir.

Anahtar Sözcükler: Tuzluluk, Çeltik, Prolin, Stoma direnci, Na, K, Cl.

Introduction

Rice (*Oryza sativa* L.) is a species native to swamps and fresh water marshes, cultivated varieties of which are among the world's most important food crops. However, the salinization of some of the areas where it is grown has shown that it to be very sensitive to salinity. Recently there has been great interest in developing varieties of rice that are resistant to salinity. However, the physiological basis of salt resistance is not yet fully understood (1).

Salinity is one of the main factors responsible for deterioration which makes soil unfit for agriculture. The development of plant species that can tolerate high salt levels is important for the ulitilzation of these soils. Biotic approaches to this probelem have received considerable attention lately (2, 3).

Many crops that have been undergone prolonged breeding and selection for yield and other desirable agronomic features can be seriously affected by conditions of excessive salinity. Recent efforts to maintain productivity under less favorable or marginal growth conditions have shown that considerable variation in salt tolerance may exist between species of the same genus, e.g., tomatoes (*Lycopersicon spp.*) (4,5); between cultivars, e.g., barley (*Hordeum vulgare* L.) (6) and sugar beet (*Beta vulgaris* L.) (7); or indeed within varieties, e.g., rice (*Oryza sativa* L.) (8).

Most plants respond to salt tolerance as typical glycophytes (9) and salt tolerance may depend on the capacity to maintain relatively low levels of Na and CI in tissues (8, 10).

In this paper, the changes in certain parameters (Na, K, CI, proline content and stomatal resistance) and the relationships between these parameters and the salinity resistance of six different rice cultivars grown under salt stress were investigated.

Materials and Methods

The experimental soil is a non-calcareous (0.1% $CaCO_3$) sandy loam with a pH of 7.8 and an EC of 0.30 mmhos/cm, both in a 1/2.5 water extract. The soil (1500 g) was placed into pots. Pots were partially salinized with NaCI (4 g NaCI/kg soil). The EC and pH of the salinized soil were 2.8 mmhos/cm and 7.4, respectively. Nitrogen (as calcium ammonium nitratel) P and K (as potassium dihydrogen phosphate) were added to all of the pots at the rates of 200 mg N/kg, 100 mg P/kg and 125 mg K/kg, respectively.

Seeds of rice cultivars (Ribe, Tri 445, Serhat 92, Kros-424, Baldo, Rocca) were sown at a rate of six seeds per pot. When the seedlings reached 5 cm in length, pots were filled with water up to 2 cm above soil level. After 60 days of growth, the stomatal resistance of the leaves was measured and aproximately 2 g of fresh leaf was collected from each repliction for proline analysis. Plants were then harvested. After weighing the fresh material, plants were washed with deionized water and dried at 70 °C in order to determine dry weight, and subsequently ground for Na, K, CI determination.

Sodium and K were determined in concentrated HNO_3 and $HCIO_4$ (4:1) digested samples by flame photometry. Chloride was analysed in aqueous extracts by potentiometric titration with $AgNO_3$ (11).

Proline was extracted from 0.5 g of fresh leaf tissue in to 10 ml of 3% sulfosalicylic acid and filtered through Whatman No 42 filter paper and determined spectrophotometrically, following the ninhydrin method described by Bates et al. (12), using pure proline (Merck, L-Proline, Art. 7434) as a standard.

Stomatal resistance was determined during the span of time (14.00-15.00) prior to harvest. The diffusie resistance of 5 leaves from each plant was simultaneously measured by the use of a steady satate porometer (EA 540-026 AP4 model, air temperature 36 °C, light intensity 350-400 µmol m^{-2} s^{-1}, relative humudity 55%).

Two treatment with four replication cultivars were compared in randomized complete design. The data obtained from different analyses and measurements were analyzed statistically by ANOVA (Minitab Package Program).

Results

The effects of salinity on the growth of plants as measured by fresh and dry weihgt are sown in Figure 1, and the analyses of variance in Table 1. The rice cultivars all had a decrease in fresh and dry weight production due to salinity. Growth reduction was more pronounced (approximately more than 50 %) in cv. Tri-445, Serhat 92, than in Ribe, Rocca, Baldo and Kros-424.

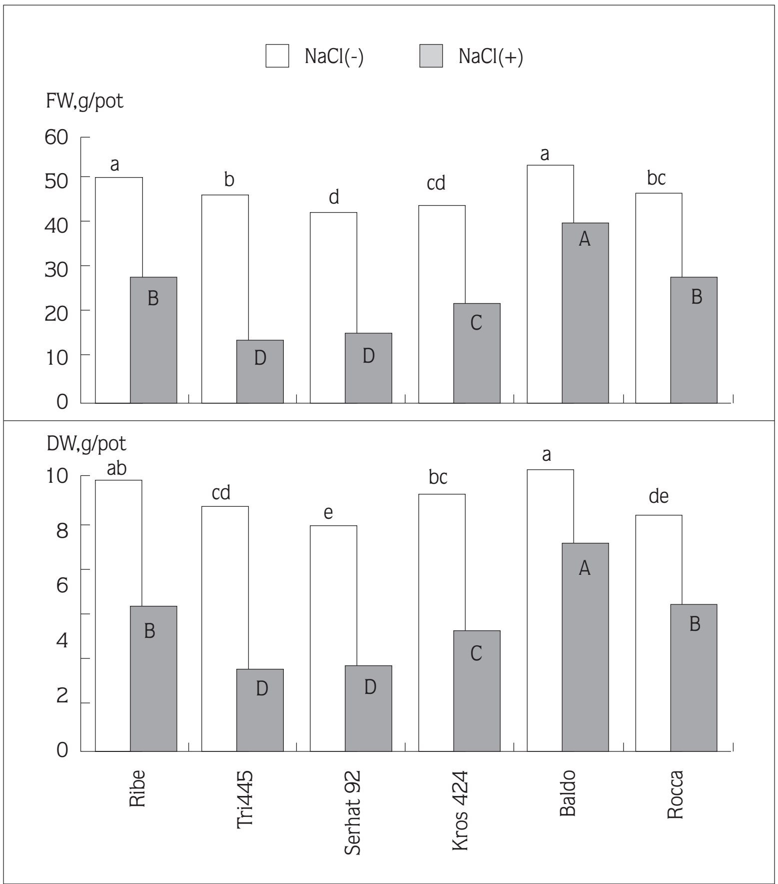

Figure 1. Fresh and dry weights of rice cultivars as affected by salinity
Means followed by the same letter are not significantly different ('Duncan's multiple-range test, $p<0.05$), capital letters for NaCl(+), small letters for NaCl(-).

Table 1. Summaries of analyses of variance (mean squares) of fresh and dry weights of the six rice cutivars.

Source of variation	df	fresh weight	dry weight
Cultivars (Cv)	5	313.55***	10.10***
Treatment	1	6451.69***	228.68***
Cv x Treatment	5	86.18***	2.95***
Error	36	3.16	0.21

*** significant at 0.01 level of probability.

Table 2. Summaries of variance (mean squares) of Na, K, Cl, proline content and stomatal resistance of six rice varieties.

Source of variation	df	Na	K	Cl	Proline	St.Res.
Cultivars (Cv)	5	0.49***	0.24***	1.88***	0.26***	2.99***
Treatment	1	8.70***	2.48***	73.36***	0.54***	11.91***
Cv x Treat.	5	0.47***	0.13***	1.90***	0.10***	0.96*
Error	36	0.01	0.02	0.07	0.02	0.34

*, ***, significant at 0.05, 0.01 levels of probability, respectively.

Table 3. Correlation coefficients of the plant parameters.

	Fresh weihgt	Dry weight	Na	K	Cl	Proline
Na	-0.892**	-0.885**				
K	0.680**	0.652**	-0.625**			
Cl	-0.917**	-0.909**	0.977**	-0.691**		
Proline	-0.583**	-0.578**	0.637**	0.106 ^{ns}	0.584**	
St.Res.	-0.364^{ns}	-0.348^{ns}	0.455^{ns}	-0.632**	0.480^{ns}	0.159^{ns}

SD (n-2)=46
** significant at 0.01 level, ns; non significant.

Salt treatment increased the Na content of all six cultivars significantly (Figure 2 and Table 2). Tri-445 and Serhat 92 accumulated more Na than Ribe, Kros-424, Baldo and Rocca.

Salt treatment also resulted in a significant decrease in the potassium content of the cultivars (Figure 2 and Table 2).

Salt treatment increased the Cl content of all cultivars consistently (Figure 2 and Table 2). Tri-445, Serhat 92 and Rocca had Significantly higher Cl contents than Ribe, Kros-424 and Baldo.

The proline content of all varieties except Rocca Increased as a result of salt treatment (Figure 3 and Table 2). Tri-445 accumulated more proline than the other cultivars.

The stomatal resistance values of all cultivars except Kros-424 increased consistently as a result of salinity (Figure 3 and Table 2). The highest stomatal resistance values were found in Baldo and Tri-445.

Discussion

While salinity inhibited growth in all cultivars, Baldo, Ribe, Rocca and Kros-424 were found

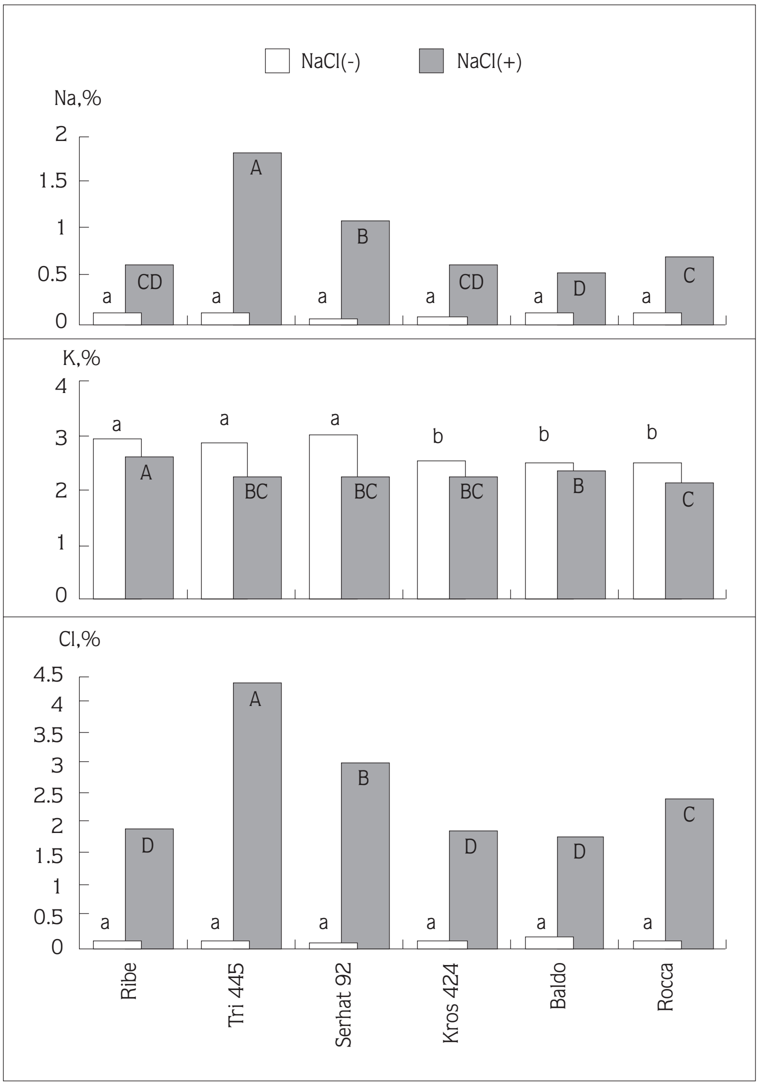

Figure 2. Sodium, K and Cl contents of rice cultivars as affected by salinity
Means followed by the same letter are not significantly different (Duncan's multiple-range test, $p<0.05$), capital letters for NaCl(+), small letters for NaCl (-).

to be significantly more saline-resistant than the others. In many crops salinity tolerance may depend on the efficiency of the root system, which can limit access of Na and Cl to the aerial parts of the plant, as reported by Lauchli and Wieneke (13). Growth may also have been inhibited by water stress, as described by Cusido et al (14). The sodium and Cl contents of the

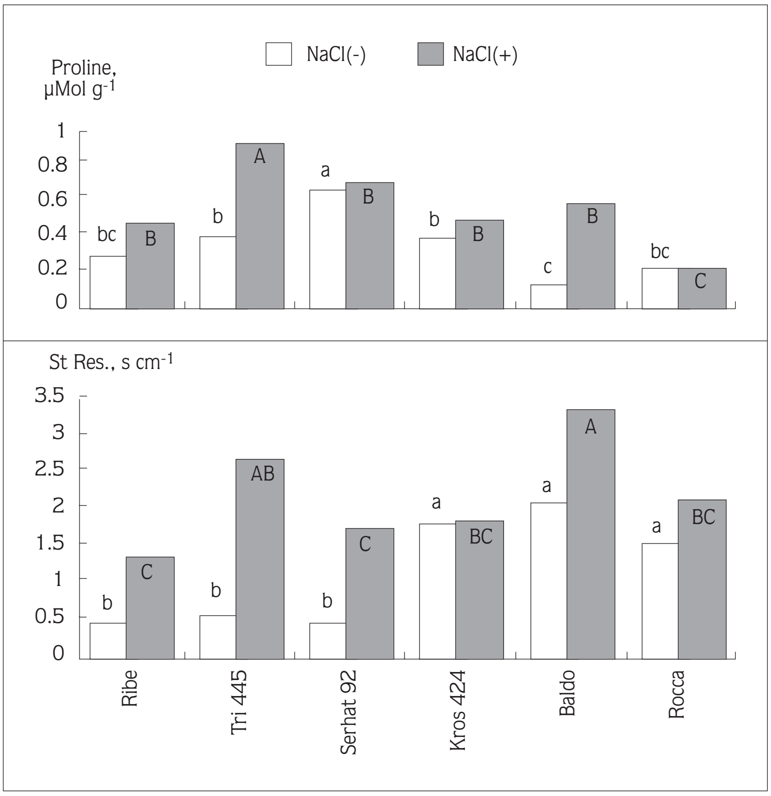

Figure 3. Proline content and stomatal resistance of rice cultivars as affected by salinity
Means followed by the same letter are not significantly different (Duncan's multiple-range test, $p<0.05$), capital letters for NaCl(+), small letters for NaCl(-).

salt-tolerant cultivars, Baldo, Ribe, Rocca and Kros-424, were lower than those of Tri-445 and Serhat 92. The fresh and dry weights of the cultivars correlated well with the Na and Cl contents in the tissue (for fresh weight, r= - 0.892** and r= - 0.917**; for dry weight, r= - 0.885** and r= -0.909**, respectively, Table 3). These relationships clearly show that the yield reduction is mainly due to excessive Na and Cl accumulation. As suggested by Flowers and Yeo (8), Yeo et al., (10), and Mengel and Kirkby (15), increased uptake of Na and Cl results in a decrease of the cell water potential that promotes water uptake. Measurement of stomatal resistance provides sensitive comparions for determining the degree of stress in plants under stress. In this study, salinity was found to cause increase in the stomatal resistance of the plants. This means that growth was also inhibited by water stress, as suggested by Cusido et al. (14). However, increase in stomatal resistance in rice cultivars due to salinity is not a reliable indicator of salt tolerance.

Salt treatment increased the absorption of Na and Cl at the expense of K, causing ionic disequilibrium in all cultivars. This finding is in agreement with studies done on corn and pigeonpea (16,17).

Salinity increased the proline content of all cultivars except Rocca. As reported by Lewitt (18) and Harivandi et al., (19), accumulated proline is correlated with tissue Na concentration for a number of plant species, strongly suggesting a possible role of proline in osmoregulation during salt stress.Similarly, in this study the proline contents of the plants correlated well with Na and Cl (r= 0.637** and r= 0.584**, respectively, Table 3). The levels of proline in the plants correlated with the ability of plants to tolerate or to adapt to saline conditions. Accumulation of proline in tissues of the plants as a response to periods of salt, drought or temperature stress has been atributed to enzyme stabilization and/or osmoregulation (20, 21). In contrast, the results of this study showed that the salt-sensitive cultivars, Tri-445 and Serhat 92, accumulated more proline than the others. It may be concluded that proline is not a reliable indicator of salt tolerance in rice.

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