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Short Communication

UPTAKE AND DISTRIBUTION OF Na^+ IN RICE GENOTYPES UNDER SALINITY CONDITION

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In Bangladesh, about 1.5 million hectares out of 2.85 million hectares of coastal and off-shores land is affected by different degrees of salinity (Murshed et al., 2008). Salinity imposes both osmotic and ionic stresses on plant (Davenport et al., 2005). The rapid onset of osmotic stress, which is associated with low water potential and show little genotypic variation (Munns, 2002). In contrast, ionic stress related growth inhibition appears slowly with a catastrophic nature and show substantial genotypic variation. It is associated with excess accumulation of toxic ions, particularly Na^+ (Munns and Tester, 2008). In this context, a mechanism needs to be develop for salt tolerant rice genotype, and understand the physiological mechanisms responsible for salinity tolerance, particularly Na^+.

A laboratory experiment was conducted at the Plant Tissue Culture Laboratory and Plant Physiology Laboratory in the Department of Crop Botany of Bangladesh Agricultural University (BAU), Mymensingh to investigate uptake and distribution of sodium (Na^+) in different organs of two rice genotypes under salinity condition. Seeds of rice cultivars BR-29 and Pokkali were obtained from Bangladesh Rice Research Institute, Gazipur. Surface sterilized seeds were germinated on water soaked filter paper and seedlings were grown hydroponically in Haogland's solution (Murshed et al., 2008) at a temperature of 25°C, relative humidity of 60% and photoperiod of 16 h (700 µmol m^{-2} s^{-1}). The treatment solutions consisted of NaCl (0 and 100 mM). A completely randomized design was used with three replications. The relative water content (RWC) values were calculated according to the formula of Barrs (1968). Leaf chlorophyll was measured according to the methods as described by Murshed et al. (2008). Sodium ion (Na^+) and Potassium ion (K^+) determination according to Murshed et al. (2008). Analysis of variance was calculated using the computer software program MSTATC. The mean differences were evaluated by Duncan's Multiple Range Test (Table 1).

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Table 1. Effect of salinity (100 mM NaCl) on dry matter yield of two rice genotypes

Genotype	NaCl (mM)	Dry matter yield (mg)		
		Root	Shoot	R/S*
	0	2.81a	20.61a	
	100	2.45c	16.93b	
	0	2.65b	15.60c	
Pokkali	100	2.20d	10.63d	
BRRI dhan29				0.136
				0.145
				0.170
				0.207

In a column, figures having common letter(s) do not differ significantly at 5% level of significance as per DMRT.* Data are derived from 3rd and 4th column.

The cultivar Pokkali produced greater dry matter yield than BRRI dhan 29 at 100 mM NaCl and also high R/S in BRRI dhan 29 indicated that shoot growth was inhibited more than root growth fo same concentration. The relative water content (RWC) in tolerant genotype (Pokkali) ranged from 74 to 86%. In contrast, the sensitive genotype (BRRI dhan 29) ranged from 53 to 85%. In case of Pokkali (tolerant), total chlorophyll content decreased by 37.7% at 100 mM NaCl while it was 62% in BRRI dhan 29 as compared to control. The result also indicated that tolerant genotype restricts the chlorophyll damage more effectively than the sensitive one.

Except leaf sheath, the Na^+ concentration in roots stem and leaf blade was higher BRRI dhan 29 than in pokkali (Table 2) and also showed that Na^+ increase was accompanied by a decrease in the K^+ concentration, indicating an apparent antagonism between Na^+ and K^+. Salinity increased Na^+/K^+ ratio both in roots and shoots of the stressed seedlings (Table 3). BRRI dhan 29 had higher Na^+ / K^+ ratio in shoots than in Pokkali, indicating that the tolerant rice plant transports less Na^+ from roots to shoots and maintains a high Na^+/K^+ ratio in its root tissues. The accumulated Na^+ was same both in Pokkali and BRRI dhan 29 under non-saline condition. The total (root + shoot) amount of Na^+ (5.56) uptake by BRRI dhan 29 was greater than that in Pokkali (5.19) at 100 mM NaCl stressed condition. The descending order of Na^+ / K^+ ratio in BRRI dhan 29 was leaf blade > leaf sheath > stem whereas it was stem > leaf sheath > leaf blade in Pokkali. The results indicated that the tolerant genotype (Pokkali) efficiently excluded Na^+ from the leaf blade. In the present study, root biomass yield was less affected than shoots. It means that shoots are more vulnerable than roots. Similar result was observed by Munns (2002). The reduction of shoot biomass was significantly higher in BRRI dhan 29 than in Pokkali. Actually, decrease in RWC in leaf increased osmotic stress that leads to close stomata (Shabala et al., 2005). As a result, CO_2 is limiting to the salinity stressed seedling and reduced biomass yield (Moradi and Ismail, 2007). According to Dionisio-Sese and Tobita (2000), salt tolerance in rice is associated with decreased shoot (stem + leaf sheath + leaf blade) Na^+ accumulation. Our results are also in agreement with the statement. High (100 mM) Na^+ concentration in the culture solution strongly inhibited acquisition and distribution of K^+ in the present study (Table 2). This antagonism may be due to the direct competition between Na^+ and K^+ at the site of ion uptake in the plasmalemma of roots.

Table 2. Effect of salinity (100 mM NaCl) on Na^+ and K^+ uptake and distribution (mg g^{-1}DM) in different parts of rice seedlings

Genotype	NaCl (mM)	Root		Stem		Leaf sheath		Leaf blade	
		Na^+	K^+	Na^+	K^+	Na^+	K^+	Na^+	K^+
	0	0.23c	2.44a	0.26c	4.80a	0.26c	6.81a	0.17c	8.98a
Pokkali	100	0.71b	0.43c	1.31b	1.45c	2.39a	5.01b	0.78b	4.19b
	0	0.21d	2.41a	0.31c	4.37a	0.29c	7.21a	0.11c	3.84b
BRRIdhan29	100	0.81a	0.87b	1.75a	3.81b	1.44b	2.32c	1.56a	2.19c

In a column, figures having common letter(s) do not differ significantly at 5% level of significance as per DMRT*.

Table 3. Effect of salinity (100 mM NaCl) on Na^+: K^+ in different parts of rice seedlings. Data are derived from table 2.

Genotype	NaCl (mM)	Root (Na^+/K^+)	Shoot (Na^+/K^+)	Stem (Na^+/K^+)	Leaf sheath (Na^+/K^+)	Leaf blade (Na^+/K^+)
	0		0.033			
	100		0.420			
Pokkali	0		0.046			
	100		0.570			
BRRI		0.094		0.054	0.038	0.018
dhan29		1.651		0.903	0.477	0.186
		0.087		0.070	0.040	0.028
		0.931		0.459	0.621	0.712

Results revealed that salt tolerant variety (Pokkali) produced higher dry matter than salt sensitive one (BRRI dhan 29) which was related to relative water content, Na^+ and K^+ content in root, stem, leaf blade and leaf sheath and chlorophyll in the leaf. In contrast, Na^+ content both in root and shoot was higher in BRRI dhan 29 than in Pokkali. Salt sensitive variety translocates more Na^+ from roots to shoots while the salt tolerant variety associated with low Na^+ accumulation in shoots, especially in leaf blade. Hence, lower Na^+ / K^+ ratio in leaf blade (shoot) of salt tolerant variety may be an important feature associated with physiological tolerance to salinity.

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