Growth Performance of Rice Genotypes at the Seedling Stage under Different Salinity Stresses

Mohammad Ferdous Ikbal[1,2,#], Mohd Y. Rafii[1,3,#], Shairul Izan Ramlee[3], Muhammad Nazmin Yaapar[3], Mirza Mofazzal Islam[2], Rakiba Shultana[4,#], Md Masud Rana[4], Mohammad Anisuzzaman[1,5], Md Azadul Haque[1,2]

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ABSTRACT

Background: Worldwide coastal rice growing areas are severely affected by salinity which has become a major constraint to rice production. Salinity is a serious soil problem in rice-growing countries, severely limiting global rice production.

Methods: In this study, the seedlings of 21 rice genotypes were tested against seven different levels of salinity concentrations (0.3, 2, 4, 6, 8, 10 and 12 dSm^{-1}) under a hydroponic system in a glasshouse condition at Field 10, Faculty of Agriculture, Universiti Putra Malaysia (UPM). Data on seedling growth and salinity injury of the tested rice genotypes were recorded.

Result: The results showed that Pokkali, FL478 and Binadhan-10 were tolerant at 12 dSm^{-1}; BRRI dhan73, BRRI dhan61, Binadhan-8, BRRI dhan67 and BRRI dhan47 were tolerant at 10 dSm^{-1}; Putra-1 were moderately tolerant at 8 dSm^{-1} and MR263, MR284, MR211 and MRQ74 were tolerant at 4 dSm^{-1} and rest of the genotypes were salt susceptible. The lower amount of Na: K and Na: Ca were measured from rice genotypes, Pokkali and FL478 at maximum salinity levels. The promising rice genotypes that were tolerant at 12 dSm^{-1} would be taken into consideration for a hybridization program to develop a new salt-tolerant rice variety.

Key words: Genotype, Na^+/K^+ ratio, Rice, Salinity, Seedling.

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food in Asian countries, accounting for 90% of total food production. As an Asian country, rice is the third most important crop in Malaysia where the self-sufficiency is about 75% since the average yield is about 4.5 t ha^{-1} season^{-1} which needs to expand to around 7 t ha^{-1} season^{-1} to meet the increasing demand (Tan *et al.*, 2015). So, further research and technological advancement are needed to expand rice production in Malaysia (Shultana *et al.*, 2020). However, the climate change effect like soil salinity is a major global barrier boosting rice production around the world (Gregorio *et al.*, 1997). In Malaysia, salinity is reported to affect around 100,000 hectares of rice crop land by 2056 and the cultivation of salt-sensitive rice genotypes can reduce rice yield by 50% (Selamat and Ismail, 2008). A previous study suggested that rice is sensitive to salt stress, especially at the seedling and reproductive stages (Aref and Rad, 2012). Soil contaminated with high levels of sodium or chloride ions can interfere with the plant's ion uptake system and interfere with the uptake of essential ions such as K^+, Ca^{2+} and NO^{3-} by the root system (Ashraf and Foolad, 2007). Individually, high concentrations of Na^+ in the soil can damage plant membrane systems, causing electrolyte leakage and oxidative damage (Mandhania *et al.*, 2006). On the other hand, high concentrations of Cl^- in the soil can damage the plant chlorophyll production mechanism causing leaf chlorosis (Tavakkoli *et al.*, 2010).

Screening of rice genotypes for salt tolerance at the early seedling stage relies on agronomical and biochemical characteristics. The seedling stage screening of rice genotypes allows faster screening, which is complicated at the vegetative and reproductive stages (Gregorio *et al.*, 1997; Ali *et al.*, 2014). Even though, several studies on rice genotype screening at the seedling stage have been reported, there is a lack of findings on Malaysian salt-tolerant rice genotypes. Therefore, this study was conducted to screen out potential salt-tolerant rice genotypes that

[1]Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia, Serdang 43400, Selangor, Malaysia.
[2]Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh.
[3]Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, Serdang 43400, Selangor, Malaysia.
[4]Division of Agronomy, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh.
[5]Division of Plant Breeding, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh.
[#]These authors contributed equally to this work as corresponding co-authors.

Corresponding Author: Rakiba Shultana, Division of Agronomy, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh. Email: rakibabrri@gmail.com

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could be used for future breeding materials to develop salt-tolerant varieties suitable to cultivate in the coastal saline region of Malaysia.

MATERIALS AND METHODS

Plant materials

Twenty-one rice genotypes with different genetic backgrounds were used in this experiment (Table 1).

Experimental location and design

This study was conducted in a glasshouse at Field 10, Faculty of Agriculture, Universiti Putra Malaysia (UPM) at 2°59′ N, 101°42′ E and 45 m above sea level. The trial was set up in a randomized complete block design following three replications with 10 plants per trial.

Experiment setup

Twenty-one rice genotypes with different origins (Table 1) were tested against seven different salinity levels. The rice variety Pokkali and FL478 were used as a salt-tolerant check and Binadhan-7 was used as a salt susceptible check. The rice genotypes were screened following a hydroponic system using the IRRI standard protocol (Gregorio *et al.*, 1997). The seeds were surface sterilized, immersed in distilled water for 24 h and then incubated for 48 h at 30°C. Pre-germinated seeds were seeded on a floating Styrofoam (38 cm length and 33 cm width) having 100 holes bottom attached with a nylon net which is adjusted in a 12-L plastic tray (34 cm height and 27 cm width).

Table 1: Genotypes used in this study including their origin.

Name of genotypes	Origin
Putra-1	Malaysia
Malaysia	
Malaysia191	
Malaysia211	
Malaysia32	
Malaysia297	
Malaysia284	
Malaysia151	
Malaysia263	
Malaysia220	
MalaysiaQ74	
Bangladesh-8	Bangladesh
Bangladesh-10	
Bangladesh-7	
Bangladesh-17	
Bangladesh47	
Bangladesh61	
Bangladesh67	
Bangladesh73	
Pokkali	India
FL478	IRRI

Application of nutrient solution and adjustment of salinity

Nutrient solution (ferrous sulphate heptahydrate and Peter Water Soluble Fertilizer 20:20:20) was added after seven days of planting. The nutrient solution must touch the bottom of the Styrofoam nylon mesh to ensure nutrient uptake by the roots. The nutrient solution was salinized using NaCl maintaining a salinity concentration of 0.3 (control), 2, 4, 6, 8, 10 and 12 dSm^{-1}. The EC of the cultures was monitored with an EC meter (Hanna HI 4321, Weilheim, Germany). The pH of the nutrient solution was adjusted to 5 using a pH meter (Hanna HI 98304).

Seedling rating for salinity tolerance

According to Gregorio *et al.* (1997), the modified standard evaluation score (SES) was used to evaluate salt stress symptoms. This assessment distinguishes susceptible genotypes from resistant and moderately resistant genotypes. Initial and final scores were recorded at 14 and 21 days after salinity treatment.

Data collection

The data on root length, shoot length, root fresh weight, shoot fresh weight, root dry weight and shoot dry weight were measured after 24 days of salt application. The shoots were separated from the roots, washed twice with tap water and twice with deionized water, bagged and oven-dried at 70°C for 3 days. Oven-dried shoot samples were ground using a mechanical grinder and sieved then the content of Na^+, K^+ and Ca^{2+} were measured. All elemental analyses were performed by acid digestion using the Micro-Kjeldahl method (Thomas *et al.*, 1967). Determinations were quantified with an atomic absorption spectrophotometer (AAS). The Na^+/K^+ ratio was determined from the concentration of Na^+ and K^+ and the Na/Ca ratio was calculated from the concentration of Na and Ca.

Statistical analysis

The collected data were statistically analyzed following Analysis of Variance (ANOVA) using SAS 9.4 software. Means were compared using LSD test ($P<0.05$).

RESULTS AND DISCUSSION

The salinity tolerance level of different rice genotypes

All the rice varieties tested showed uniform growth under non-salinized conditions. Whilst, under salinized conditions, the plants showed a wide phenotypic variation. Among 21 rice genotypes, Pokkali, FL478 and Binadhan-10 were found to tolerate 12 dSm^{-1} of salinity. BRRI dhan73, BRRI dhan61, Binadhan-8, BRRI dhan67 and BRRI dhan47 were tolerant at 10 dSm^{-1}; Putra-1 were moderately tolerant at 8 dSm^{-1} and MR263, MR284, MR211 and MRQ74 were tolerant at 4 dSm^{-1} and rest of the genotypes were salt susceptible. This finding is per Kranto *et al.* (2016) who stated that Pokkali is more salt tolerant than other rice cultivars. Muti *et al.* (2021) also found that Pokkali, FL478 and Binadhan-10 are more salt-tolerant than the other rice genotypes.

The effect of salinity on the root length of tested rice varieties

The root length did not vary significantly under the non-salinized condition among the rice genotypes (Table 2). At 2 dSm^{-1}, significantly the highest root length was recorded for the rice genotype MR297 (28.25 cm). Further, at 4 dSm^{-1}, the highest root length was recorded for the rice genotypes Pokkali (26.49 cm) and FL478 (26.32 cm). Likewise, at 6 dSm^{-1}, FL478 (25.04 cm) and Pokkali (24.76 cm) were recorded for the highest root length. Similarly, at 8, 10 and 12 dSm^{-1}, Pokkali (23.57 cm, 21.54 cm and 18.83 cm respectively) was recorded for the highest root length. The lowest root length reduction was recorded by the rice genotypes FL478 (0.17%), BRRI dhan61 (2.03%), BRRI dhan47 (5.92%), Pokkali (13.15%), Pokkali (20.63%) and Pokkali (30.61%) respectively at 2, 4, 6, 8, 10 and 12 dSm^{-1}.

Salt stress had a considerable effect on root length, but this varied with rice genotypes. Earlier, it was reported that at high salt concentrations, roots were reduced rapidly (Hoque *et al.*, 2015). Previously, root length reduction in response to salt stress was reported by Acosta-Motos *et al.* (2017) and Ali *et al.* (2014). The phenotypic screening showed that tolerant genotypes grow their roots and shoots more quickly than susceptible genotypes and are less vulnerable to salt-induced damage. This may be because of their inherent defence mechanisms against salinity damage.

The effect of salinity on the shoot length of 21 rice genotypes at the seedling stage

The rice genotype Pokkali consistently produced the highest shoot length regardless of salinity concentrations (Table 3). At 2 and 4 dSm^{-1} of salinity, the shoot length of the tested genotypes did not vary significantly. However, at 6, 8, 10 and 12 dSm^{-1}, Pokkali and FL478 consistently produced the highest shoot length. Moreover, no significant difference in shoot length was recorded by the rice genotype Pokkali (38.71 cm), FL478 (34.44 cm) and Binadhan-10 (31.70 cm) at the highest level of salinity (12 dSm^{-1}). Regarding the shoot length reduction, Binadhan-10 showed the lowest reduction which is reduced by 2.19% and 9.33% at 2 and 4 dSm^{-1} respectively. The rice genotypes Pokkali and FL478 were reduced by 24.19%, 38.85%, 56.09% and 24.71%, 41.09% and 57.73% at 8, 10 and 12 dSm^{-1} respectively.

The rice genotypes Pokkali and FL478 consistently generated the longest shoots with the least amount of shoot length reduction. The lowest salt accumulation in the cell wall did not affect cell wall elasticity resulting in increased shoot length. These results support those of Bhowmik *et al.* (2009) who have screened 11 rice varieties for salinity tolerance and observed that resistant varieties have higher plant height and dry biomass. Besides, tolerant plants can impede the upward translocation of sodium ions by

Table 2: The effect of salinity on the root length (cm) of 21 rice genotypes at seedling stage.

Genotypes	Salinity level						
	0 dSm^{-1}	2 dSm^{-1}	4 dSm^{-1}	6 dSm^{-1}	8 dSm^{-1}	10 dSm^{-1}	12 dSm^{-1}
Binadhan-17	25.48a	25.18a	16.45b	9.72c	8.08cd	6.59de	5.16e
Putra-1	27.78a	27.01ab	25.83b	21.21c	16.13d	9.68e	8.16e
Maria	25.32a	24.76a	16.20b	9.74c	8.01cd	7.37de	5.72e
MR191	25.11a	24.41a	16.22b	10.07c	8.46d	7.09d	5.62e
FL478	28.58a	28.53a	26.32b	25.04c	23.28d	20.26e	17.26e
MRQ74	25.65a	24.82a	15.61b	9.75c	8.12cd	7.40de	5.79e
Pokkali	27.14a	26.95a	26.49b	24.76c	23.57d	21.54e	18.83f
BRRI dhan67	26.32a	26.05a	25.14a	22.93b	20.13c	17.09d	12.28e
BRRI dhan47	26.00a	25.91a	25.03a	24.46a	19.37b	15.01c	10.90d
MR211	25.01a	24.39a	16.22b	10.20c	8.07d	7.03de	5.90e
MR232	24.97a	24.52a	15.98b	9.62c	8.58c	7.28d	5.74e
MR297	29.06a	28.25a	17.94b	12.18c	10.99d	8.98e	6.31f
MR284	25.46a	25.13a	17.13b	10.06c	8.91cd	7.92d	6.15e
Binadhan-7	25.30a	24.1a	14.02b	8.27c	6.51d	5.04de	4.04e
Binadhan-8	25.25a	24.91a	23.73ab	22.77b	18.93c	12.50d	8.92e
Binadhan-10	26.94a	26.73a	25.50a	23.47b	21.84c	19.61d	15.93e
BRRI dhan73	26.65a	26.12a	25.67a	24.41b	20.81c	17.00d	12.04e
MR151	24.58a	24.15a	16.23b	9.36c	8.18cd	6.81de	5.57e
BRRI dhan61	25.59a	24.99a	25.07a	22.38b	20.97c	16.00d	11.19e
MR263	24.50a	24.37a	16.27b	9.73c	8.13cd	6.49de	5.64e
MR220	24.82a	24.06a	15.76b	9.65c	8.35cd	6.78de	5.51e
CV (%)	2.19	2.03	2.98	3.66	4.16	6.11	6.00
LSD (0.05)	0.94	0.85	0.99	0.95	0.93	1.12	0.86

According to the LSD test at $P>0.05$, means with the same letter in the same row are not significantly different.

Table 3: The effect of salinity on the shoot length (cm) of 21 rice genotypes at seedling stage.

Genotypes	Salinity level						
	0 dSm^{-1}	2 dSm^{-1}	4 dSm^{-1}	6 dSm^{-1}	8 dSm^{-1}	10 dSm^{-1}	12 dSm^{-1}
Binadhan-17	71.30a	70.75a	61.71b	41.26c	29.00d	21.79e	14.65f
Putra-1	78.72a	76.94ab	72.25b	61.83c	42.90d	24.46e	19.04e
Maria	66.96a	65.80a	60.44b	41.16c	29.24d	21.51e	14.43f
MR191	68.52a	65.00ab	60.32b	40.62c	29.72d	20.86e	14.70f
FL478	81.48a	79.05a	72.57bc	65.67cd	61.35d	48.00e	34.44f
MRQ74	67.12a	65.36a	58.95b	39.18c	28.94d	21.45e	14.43f
Pokkali	88.15a	85.61a	79.87b	73.87c	66.83d	54.19e	38.71f
BRRI-67	77.32a	73.87b	69.96c	61.91d	51.74e	39.10f	25.93g
BRRI-47	70.57a	67.17a	60.53b	53.49c	44.23d	32.65e	23.65f
MR211	65.32a	64.06a	58.96b	41.06c	30.87d	20.68e	14.14f
MR232	67.90a	65.19ab	59.59b	40.73c	30.17d	20.25e	14.98f
MR297	81.47a	79.48a	61.47b	42.34c	29.07d	20.72e	13.56f
MR284	65.57a	65.45a	51.60b	42.25c	25.35d	19.35e	14.52f
Binadhan-7	65.19a	64.93a	52.83b	35.67c	24.84d	18.31e	12.36e
Binadhan-8	75.10a	73.17a	65.37b	55.56c	45.51d	31.73e	22.11f
Binadhan-10	77.94a	76.23a	70.67b	64.92c	58.43d	45.58e	31.70f
BRRI73	76.59a	75.61a	69.61b	60.19c	50.08d	36.90e	25.49f
MR151	65.75a	64.21a	57.15b	40.11c	29.94d	20.08e	14.25f
BRRI61	74.69a	72.45a	66.72b	58.48c	47.80d	34.36e	23.10f
MR263	65.19a	64.79a	57.33b	39.40c	29.48d	21.08e	13.50f
MR220	65.13a	63.14a	56.38b	40.13c	28.98d	20.87e	12.82f
CV (%)	2.63	3.17	3.44	3.61	4.13	5.32	5.81
LSD (0.05)	3.13	3.67	3.58	2.95	2.64	2.48	1.88

According to the LSD test at P>0.05, means with the same letter in the same row are not significantly different.

maintaining a higher shoot-to-root ratio for better survival under salinity stress (Vaishnav *et al.*, 2019).

Effect of salinity on root and shoot dry weight

Root dry weight did not vary significantly among the rice varieties at 2 and 4 dSm^{-1} of salinity while significant variation was observed at 6, 8, 10 and 12 dSm^{-1} of salinity (Table 4 and 5). The highest root dry weight was recorded by the rice genotype FL478 (0.25 g) at 6 dSm^{-1} of salinity. Moreover, at the highest saline condition (12 dSm^{-1}), FL478 was recorded for the highest root dry weight (0.15 g). Shoot dry weight did not vary significantly among the rice varieties in non-saline conditions and also at 2 dSm^{-1} of salinity. Shoot dry weight significantly varied at 4, 6, 8, 10 and 12 dSm^{-1}. At all salinity levels, the highest shoot dry weight was recorded by the rice genotype Pokkali (0.98 g).

A significant decrease in shoot and root dry weight with increasing salinity was recorded in 21 rice genotypes. Hakim *et al.* (2014) stated that the decrease in the dry weight of shoots and roots may be attributed to several factors such as (i) decreased photosynthesis per unit leaf area since salt stress leads to an insufficient supply of carbohydrates required for shoot growth, (ii) lower water potential because of reduced turgor pressure and (iii) direct growth retardation due to disruption of mineral supply. Moreover, salinity affected the final cell size and cell production rate, resulting in decreased shoot and root dry weight. Likewise, Khatun *et al.* (2013) and Al-Saady (2015) observed a decrease in the shoot and root length and biomass for all tested wheat cultivars with increasing NaCl concentration.

Effect of salinity on Na/K and Na/Ca ratio

The ratio of Na: K and Na: Ca of 21 rice genotypes varied significantly at 2, 4, 6, 8, 10 and 12 dSm^{-1} of salinity (Table 6 and 7). The lower ratio of Na/K and Na/Ca was consistently measured from the rice genotype Pokkali and FL478 at different salinity levels. The accumulation of Na^+ and impairment of K^+ nutrition are the key features of salt-stressed plants. The influx of K^+ and efflux of Na^+ is a common strategy of plants to maintain the cytoplasmic Na^+/K^+ ratio under salt stress conditions. Therefore, several reports stated the beneficial effects of high K^+/Na^+ ratios on crop salinity tolerance. According to the findings of Hoque *et al.* (2015), the K^+/Na^+ ratio is a scientifically established and genetically accepted measure of plant salinity tolerance. Several scientists have concluded that as salinity increases, sodium levels in rice increase and potassium levels decrease (Solangi *et al.*, 2016; Theerawitaya *et al.*, 2015). Based on the Na^+/K^+ ratio, the rice genotype Pokkali, FL478 and Binadhan-10 showed high tolerance to extreme salinity. Hasan *et al.* (2015) reported a larger accumulation of toxic ions (Na^+) in the leaf of salt susceptible variety causing a

Table 4: The effect of salinity on the root dry weight (g) of 21 rice genotypes at seedling stage.

Genotypes	Salinity level						
	0 dSm^{-1}	2 dSm^{-1}	4 dSm^{-1}	6 dSm^{-1}	8 dSm^{-1}	10 dSm^{-1}	12 dSm^{-1}
Binadhan-17	0.26a	0.25a	0.21b	0.15c	0.12cd	0.11ef	0.07f
Putra-1	0.29a	0.28a	0.24b	0.18c	0.15d	0.12e	0.09e
Maria	0.24a	0.22a	0.17b	0.14b	0.11c	0.10c	0.07c
MR191	0.23a	0.22a	0.19b	0.15c	0.12d	0.10e	0.09e
FL478	0.31a	0.30a	0.27b	0.25b	0.22c	0.19d	0.15d
MRQ74	0.23a	0.22a	0.18b	0.14bc	0.13cd	0.11de	0.10e
Pokkali	0.29a	0.28a	0.26b	0.23b	0.20c	0.19d	0.13d
BRRI-67	0.25a	0.24a	0.21b	0.17c	0.14d	0.11e	0.09e
BRRI-47	0.21a	0.20a	0.18b	0.15c	0.13d	0.10d	0.08e
MR211	0.20a	0.19a	0.16b	0.14bc	0.13bc	0.09c	0.08c
MR232	0.18a	0.17a	0.15b	0.13b	0.12bc	0.10cd	0.09d
MR297	0.28a	0.27a	0.23b	0.15b	0.13bc	0.11c	0.09c
MR284	0.22a	0.22a	0.18b	0.14bc	0.13c	0.11d	0.08d
Binadhan-7	0.23a	0.22a	0.14b	0.11c	0.09d	0.08d	0.06e
Binadhan-8	0.22a	0.21a	0.19b	0.13c	0.11d	0.10d	0.09d
Binadhan-10	0.31a	0.27a	0.25b	0.19c	0.16d	0.14d	0.12d
BRRI-73	0.29a	0.30a	0.21b	0.16c	0.13cd	0.11d	0.09e
MR151	0.22a	0.20a	0.16b	0.13bc	0.10cd	0.08de	0.07e
BRRI-61	0.23a	0.22a	0.17b	0.15bc	0.13cd	0.12de	0.11e
MR263	0.21a	0.20a	0.16b	0.11c	0.10d	0.09d	0.07e
MR220	0.22a	0.22a	0.17b	0.14c	0.13d	0.11d	0.08
CV (%)	6.10	10.50	13.45	12.64	14.13	15.19	17.30
LSD (0.05)	0.02	0.04	0.04	0.03	0.03	0.03	0.03

According to the LSD test at P>0.05, means with the same letter in the same row are not significantly different.

Table 5: The effect of salinity on the shoot dry weight (g) of 21 rice genotypes at seedling stage.

Genotypes	Salinity level						
	0 dSm^{-1}	2 dSm^{-1}	4 dSm^{-1}	6 dSm^{-1}	8 dSm^{-1}	10 dSm^{-1}	12 dSm^{-1}
Binadhan-17	0.75a	0.74a	0.66b	0.41c	0.27d	0.18e	0.16f
Putra-1	0.85a	0.87a	0.56b	0.44c	0.23d	0.19e	0.14f
Maria	0.69a	0.71a	0.54b	0.37c	0.25d	0.19e	0.12f
MR191	0.70a	0.68a	0.61b	0.36c	0.24d	0.17e	0.12f
FL478	1.05a	1.02a	0.94b	0.84c	0.70d	0.65e	0.47f
MRQ74	0.75a	0.72a	0.63b	0.36c	0.22d	0.18e	0.12f
Pokkali	1.14a	1.10a	0.98b	0.86c	0.72d	0.66e	0.51f
BRRI-67	0.82a	0.81a	0.69b	0.53c	0.44d	0.30e	0.21f
BRRI-47	0.67a	0.66a	0.58b	0.47c	0.26d	0.22e	0.18f
MR211	0.63a	0.61a	0.51b	0.31c	0.21d	0.16e	0.13f
MR232	0.68a	0.66a	0.49b	0.35c	0.25d	0.17e	0.12f
MR297	0.99a	0.97a	0.73b	0.44c	0.37d	0.22e	0.15f
MR284	0.69a	0.67a	0.55b	0.39c	0.31d	0.19e	0.12f
Binadhan-7	0.68a	0.66a	0.41b	0.28c	0.20d	0.15e	0.10f
Binadhan-8	0.77a	0.75a	0.63b	0.50c	0.41d	0.30e	0.20f
Binadhan-10	0.77a	0.76a	0.72b	0.65c	0.49d	0.38e	0.29f
BRRI-73	0.79a	0.77a	0.70b	0.54c	0.42d	0.31e	0.22f
MR151	0.67a	0.69a	0.52b	0.41c	0.25d	0.18e	0.13f
BRRI-61	0.75a	0.76a	0.61b	0.48c	0.31d	0.24e	0.19f
MR263	0.68a	0.66a	0.49b	0.31c	0.22d	0.17e	0.12f
MR220	0.63a	0.64a	0.47b	0.27c	0.19d	0.16d	0.11e
CV (%)	4.47	4.59	3.99	6.45	7.94	8.85	9.26
LSD (0.05)	0.06	0.06	0.04	0.05	0.04	0.04	0.03

According to the LSD test at P>0.05, means with the same letter in the same row are not significantly different.

Table 6: The effect of salinity on the Na/K ratio of 21 rice genotypes at the seedling stage.

Genotypes	Salinity level						
	0 dSm^{-1}	2 dSm^{-1}	4 dSm^{-1}	6 dSm^{-1}	8 dSm^{-1}	10 dSm^{-1}	12 dSm^{-1}
Binadhan-17	0.11a	0.13a	0.16ab	0.61a	0.72a	1.01a	1.20a
Putra-1	0.10a	0.14a	0.13ab	0.48a	0.56a	0.87a	0.98a
Maria	0.12a	0.15a	0.17ab	0.58a	0.66a	0.92a	1.18a
MR191	0.11a	0.12a	0.16ab	0.57a	0.64a	0.97a	1.17a
FL478	0.05a	0.06b	0.07b	0.19b	0.23b	0.46b	0.55b
MRQ74	0.11a	0.15a	0.18ab	0.56a	0.65a	0.91a	1.14a
Pokkali	0.05a	0.06b	0.06b	0.16b	0.24b	0.45b	0.53b
BRRI-67	0.05a	0.06b	0.10b	0.45a	0.48a	0.77a	0.86a
BRRI-47	0.07a	0.09b	0.10b	0.43a	0.45a	0.71a	0.81a
MR211	0.10a	0.14a	0.16ab	0.57a	0.71a	0.94a	1.19a
MR232	0.12a	0.14a	0.15ab	0.54a	0.67a	0.92a	1.18a
MR297	0.11a	0.13a	0.26a	0.53a	0.62a	0.96a	1.25a
MR284	0.12a	0.15a	0.18ab	0.52a	0.68a	0.99a	1.23a
Binadhan-7	0.10a	0.13a	0.17ab	0.58a	0.69a	1.02a	1.29a
Binadhan-8	0.07a	0.15a	0.19ab	0.37a	0.43a	0.68a	0.76a
Binadhan-10	0.05a	0.07b	0.08b	0.23b	0.27b	0.57b	0.65b
BRRI-73	0.07a	0.08b	0.09b	0.26b	0.33a	0.61a	0.69b
MR151	0.10a	0.15a	0.15ab	0.57a	0.59a	0.99a	1.17a
BRRI-61	0.08a	0.09b	0.09b	0.33a	0.37a	0.63a	0.71a
MR263	0.12a	0.15a	0.17ab	0.51a	0.69a	0.91a	1.19a
MR220	0.11a	0.14a	0.16ab	0.53a	0.65a	0.97a	1.17a
CV (%)	22.40	16.74	12.49	6.90	5.07	3.60	3.75
LSD (0.05)	0.03	0.03	0.03	0.05	0.04	0.05	0.08

According to the LSD test at P>0.05, means with the same letter in the same row are not significantly different.

Table 7: The salinity effcet on the Na/Ca ratio of 21 rice genotypes at the seedling stage.

Genotypes	Salinity level						
	0 dSm^{-1}	2 dSm^{-1}	4 dSm^{-1}	6 dSm^{-1}	8 dSm^{-1}	10 dSm^{-1}	12 dSm^{-1}
Binadhan-17	3.27a	3.44a	11.32a	12.41a	16.91a	17.86a	18.75a
Putra-1	0.99c	1.04c	2.56c	3.12b	3.98b	6.12b	8.32b
Maria	3.43a	3.51a	10.64a	13.37a	16.13a	16.92a	17.52a
MR191	3.21a	3.29a	10.32a	12.36a	15.14a	15.97a	16.43a
FL478	0.37c	0.40c	0.57c	1.19b	1.76b	2.46b	3.51b
MRQ74	3.36a	3.41a	11.21a	14.46a	16.64a	17.51a	18.32a
Pokkali	0.36c	0.39c	0.54c	1.16b	1.65b	2.41b	3.38b
BRRI-67	0.87c	0.90c	1.89c	2.25b	3.65b	5.91b	7.97b
BRRI-47	0.81c	0.87c	1.73c	2.13b	3.02b	5.69b	7.92b
MR211	2.98a	3.04a	10.04a	14.32a	17.12a	17.75a	18.39a
MR232	3.17a	3.21a	11.82a	13.31a	16.39a	17.27a	18.14a
MR297	2.34a	2.39b	4.72b	13.42a	17.11a	17.91a	18.89a
MR284	3.29a	3.34a	11.91a	14.32a	16.32a	17.89a	18.68a
Binadhan-7	3.87a	3.92a	12.94a	14.41a	17.42a	17.97a	18.98a
Binadhan-8	0.75c	0.81c	1.35c	1.97b	2.97b	5.01b	7.83b
Binadhan-10	0.51c	0.57c	0.68c	1.35b	2.27b	3.01b	4.80b
BRRI-73	0.59c	0.64c	0.91c	1.58a	2.47b	3.71b	6.84b
MR151	3.28a	3.31a	11.76a	13.39a	16.41a	17.79a	18.17a
BRRI-61	0.67c	0.73c	1.08c	1.83b	2.71b	3.94b	6.94b
MR263	3.38a	3.42a	11.23a	13.31a	16.29a	17.81a	18.53a
MR220	3.54a	3.62a	12.65a	14.53a	16.45a	17.64a	18.47a
CV (%)	2.11	2.87	1.24	0.93	0.70	1.31	2.71
LSD (0.05)	0.07	0.10	0.14	0.13	0.12	0.26	0.59

According to the LSD test at P>0.05, means with the same letter in the same row are not significantly different.

sharp decline of K^+ content and K^+/Na^+ ratios causing ion poisoning and physiological injuries. Ahmad *et al.* (2006) reported a significant increase in Na^+ ions and a decrease in K^+ ions in the shoots and roots of two barley cultivars with increasing salinity. The current investigation showed a lower accumulation of calcium ions with the increase in salinity. However, tolerant plants showed a higher accumulation of Ca thus reducing the ratio of Na/Ca. Calcium is essential for the maintenance of cell membrane integrity (Reshna and Beena, 2021). Salt-sensitive genotypes expressed more nutritional imbalance while the salt-tolerant varieties were able to maintain balance among the nutrients in the tissues (Hakim *et al.*, 2014). Calcium reduced uptake of Na^+ concomitant with higher tissue K^+/Na^+ in seedlings, comparatively more in salt-tolerant Nona Bokra than in salt-sensitive IR-64, together with a significant increase in root PM H^+ATPase in the former, but not in the latter (Gupta and Shaw, 2021).

CONCLUSION

To select a better pool of varieties, analyzing the physicochemical properties of the rice varieties at 12 dSm^{-1} would be the way forward and those genotypes would be used as donor parents in the MABC program. The promising rice varieties that are tolerant at 12 dSm^{-1} would be taken into consideration for a hybridization program in Malaysia to breed salinity-tolerant genotypes. Hence, the rice varieties Pokkali, FL478 and Binadhan-10 could be considered for further research.

Conflicts of interest

The authors have declared no conflict of interest.

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