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RESEARCH ARTICLE

Agriculture

Screening eighty traditional and improved rice genotypes in Sri Lanka for salinity tolerance at the seedling stage in *Yoshida* solution

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Abstract: A total of eighty different rice genotypes consisting of fifty-three traditional rice accessions and twenty-seven improved rice varieties were evaluated for salinity tolerance. To identify the tolerant genotypes and the relationship between tolerance level with plant height and dry matter accumulation, the seedlings were subjected to electrical conductivity (EC) ~12 dSm^{-1} for ten and sixteen days separately at the seedling stage. The salinity tolerance of the seedlings was evaluated by standard evaluation scores (SES). Plant height, and total, shoot, and root-dry matter were evaluated in stressed and controlled plants. *Rathuheenati4992* was highly tolerant at salinity stresses, and *Heenati4618, Kaluwee3728, Mawee (5531, 3618)*, and *Pokkali3573* were highly tolerant at the 10-day and tolerant at the 16-day salinity stress. *Pokkali3881* was moderately tolerant at both stress conditions. Improved rice varieties *At354* and *Bg250* were highly tolerant at 10-day salinity stress and tolerant at 16-day salinity stress. Cultivation of highly susceptible improved rice varieties, *Bg360, At306, At362, Ld368 At405, At402, Ld371, Bw272-6b, Ld365*, and *Bg352* must be avoided in salinized soils. There was no correlation between plant height and salinity tolerance (r = -0.381, α = 0.000), salinity tolerance and total dry matter (r = 0.325 α = 0.002), salinity tolerance and root dry matter (r = 0.294, α = 0.008), or salinity tolerance and shoot dry matter (r = 0.061, α = 0.594). Plant height or dry matter accumulation can be considered unreliable parameters for salinity tolerance screening since they differ with the genotype. The highly tolerant and tolerant genotypes must be further studied at different growth stages.

Keywords: Improved rice, salinity tolerance, seedling stage, Sri Lanka, traditional rice accessions.

INTRODUCTION

More than 50% of the world's population consumes rice as their primary calorie source, with 80% carbohydrates (USDA, 2018). Latin American countries, the USA, Europe, Africa, and Asia grow rice worldwide, while an average Asian consumes around 150 kg yearly (Papademetriou, 2000).

Rice cultivation experiences various environmental stresses, such as salinity, drought, flood, heat, cold, topography, and soil factors (Mitin, 2009). Salinity is the second most important abiotic stress that decreases rice productivity worldwide (Isayenkov, 2012), next to drought (Gregorio *et al*., 1997). Though some lands are naturally salinized by rock weathering (Moreira-Nordemann, 1984), climate change and inappropriate land usage collectively cause the salinization of one-third of the irrigated lands (Machado & Serralheiro, 2017; Ullah *et al*., 2021). Excessive irrigation accumulates salts, and limited drainage intensifies salinity in the fields (Van der Zee *et al*., 2017). Evaporation accelerates salinization in dry zone fields (Vidal, 2019).

About sixty million hectares of rice-cultivating lands are affected by salinity in Asia (Papademetriou, 2009). Due to the absence of data on actual salinity-affected areas, the economic impact of salinization has not been

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reported in Sri Lanka (Thiruchelvam & Pathmarajah, 1999). Being an island, Sri Lanka experiences both inland (Rengasamy, 2016) and coastal salinity in different districts (Kendaragama & Bandara, 2000). Rice fields near the coastal belts develop salinity due to seawater intrusion (Opatha & Lokupitiya, 2019). By 1978, around 0.112 million ha of rice lands had been affected by salinity with electrical conductivity over 4 dSm^{-1} (Panabokke, 1978). After the tsunami in 2004, 4000 ha of the coastal belt in Sri Lanka developed salinity (Sirisena & Wanigasundera, 2021).

Salinity stress reduces plant growth and yield by reducing water and nutrient uptake (Corwin, 2021). Salinity stress badly affects germination (Vibhuti *et al*., 2015) seedling growth (Vibhuti *et al*., 2015; Senanayake *et al*., 2017), and survival ability (Mishra *et al*., 2021), at vegetative (Zeng *et al*., 2001), panicle initiation (Rad *et al*., 2011) and heading (Rad *et al.*, 2011; Gerona *et al*., 2019) stages. Yield components, such as the number of spikelets (Shereen *et al*., 2005), filled grain percentage (Abdullah *et al.*, 2001), and per plant yield have also been reduced under salinity stress (Zeng *et al*., 2001; Raza *et al*, 2005; Singh & Sengar, 2014).

The effect of salinity is minimized by soil amendment (Minhas & Sharma, 2003), proper drainage (Rhoades, 2016), plant transplanting and minimizing evaporation (Gurung & Azad, 2013). Improving rice varieties with salinity stress significantly increases rice production (Haque *et al*., 2021). Identifying new tolerant genetic materials by screening genotypes for salinity tolerance is essential for directly introducing or incorporating elite lines in rice varietal improvement programmes (Vasudevan *et al*., 2014). Breeders must integrate yield and salinity tolerance into the same genotype by eliminating unfavourable traits for commercial cultivation. Broadening the existing genetic base of rice expands the possibilities of new gene combinations for breeding programmes (Brozynska *et al*., 2016). In such a study, out of 185 rice genotypes, fifteen genotypes at the germination stage and twenty-eight at the seedling stage were salinity-tolerant (Sakina *et al*., 2016). Several other studies have been conducted to find salinity tolerance in different genetic sources (Supplementary Table I). Indonesian researchers (Hairmansis *et al.*, 2017) and the International Rice Research Institute (IRRI, 2006) have developed salinity-tolerant rice varieties. Improved rice varieties *Bw400*, *Bg369*, *At353*, and *At354,* have been recommended for differently saline soils in Sri Lanka (RRDI, 2018).

Sri Lankan traditional rice accessions, *Mas samba, Galpawee, Mahasuduwee, Godawee, Rathkara,* and *Handiran,* have scored more than 35% survival rates under salinity stress (Pradeepika *et al*., 2014), and *Sudu Karayal* (Pradeepika *et al*., 2014), *Godawee* and *Alwee* (Dahanayaka *et al.*, 2015), *Pachchaperumal* (Pradheeban, 2014), *Herath* and *Ranhiriyal* (Ranawake & Dahanayake, 2012) are some of the traditional rice accessions which have performed better than the other accessions under salinity stress.

Imposing salinity stress has been done by using different electrical conductivity (EC) levels or Na^+ concentrations, and different morphological and biochemical parameters have been used to evaluate the materials compared to positive control and sensitive check varieties (Supplementary Table I).

Salinity-tolerant character in rice is not a single-factor trait; thus, screening for salinity tolerance and improving salinity tolerance in rice face several difficulties. Genetic factors and genetic environment interactions significantly affect salinity tolerance (Krishnamurthy *et al*., 2016; Rasel *et al*., 2021). Salinity tolerance links with poor quality characteristics such as low yield, poor grain quality, and long age in rice (Ravikiran *et al*., 2018). Field screening procedures are impractical for salinity screening due to uncontrolled environmental factors in the field. Hence, preliminary screening must be done under controlled environmental conditions to determine the tolerant genotypes (Gregorio *et al*., 1997). Laboratory or greenhouse screening experiments (Souleymane *et al*., 2015), manipulation of *Yoshida* solution at EC 5 dSm^{-1} (Ranawake *et al*., 2014) and EC 7 dSm^{-1} (Chen *et al.*, 2020), or hydroponic systems (Hakim *et al*., 2010; Kranto *et al*., 2016; Tabassum *et al*., 2021) are commonly applied techniques for salinity tolerance screening (Supplementary Table I).

Morphological or physiological changes in rice due to salinity stress have been used to evaluate the level of tolerance or susceptibility of rice to salinity stress. Several salinity-affected traits are leaf length, leaf folding leaf tip burning, dry or dead leaves, burned patches on leaves (Gregorio *et al*., 1997), and reduced chlorophyll contents in the leaves (Singh *et al*., 2014; Tabassum *et al.*, 2021). Further, rice reduces leaf elongation and new leaf emergences (Hakim *et al.*, 2010; Kranto *et al*., 2016; Tabassum *et al.*, 2021). The plant survival rate, reduction of plant height, tillering ability (Razzaque *et al*., 2009), and days to flowering (Joseph, 2013) have also been altered under salinity stress. Reduction in the number of spikelets per panicle and seed yield per panicle (Zeng *et al*., 2001), panicle length, spikelets number, and fertility percentage have also been altered during the salinity stress (Joseph, 2013).

Pokkali and *Nona-Bokara* are used as the positive control, and *IR29* and *IR29* are used as the sensitive genotype in many salinity-tolerant studies in rice (Supplementary Table I).

Further, rice has been evaluated in different growth stages for salinity tolerance: at germination (Pradheeban *et al*., 2015), seedling (Gregorio *et al*., 1997; Khan *et al*., 1997), vegetative (Ranawake *et al*., 2014) and maturity (Tabassum *et al*., 2021) stages (Supplementary Table I). The seedling and early seedling stages are the most sensitive stages for salinity stress in rice (Grattan *et al*., 2002).

Screening genotypes for salinity tolerance at the early growth stages ensures crop establishment and survival at the latter growth stages. The parameters considered for salinity tolerance screening must be reliable and convenient. Since the salinity-induced morphological and physiological changes in rice are complex, visual characters are evaluated in salinity tolerance screening in rice (Gregorio *et al*., 1997).

Plant shoot and root weight are reduced under salinity stress at the seedling and vegetative stage (Razzaque *et al*., 2009). Tolerant and susceptible genotypes have recorded different reduction rates in total biomass, and shoot and root dry matter under salinity stress (Lutts *et al*., 1995; Zeng *et al.*, 2001; Souleymane *et al.*, 2015; Tabassum *et al.*, 2021). The reliability of such characteristics as parameters in salinity tolerance screening is doubtful. In the present study, while screening salinity tolerance in improved and traditional rice genotypes using IRRI adapted technique (Gregorio *et al*., 1997), the possibility of using plant height, total dry matter weight, and shoot and root dry matter weight as evaluation parameters was assessed.

MATERIALS AND METHODS

Plant materials

Eighty rice genotypes, including fifty-three traditional rice accessions and twenty-seven improved varieties, were collected from the Plant Genetic Resources Centre, Gannoruwa, Sri Lanka (PGRC, 1999). Tolerant and susceptible check varieties used in the study were Pokkali and IR, respectively.

Experimental design and procedure

The experiment was conducted according to a randomized complete block design with four replicates, and ten plants were included in each replicate. Dormancy broken surface-sterilized rice seeds were germinated in distilled water for three days and transferred to *Yoshida* solution (Gregorio *et al*., 1997). Using sodium chloride, the Yoshida solution's electrical conductivity (EC) was increased up to EC ~ 6 dSm^{-1}. The calibration curve was plotted to manage the EC of the *Yoshida* solution. After three days at EC 6 dSm^{-1}, the salinity level was increased to 12 dSm^{-1}, and seedlings were kept in the same condition for 16 days. The medium was renewed at intervals of two days. The *Yoshida* solution was prepared according to Yoshida *et al*. (1972).

Scoring visual salt injuries using standard evaluation scores (SES)

Plants were evaluated according to the IRRI standard scores for visible salt injury (Gregorio *et al*., 1997) at ten and sixteen days of salinization (Supplementary Figure I).

Determination of plant height and biomass accumulation

After visual scoring, plant height was measured. The stressed plants and control plants were kept at 70^{o}C for five days until a constant dry matter weight was recorded, and the per-plant shoot dry weight, root dry weight, and total dry weight were measured. The shoot, root, and total dry weight reduction percentages were calculated as a percentage of the difference between the dry weight of the salinity-stressed plants (DWSP) and the control plants (DWCP); {(DWSP-DWCP)/DWCP}*100.

Data analysis

Data were analyzed using ANOVA with Statistical Analysis System (SAS Institute Inc., 2000). Duncan's multiple range test separated means.

RESULTS AND DISCUSSION

Salinity tolerance of traditional rice accessions as scored by standard evaluation scores (SES)

According to the SES, *Dahanala3917, Heenati4618, Kaluwee3728, Mawee (8497, 5531, 3618), Murungakayan3921, Pokkali3573, Rathuwee3905*, and *Rathuheenati (6249, 4992),* and improved varieties *Bg250* and *At354* were highly tolerant at the10-day salinity stress at EC 12 dSm^{-1}. However, among traditional rice accessions highly tolerant at the 10-day salinity stress, only *Rathuheenati6229* was highly tolerant at the 16-day salinity stress. *Heenati4618, Kaluwee3728, Pokkali3573,* and *Mawee (5531, 3618)* were tolerant, and *Mawee3487* and *Rathuwee3905* were moderately tolerant at the 16-day salinity stress though they were highly tolerant at the 10-day salinity stress. Finding *Rathuheenati4992* as a highly tolerant accession at both 10-day and 16-day salinity stresses is a promising finding in the present study. The most tolerant accessions next to *Rathuheenati4992* were *Heenati4618, Kaluwee3728, Mawee (5531, 3618)*, and *Pokkali3,* which were highly tolerant at the 10-day and tolerant at the 16-day salinity stress. Among the tolerant accessions at the 10-day salinity stress, only *Kaluheenati7802* was tolerant at 16 days. In contrast, all other traditional accessions that were tolerant at the 10-day salinity stress were moderately tolerant, susceptible or highly susceptible at the 16-day salinity stress. *Kaluheenati7802* would be a promising accession to withstand the salinity stress better than many of the highly salinity tolerant accessions at the 10-day salinity stress, that were not highly tolerant or tolerant at the 16-day salinity stress (Table 1).

There are several *Pokkali* accessions in the farmer fields and the germplasm collections. These accessions could be the same or different in their genetic make-up. In the present study, two *Pokkali* accessions *(3881, 3573)* were evaluated, and *Pokkali3573* was highly tolerant at the 10-day salinity stress while moderately tolerant at the 16-day salinity stress. However, *Pokkali3881* was moderately tolerant at both stress conditions (Table 1). Dahanayaka *et al.* (2015) reported that *Pokkali5556* is salinity tolerant, and Noorzuraini *et al.* (2021) reported that two different *Pokkali* lines (accession numbers were not given) are salinity tolerant. *Pokkali* has been reported as salinity tolerant at the seedling stage (Heenan *et al*., 1988; Wijerathna *et al*., 2011; de Costa *et al*., 2012b; Senanayake *et al*., 2017) and the panicle stage (Heenan *et al*., 1988). *Pokkali* serves as the tolerant check variety for salinity tolerance studies (El-Shabrawi *et al.*, 2010; Chunthaburee *et al*., 2016; Sampangi-Ramaiah *et al*., 2020). De Costa *et al*. (2012a) used *Pokkali* as the check variety in an osmotic and ionic stress tolerance study; El-Shabrawi *et al.* (2010) as a positive control for a salinity tolerant physiological marker; and Sampangi-Ramaiah *et al.* (2020) as a reference for a salinity tolerant endophyte producer.

Salinity tolerance of improved rice varieties as scored by standard evaluation scores (SES)

Improved rice varieties *At354* and *Bg250* were highly tolerant at the 10-day salinity stress, and both were tolerant at the 16-day salinity stress (Table 1). *At354* has been recorded as salinity tolerant at the seedling stage (Senanayake *et al*., 2017) and used as the standard check variety in a study carried out to evaluate the varietal performances under salinity stress (de Costa *et al*., 2012a; Pradeepika *et al*., 2014). Under experimental conditions, *At354* has performed better than *Pokkali* (de Costa *et al*., 2012b) and has recorded a 77% survival rate under salinity stress at the seedling stage (Dahanayaka *et al*., 2015). Pradheeban *et al*. (2014) has reported that *At354* is a highly salinity-tolerant accession at the germination stage, the same as *Pokkali*. Highly salinity tolerant *Bg250* is a short-day variety (85 days) with an average yield of 4.5 t/ha in Sri Lanka. It has been recommended for drought and flood-prone fields to escape the stress (RRDI, 2018). *Bg250* has been recorded as a highly salinity-tolerant accession to the level of *Pokkali* at the germination stage (Pradheeban *et al*., 2014) and at the seedling stage after the seeds were treated with *Imidacloprid* 70% WS (Gaucho), *Thiamethoxam* 70% WS (Cruiser), and *Nitrophenolate* 0.5% WS (Atonik) (Ranawake *et al*., 2013).

Among the improved rice varieties, *Bw400, Bg369*, and *At353* were tolerant at the 16-day salinity stress, along with *Bg250* and *At354* were highly salinity-tolerant at the 10-day salinity stress. *Bg369* and *At353* were tolerant at both stress conditions. *Bg45*5 and *Swarnasub1* were moderately tolerant at 16-day salinity stress, and *Bg350* was moderately tolerant at both 10-day and 16-day salinity stresses. *Bg369* has been reported as a salinity-tolerant rice variety (Senanayake *et al*., 2017). *At354*, *Bw400, Bg369*, and *At353* have been recommended for differently salinized fields in Sri Lanka and have fallen into different yield and age categories (RRDI, 2018).

Four improved rice varieties, namely *Bg360, At306, At362,* and *Ld368,* were highly susceptible even at the 10-day salinity stress, while ten accessions including the same varieties that were highly susceptible at 10-day and *At405, At402, Ld371, Bw272-6b, Ld365*, and *Bg352* were highly susceptible at 16-day salinity stress (Table 1). These varieties should not be grown in saline-prone areas in Sri Lanka.

Table 1: Salinity tolerance of rice genotypes on the 10th and 16th day salinity stress at the seedling stage

		Highly tolerant	Tolerant	Moderately tolerant	Susceptible		Highly susceptible
Salinity stress at 6 dS/m for 10 days	Traditional rice accessions	*Dahanala3917*	*Kalubalawee5479*	*Dikwee3741*	*Dikwee3504*	*Murungakayan6263*	*Kuruwee3552*
		Heenati4618	*Kaluheenati5191*	*Dikwee2203*	*Heenati6402*	*Murungakayan3490*	
		Kaluwee3728	*Kaluheenati7802*	*Kalubalawee3976*	*Heenati4935*	*Dahanala3304*	
		Mawee8497	*Kaluheenati4621*	*Kalubalawee5480*	*Heenati3936*	*Podiwee3109*	
		Mawee5531	*Murungakayan 3492*	*Kaluheenati4991*	*Heenati3707*	*Rathuheenati5486*	
		Mawee3618	*Polayal3661*	*Mawee8552*	*Heenati4524*	*Suduheenati3932*	
		Murungakayan 3921	*Ratawee3466*	*Mawee4145*	*Mawee8551*	*Sudurusamba2202*	
		Pokkali3573	*Rathuwee3473*	*Murungakayan 3809*	*Mawee3683*	*Kaluwee3876*	
		Rathuwee3905	*Suduheenati7799*	*Pokkali3881*	*Mawee5384*	*Kaluheenati3471*	
		Rathuheenati6249	*Kuruwee3982*	*Ratawee3655*	*Kuruwee3898*		
		Rathuheenati4992		*Sudurusamba3671*	*Kuruwee3465*		
	Improved	*Bg250*	*Bg359, Bg369*	*Bg350*	*Bg350*	*Bw453*	*Bg360*
		At354	*Bg455, At353*	*Ld371*	*At308*	*Ld365*	*At306*
			Bw367, Bw400	*IRRI64*	*At402*	*Ld408*	*At362*
			IRRI64		*At405*	*Sambamasuri*	*Ld368*
			Swarnasub1		*Bw272-6b*	*Bg352*	
			Heenati4618	*Dikwee3504*	*Dahanala3917*	*Kalubalawee3976*	*Dikwee2203*
Salinity stress at 6 dSm-1 for 16 days	Traditional rice accessions	*Rathuheenati4992*	*Kaluwee3728*	*Heenati4935*	*Dahanala3304*	*Murungakayan3921*	*Heenati3707*
			Kaluheenati7802	*Heenati3936*	*Dikwee3741*	*Murungakayan3492*	*Mawee3683*
			Mawee5531	*Kalubalawee5479*	*Heenati6402*	*Murungakayan3490*	*Murungakayan 3495*
			Mawee3618	*Kaluheenati4991*	*Heenati4524*	*Ratawee3466*	*Podiwee3109*
			Pokkali3573	*Kaluheenati4621*	*Kaluheenati 5191*	*Rathuwee3473*	*Rathuheenati6249*
				Kaluheenati3471	*Kuruwee3982*	*Suduheenati7799*	*Rathuheenati5486*
				Mawee8497	*Kuruwee3552*	*Suduheenati3932*	*Sudurusamba2202*
				Murungakayan 3809	*Kuruwee3465*	*Sudurusamba3671*	*Mawee8551*
				Pokkali3881	*Kuruwee3898*	*Kaluwee3876*	*Murungakayan 6263*
				Polayal3905	*Mawee8552*		
				Ratawee3655	*Mawee3704*		
				Rathuwee3905			
	Improved		*Bw400*	*Bg350*	*Bg300*	*Ld408*	*At405, Bg360*
			Bg250	*Bg455*	*Bg359*	*IRRI64*	*Bw272-6b, Ld371*
			Bg369	*Swarnasub1*	*At308*	*IRRIsub1*	*Ld365, At306*
			At353		*Bw367*	*Sambamasuri*	*Ld368, At362*
			At354		*Bw453*	*Ld368*	*Bg352, At402*

Yield and agronomic characteristics of studied key genotypes were greatly varied under field conditions (*Unpublished data by the authors*).

Ientification of the tolerance category into which the rice genotype is included is convenient for future practices. Among the traditional genotypes, 20.7% was highly tolerant, 16.9% tolerant, 20.7% moderately tolerant and 39.6% susceptible or highly susceptible at the 10-day salinity stress, while the values changed to 1.9, 11.3, 24.5, and 62.2% respectively at the 16-day salinity stress.

Identifying different tolerance categories in salinity stress studies in rice is a common practice. Three categories, namely tolerant, moderately tolerant, and sensitive, have been identified based on physio-morphological indices evaluated at EC 10 dSm^{-1} salinity stress in the rice seedling stage by Pongprayoon *et al.* (2019). They reported that the variety *Riceberry* is salinity tolerant, five cultivars are moderately tolerant, and two cultivars are susceptible. Germplasm consisting of 114 genotypes recorded 7% highly tolerant, 20.14% tolerant, 36.84% moderately tolerant, 28.95% susceptible, and 7% highly susceptible at the germination stage in a Petri dish method under a 120 mM salt concentration (Zhang *et al.*, 2021). Another continued study from 2012 to 2021 in India reported that out of 1500 different rice genotypes, only 5% were salinity tolerant and out of 7500 rice lines, only 3.2% were salinity tolerant at the seedling stage under 10 dSm^{-1} salinity stress (Krishnamurthy *et al.*, 2022). A collection of another 110 Sri Lankan genotypes consisting of both improved and traditional rice accessions has also recorded 5.9% highly tolerant, 24.5% tolerant, 29.4% moderately tolerant, 31.4% susceptible, and 8.8% highly susceptible genotypes under a hydroponic system at a salinity level of 100 mM Na^{+} (de Costa *et al.*, 2012a). The percentages of highly salinity tolerant and tolerant rice genotypes in the studied Sri Lankan rice germplasm are significantly greater than those of the other studies.

Salinity tolerance in traditional rice accessions

Salinity tolerance levels in traditional rice accessions are more sustainable than improved rice varieties. Only *Kuruwee3552* was highly susceptible to 10-day salinity stress among the traditional rice accessions. Around 40% acquired at least a minimum tolerance level, proving the adaptability of naturally evolved traditional genotypes for saline fields (Table 1). Although highly tolerant improved rice varieties and traditional rice accessions at the 10-day salinity stress have been downgraded to lower-level salinity tolerant/susceptible groups at the 16-day salinity stress, *Rathuheenati4992* was able to withstand severe 16-day salinity stress as well as the 10-day salinity stress. The sustainability of traditional rice accessions under salinity stress was exhibited in many traditional rice accessions by remaining at the same tolerance level at both 10-day and 16-day salinity stresses: *Rathuheenati6229* was highly tolerant, *Kaluheenati7802* was tolerant, *Kaluheenati4991*, *Murungakayan3809*, *Pokkali3881*, *Murungakayan3809,* and *Rathuwee3655* were moderately tolerant at both stresses (Table 1). The broad genetic diversity in Sri Lankan traditional rice gene pool gives a great chance to select promising accessions other than *Pokkali* for future breeding programmes.

Dry matter reduction and salinity tolerance of studied rice genotypes

When subjected to extended periods of salinity, plants undergo ionic stress, resulting in early aging of mature leaves and subsequently reducing the available photosynthetic area, which, in turn, affects leaf water potential and the production and distribution of assimilated dry matter (Cramer & Nowak, 1992; Bradford, 1994). However, there is no unique relationship between salinity tolerance level and dry matter accumulation or reduction, compared to that of control plants at the salinity stress in the studied genotypes. The shoot, root, and total dry matter reduction and accumulation varied in different ranges regardless of the tolerance level: shoot dry matter 24.53% reduction to 63.14% accumulation, root dry matter 36.15% reduction to 6.61% accumulation, total dry matter 31.76% reduction to 15.39% accumulation.

Dry matter reduction and accumulation under salinity stress were evident in the highly tolerant or tolerant groups. *Pokkali3573* reported dry matter reduction in the shoot (24.53%), root (36.15%), and total dry matter (31.76%). *Mawee3618* and *At353* reported the highest shoot (63.14%), and root (63.14%) dry matter accumulation, and *Pokkali3573* reported the highest shoot dry matter reduction (24.53%). Further, *Kaluwee3728* and *Bg250* accumulated the highest root dry matter (6.61%), and *Pokkali3573* reduced the root dry matter by 36.15%. Highly salinity tolerant *Rathuheenati4992* reduced the shoot and total dry matter. Still, it increased the root dry weight at salinity stress, indicating that its root system grows under salinity stress while shoot growth is limited (Table 2).

Dry matter reduction and dry matter accumulation in shoot, root, or both were significantly changed in the moderately salinity tolerant group. Among thirteen traditional rice accessions and three modern varieties, *Kaluheenati4621* reported the highest significant shoot dry matter reduction (58.13%) and *Bg350* recorded the highest shoot dry matter accumulation (84.55%).

The highest root dry matter reduction was reported in *Dikwee3504* (62.07%), and *Heenati3936* recorded the highest root dry matter accumulation (59.87%). Traditional rice accession *Polayal3661* recorded the lowest total dry matter accumulation (0.94%), and *Kalubalawee5479* recorded the highest total dry matter accumulation (59.87%). However, *Ratawee3655* and *Pokkali3881* reduced the dry matter accumulation in both shoots and roots. These values emphasize the variations in shoot, root or total dry matter accumulation and reduction in rice genotypes at the seedling stage under the salinity stress even though they belong to the same tolerance level. Usually, the root dry matter accumulation is reduced under salinity stress (Singam *et al*., 2011). Though the slightest reduction of dry matter in salinity-tolerant genotypes under salinity stress is evident (Ashraf & Bhatti, 2000; Souleymane *et al*., 2015; Tabassum *et al*., 2021a), the studied genotypes behaved differently. A broad diversity exists in dry matter partitioning and dry matter reduction and accumulation in highly tolerant, tolerant or moderately tolerant rice genotypes at the salinity stress.

Table 2: Shoot dry matter, root dry matter, and total dry matter reduction in highly tolerant, tolerant, and moderately tolerant rice genotypes in the seedling stage at the 16-day salinity stress

HT & T genotypes	SD	RD	TD	MT genotypes	SD	RD	TD
Rathuhenati4992(HT)	8.97 c	-1.05 c	2.99 d	*Dikwee3504*	-31.93 e	62.07 a	48.48 a
Heenati4618	-4.48 d	4.63 b	1.13 d	*Heenati4935*	40.67 b	-1.70 g	12.95 d
Kaluwee3728	-0.90 d	-6.61 d	-4.50 e	*Heenati3936*	-7.36 d	-59.87 j	-4.85 h
Kalubalawee5480	-33.13 e	35.05 a	23.20 b	*Kalubalawee5479*	-84.27 g	-48.28 i	-61.23 i
Mawee5531	-60.25 f	2.70 bc	-14.34 f	*Kaluheenati4991*	17.85 c	-1.97 g	4.09 e
Mawee3618	-63.14 f	6.31 b	-15.39 f	*Kaluheenati4621*	58.13 a	-4.57 g	25.25 c
Pokkali3573	24.53 a	36.15 a	31.76 a	*Kaluheenati3471*	-11.54 d	24.24 d	13.66
Bg250	-0.90 d	-6.61 d	-4.50 e	*Mawee8497*	19.84 c	-4.65 g	4.04 e
Bg369	5.37 b	1.73 bc	6.71 c	*Murungakayan3809*	-37.15 e	-0.99 g	-10.56 g
At353	-63.14 f	6.31 b	-15.39 f	*Pokkali3881*	14.60 c	42.24 c	35.73 b
At354	15.37 b	1.72 bc	6.71 c	*Polayal3661*	24.92 c	-24.79 h	-0.94 f
Bw400	15.36 b	1.73 bc	6.71 c	*Ratawee3655*	46.19 b	53.49 b	49.58 a
CV	-23.46	15.13	9.9	*Rathuwee3905*	19.88 c	-3.97 g	6.25 e
				Bg350	-84.55 g	15.01 e	-7.89 g
				Bg455	-2.27 d	6.33 f	4.03 e
				Swarnasub1	-60.89 f	22.27 d	13.73 d
				CV	-13.8	17.39	38.22

HT: Highly tolerant, T: Tolerant, MT: Moderately tolerant SD: Shoot dry matter, RD: Root dry matter, TD: Total dry matter

In the susceptible group, 62.5% of genotypes reduced the shoot dry matter at the salinity stress, but there is a significant variation in the degree of reduction or accumulation. The highest root dry matter reduction (81.68%) was observed in *IRRIsub1,* and the highest root dry matter accumulation (49.04%) was observed in *IRRI64* (Table 3). Traditional rice accessions *Kaluwee3876, Kuruwee* (*3898, 3552, 3465*), *Suduheenati3932,* and improved variety *Bg300* increased the total dry matter while other genotypes reduced the total dry matter under salinity stress. Traditional rice accession *Dahanala3917* had not reduced the total dry matter under salinity stress. Genotypes in the salinity susceptible group record a spectrum of dry matter reduction or accumulation patterns in root, shoots, or both under salinity stress.

In the highly susceptible group, only four accessions, *Murungakayan3495* (35.78%), *Sudurusamba2202* (64.18%), *Bg360* (15.41%), and *Bw272-6b* (75.30%) accumulated the shoot dry matter and two traditional rice accessions, *Murungakayan3495* (2.82%), and *Rathuheenati6249* (48.16%), and improved variety *At402* (14.01%) accumulated root dry matter under salinity stress. All other rice genotypes showed shoot and root dry matter reductions under salinity stress. Being highly susceptible, *Murungakayan3495* was the only highly susceptible genotype that increased the total dry matter accumulation under salinity stress.

Table 3: Shoot dry matter, root dry matter, and total dry matter reduction of susceptible and highly susceptible rice genotypes in the seedling stage at the 16-day salinity stress

S Genotypes	SD	RD	TD	HS Genotypes	SD	RD	TD
Dahanala3917	9.21 ^{gh}	-5.23 ^{k}	0.00 ^{j}	*Dikwee2203*	39.48 ^{b}	22.90 ^{gh}	28.67 ^{e}
Dahanala3304	-15.18 ^{l}	32.07 ^{g}	19.27 ^{efg}	*Heenati3707*	20.88 ^{d}	56.50 ^{b}	45.66 ^{b}
Dikwee3741	56.81 ^{d}	-17.67 ^{l}	25.44 ^{d}	*Mawee3683*	25.67 ^{d}	2.83 ^{k}	12.10 ^{j}
Heenati6402	14.45 ^{g}	51.26 d	44.39 ^{a}	*Mawee8551*	37.52 ^{bc}	40.80 ^{d}	39.53 ^{c}
Heenati4524	4.29 ^{hi}	-1.98 ^{k}	0.34 ^{j}	*Murungakayan6263*	40.28 ^{b}	22.62 ^{gh}	25.65 ^{f}
Kaluwee3876	-3.00 ^{ij}	-31.05 ^{m}	-22.92 ^{k}	*Murungakayan3495*	-35.78 ^{f}	-2.82 ^{l}	-12.54 ^{l}
Kalubalawee3976	58.33 ^{cd}	11.18 ^{j}	37.28 ^{b}	*Podiwee3109*	69.41 ^{a}	16.33 ^{ij}	23.59 ^{fj}
Kaluheenati5191	16.11 ^{g}	15.70 ^{j}	15.89 ^{gh}	*Rathuheenati6249*	60.16 ^{a}	-48.16 ^{n}	14.74 ^{i}
Kuruwee3982	34.55 ^{f}	-12.96 l	10.87 ^{i}	*Rathuheenati5486*	37.52 ^{bc}	40.80 ^{d}	39.55 ^{c}
Kuruwee3898	-71.43 ^{o}	-34.06 ^{m}	-44.68 ^{l}	*Sudurusamba2202*	-64.18 ^{g}	104.15 ^{a}	35.02 ^{d}
Kuruwee3552	66.07 ^{bc}	66.07 ^{c}	-24.83 ^{k}	*Bg352*	69.41 ^{a}	16.33 ^{ij}	23.59 ^{fg}
Kuruwee3465	74.18 ^{ab}	74.18 ^{b}	-52 15 ^{m}	*Bg360*	-15.41 ^{e}	32.67 ^{e}	24.62 ^{fg}
Mawee8552	-39.17 ^{m}	38.80 ^{f}	20.67 ^{ef}	*At306*	27.88 ^{cd}	14.58 ^{j}	17.98 ^{h}
Mawee3704	4.33 ^{hi}	30.16 ^{gh}	22.29 ^{de}	*At362*	23.17 ^{d}	54.40 ^{b}	47.32 ^{ab}
Mawee5384	-1.41 ^{ij}	32.33 g	18.72 ^{efg}	*At402*	44.63 ^{b}	-14.01 ^{m}	5.74 ^{k}
Murungakayan3921	11.16 ^{gh}	-2.79 ^{k}	1.99 ^{j}	*At405*	60.11 ^{a}	46.03 ^{c}	49.27 ^{a}
Murungakayan3492	-14.23 ^{kl}	31.31 ^{g}	19.15 ^{efg}	*Bw272-6b*	-75.30 ^{h}	30.80 ^{ef}	22.48 ^{g}
Murungakayan3490	4.29 ^{hi}	-1.98 ^{k}	0.34 ^{j}	*Ld365*	39.49 ^{b}	20.46 ^{hi}	25.70 ^{f}
Ratawee3466	13.25 ^{gh}	31.59 ^{g}	25.81 ^{d}	*Ld368*	37.35 ^{bc}	26.57 ^{fg}	28.50 ^{e}
Rathuwee3473	42.80 ^{e}	34.85 ^{fg}	36.59 ^{b}	*Ld371*	40.28 ^{b}	22.62 ^{gh}	25.65 ^{f}
Suduheenati7799	-6.52 ^{jk}	24.49 ^{hi}	15.44 ^{gh}	*CV*	27.09	13.5	6.74
Suduheenati3932	-71.43 ^{o}	-34.06 m	-44.68 ^{nl}				
Sudurusamba3671	-16.26 ^{l}	51.34 d	33.56 ^{bc}				
Bg300	-3.00 ^{ij}	-31.05 ^{m}	-22.92 ^{k}				
Bg359	44.61 ^{e}	44.64 ^{e}	44.62 ^{a}				
At308	60.76 ^{cd}	21.35 ^{i}	36.73 ^{b}				
Bw367	-60.61 ^{n}	30.60 ^{g}	13.89 ^{hi}				
Bw453	61.81 ^{cd}	11.59 ^{j}	31.06 ^{c}				
Ld408	47.13 ^{e}	29.35 ^{gh}	35.41 ^{b}				
IRRIsub1	-73.44 ^{o}	81.68 ^{a}	24.92 ^{d}				
IRRI64	79.74 ^{a}	-49.04 ^{n}	34.64 ^{bc}				
Sambamasuri	66.09 ^{bc}	-0.65 ^{k}	16.76 ^{fgh}				
CV	46.63	24.11	21.44				

S: Susceptible, HS: Highly susceptible, SD: Shoot dry matter, RD: Root dry matter, TD: Total dry matter

The presence of salinity has notably diminished the heights of all paddy cultivars throughout the specified growth stages when compared to the control treatments (Puvanitha & Mahendran, 2017). The seedling growth has reduced in salinity-susceptible varieties (Razzaque *et al*., 2009), and salinity has reduced dry matter by about 90% (Asch *et al*., 2000), including root dry matter (Singam *et al*., 2011). The level of salinity tolerance and dry matter reduction are genetically decided (Narayanan & Sree Rangasamy, 2008), and the degree of variation in dry matter reduction or accumulation changes with the genotype (Suriyan *et al.*, 2009). Efficiency reduction of photosynthesis, expression changes in transporter genes whose expression depends on Na^+ and K^+ availability, inability to absorb soil nutrition, and changes in ethylene biosynthesis directly reduce plant dry matter under salinity stress (El-Shabrawi *et al*., 2010; Puteh & Mondal, 2015; Kaur *et al*., 2016; Li *et al*., 2018; Mishra *et al*., 2021b). Overall dry matter reduction or accumulation may change once these salinity tolerance mechanisms are differently affected in different genotypes.

Table 4: Correlation between different parameters studied in screening for salinity tolerance at the seedling stage

Parameters	r	p
Susceptible level on 10th day × Total dry matter reduction (%)	0.151	0.182
Susceptible level on 10th day × Root dry matter reduction (%)	-0.068	0.550
Susceptible level on 10th day × Shoot dry matter reduction (%)	0.184	0.102
Susceptible level on 10th day × Plant height treatment	-0.334**	0.002
Total dry matter reduction (%) × Root dry matter reduction (%)	0.297**	0.007
Total dry matter reduction (%) × Shoot dry matter reduction (%)	0.405*	0.000
Root dry matter reduction (%) × Shoot dry matter reduction (%)	-0.105	0.353
Plant height × Shoot dry matter reduction (%)	-0.330**	0.003
Plant height × Total dry matter reduction (%)	-0.170	0.125
Plant height × Shoot dry matter reduction (%)	-0.330**	0.003
Plant height treatment × Plant height control	0.400**	0.000
Susceptible level on 16th day × Total dry matter reduction (%)	0.325**	0.003
Susceptible level on 16th day × Shoot dry matter reduction (%)	0.061	0.594
Susceptible level on 16th day × Root dry matter reduction (%)	0.294**	0.008
Susceptible level on 16th day × Plant height treatment	-0.381**	0.000
Susceptible level on 10th day × Tolerant level on 16th day	0.634**	0.001

r: Pearson's correlation coefficient, p: probability, *correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Correlation of dry matter accumulation and salinity tolerance

Correlation analysis was performed to understand the relationship between dry matter accumulation or reduction and salinity tolerance or susceptible levels at the seedling stage at the 10-day and 16-day salinity stress (Table 4). The correlation was positive and nonsignificant ($r = 0.152$, $\alpha = 0.182$) between the susceptible level and total dry matter reduction of seedlings at the 10-day salinity stress and at the 16-day salinity stress ($r = 0.325$, $\alpha = 0.003$). A prolonged period of salinity stress is needed for a significant change in plant dry matter reduction under salinity stress (François *et al*., 1994). The type of correlation depends on the studied genetic materials and their tolerance mode at salinity stress.

There was a significant weak correlation ($r = 0.405$, $\alpha = 0.000$) between the total dry matter reduction and shoot dry matter reduction, which was greater than the correlation coefficient (r = 0.297, α = 0.007) of total dry matter reduction and root dry matter reduction, which suggests that shoots is more severely affected by salinity stress than roots. A positive, weak, but significant correlation between total dry matter reduction and root dry matter reduction at both 10-day salinity stress (r = 0.297, α = 0.007) and 16-day salinity stress (r = 0.294, α = 0.008) explains that the decrease in root dry matter is distinct under salinity stress (Durga *et al*., 2021).

Table 5: Plant height of genotypes in different salinity tolerant groups at the control condition and the salinity stress condition

Tolerant & highly tolerant		
Genotype	T	C
*Rathuheenati4992**	18.79 b	17.64 c
Heenati4618	22.28 a	17.61 c
Kaluwee3728	15.60 c	20.78 a
Kalubalawee5480	11.44 e	16.85 d
Mawee5531	14.71 d	18.82 b
Mawee3618	8.24 g	20.71 a
Pokkali3573	22.23 a	15.54 e
Bg250	15.60 c	20.78 a
Bg369	10.66 f	13.06 f
At353	8.24 g	20.71 a
At354	10.66 f	13.06 f
Bw400	10.66 f	13.06 f
CV	7.66	9.55

Moderately tolerant		
Genotype	T	C
Dikwee3504	21.11^{a}	13.07^{f}
Heenati4935	15.30^{d}	14.72^{e}
Heenati3936	18.33^{b}	18.25^{c}
Kalubalawee5479	15.54^{cd}	14.45^{e}
Kaluheenati4991	13.69^{f}	9.76^{h}
Kaluheenati4621	10.86^{g}	22.51^{a}
Kaluheenati3471	16.00^{c}	10.43^{g}
Mawee8497	14.98^{de}	16.47^{d}
Murungakayan3809	21.15^{a}	14.59^{e}
Pokkali3881	18.19^{b}	14.64^{e}
Polayal3661	13.72^{f}	14.95^{e}
Ratawee3655	15.96^{c}	22.61^{a}
Rathuwee3905	14.49^{e}	21.50^{b}
Bg350	14.44^{e}	8.05^{i}
Bg455	10.46^{g}	9.21^{h}
Swarnasub1	6.81^{h}	8.11^{i}
cv	12.88	3.08

Susceptible		
Genotype	T	C
Dahanala3917	14.97^{g}	10.82^{q}
Dahanala3304	16.41^{e}	15.64^{i}
Dikwee3741	18.00^{cd}	29.50^{b}
Heenati6402	18.14^{cd}	20.28^{d}
Heenati4524	21.42^{a}	15.62^{i}
Kaluwee3876	8.64^{jk}	12.16^{o}
Kalubalawee3976	20.11^{b}	25.78^{c}
Kaluheenati5191	16.45^{e}	17.78^{f}
Kuruwee3982	18.13^{cd}	16.66^{g}
Kuruwee3898	14.70^{g}	9.94^{r}
Kuruwee3552	11.54^{h}	7.47^{u}
Kuruwee3465	10.17^{i}	6.99^{w}
Mawee8552	21.16^{a}	19.18^{e}
Mawee4145	14.72^{g}	17.64^{f}
Mawee5384	19.89^{b}	41.20^{a}
Murungakayan3921	10.01^{i}	15.52^{i}
Murungakayan3492	17.63^{d}	16.50^{h}
Murungakayan3490	21.92^{a}	15.62^{i}
Ratawee3466	14.63^{g}	9.62^{s}
Rathuwee3473	16.17^{ef}	15.24^{j}
Suduheenati7799	18.75^{c}	12.08^{o}
Suduheenati3932	15.42^{fg}	9.94 r
Sudurusamba3671	15.52^{efg}	9.59 s
Bg300	8.63^{jk}	12.16^{o}
Bg359	9.42^{ij}	13.97^{l}
At308	8.32^{vk}	12.48^{n}
Bw367	9.97^{i}	7.97^{t}
Bw453	8.09^{k}	11.57^{p}
Ld408	6.64^{l}	9.62 s
IRRIsub1	18.98^{c}	13.38^{m}
IRRI64	7.98^{k}	15.10^{k}
Sambamasuri	5.32^{m}	7.15^{v}
CV	4.47	7.3

Highly susceptible		
Genotype	T	C
Dikwee2203	12.32^{g}	17.13^{e}
Heenati3707	14.42^{e}	22.17^{b}
Mawee3683	16.00^{d}	22.48^{a}
Mawee8551	16.36^{c}	19.85^{c}
Murungakayan6263	7.77^{l}	9.68^{j}
Murungakayan3495	23.16^{a}	18.84^{d}
Podiwee3109	5.55^{q}	18.94^{d}
Rathuheenati6249	22.08^{b}	10.93^{h}
Rathuheenati5486	16.36^{c}	19.85^{c}
Sudurusamba2202	6.87^{n}	14.50 f
Bg352	5.55^{q}	18.94^{d}
Bg360	7.50^{m}	6.77^{m}
At306	11.34^{h}	6.43^{n}
At362	13.55 f	13.00^{g}
At402	11.17^{i}	10.86^{h}
At405	9.34^{j}	10.44^{i}
Bw272-6b	9.18^{k}	7.10 l
Ld365	6.64^{o}	9.45^{k}
Ld368	6.16^{p}	4.33^{0}
Ld371	7.77^{l}	9.68^{j}
CV	5.38	10.66

*Highly tolerant genotype, T: Salinity treated plants, C: Control plants

Plant height and salinity tolerance

A plant height reduction is expected at salinity stress due to the decreases in chlorophyll content (Hakim *et al*., 2014), but some genotypes behaved differently in the present study (Table 5). Some salinity-stressed genotypes increased the plant height more than the control plants in each different salinity tolerant or susceptible group. In the highly salinity tolerant and tolerant group, out of twelve genotypes, three genotypes (*Rathuheenati4992, Heenati4818,* and *Pokkali3573*) increased the plant height at salinity stress compared to that of their control plants. In the moderately tolerant group, out of sixteen genotypes, eight genotypes increased the plant height (*Dikwee3504, Heenati4935, Kalubalawee5479, Kaluheenati4991, Murungakayan3809, Pokkali3881,* and *Bg455)* under salinity stress more than that of control plants. Sixteen genotypes out of twenty-eight in the susceptible group and eight out of twenty in the highly susceptible group performed similarly (Table 5). Generally, the plant height of the rice varieties decreases under salinity stress compared to control plants (Hakim *et al*., 2010; Umar, 2016). Different genetic constituents that are responsible for growth and salinity tolerance mechanisms respond to salinity stress at different rates in rice.

According to the correlation analysis, there were a significant yet weak and negative correlation between the tolerance level and the plant height at the 10-day ($r = -0.334$, $\alpha = 0.002$) and 16-day ($r = -0.381$, $\alpha = 0.000$) salinity stress (Table 4). A significant negative correlation between plant height and salinity tolerance has been reported in many studies (Khan *et al*., 1997; De Leon *et al*., 2015; Razzaq *et al*., 2020; Durga *et al*., 2021). However, *Pokkali* performed differently (Dionisio-Sese & Tobita, 1998), and a nonsignificant positive correlation between the same has also been reported (Asch *et al*., 2000), which supports the idea that different genotypes respond to salinity differently yet retain the same tolerance level. Plant height cannot be considered as an accurate salinity-tolerant selection criterion since individual rice genotypes respond differently to salinity stress.

CONCLUSIONS

The present study screened eighty traditional rice accessions and modern rice varieties in Sri Lanka for salinity tolerance at EC ~12 dSm^{-1} for ten and sixteen days at the seedling stage. The standard evaluation scoring method was used to evaluate the salinity tolerance, and shoot, root, and total dry matter in salinity-stressed and control plants were assessed to understand the relationship between salinity tolerance and dry matter accumulation or reduction. The traditional rice accession, *Rathuheenati4992,* was highly salinity tolerant, and *Henati4618, Kaluwee3728, Mawee (5531, 3618)*, and *Pokkali3573* were salinity tolerant at the 16-day salinity stress. There are genetically different *Pokkali* accessions with different salinity tolerance levels; *Pokkali3573* was highly tolerant, and *Pokkali3881* was moderately tolerant. Sri Lankan improved rice varieties *Bg250*, *At354, Bw400, Bg369*, and *At353* were tolerant at 16-day salinity stress. Improved rice varieties, *Bg360, At306, At362, Ld368 At405, At402, Ld371, Bw272-6b, Ld365*, and *Bg352* were highly susceptible to salinity, and their cultivation must be avoided in salinized soils. Salinity tolerance in traditional rice accessions is more sustainable: Around 40% of traditional rice accessions were moderately tolerant or highly tolerant. Dry matter reduction and accumulation varied with the genotype under the salinity stress. According to the correlation analysis, plant height ($r = -0.381$, $\alpha = 0.00$) cannot be considered a selection criterion for salinity stress, and salinity stress affects the plant height of the individual rice genotype at the seedling stage. There was no correlation ($r = 0.325$, $\alpha = 0.003$) between the tolerant or susceptible level and total dry matter reduction or accumulation under salinity stress; dry matter accumulation or reduction is not a criterion to use as a parameter for salinity tolerance at the seedling stage. These findings would differ in prolonged stresses or other growth stages. Further studies at different growth stages are needed to confirm the results.

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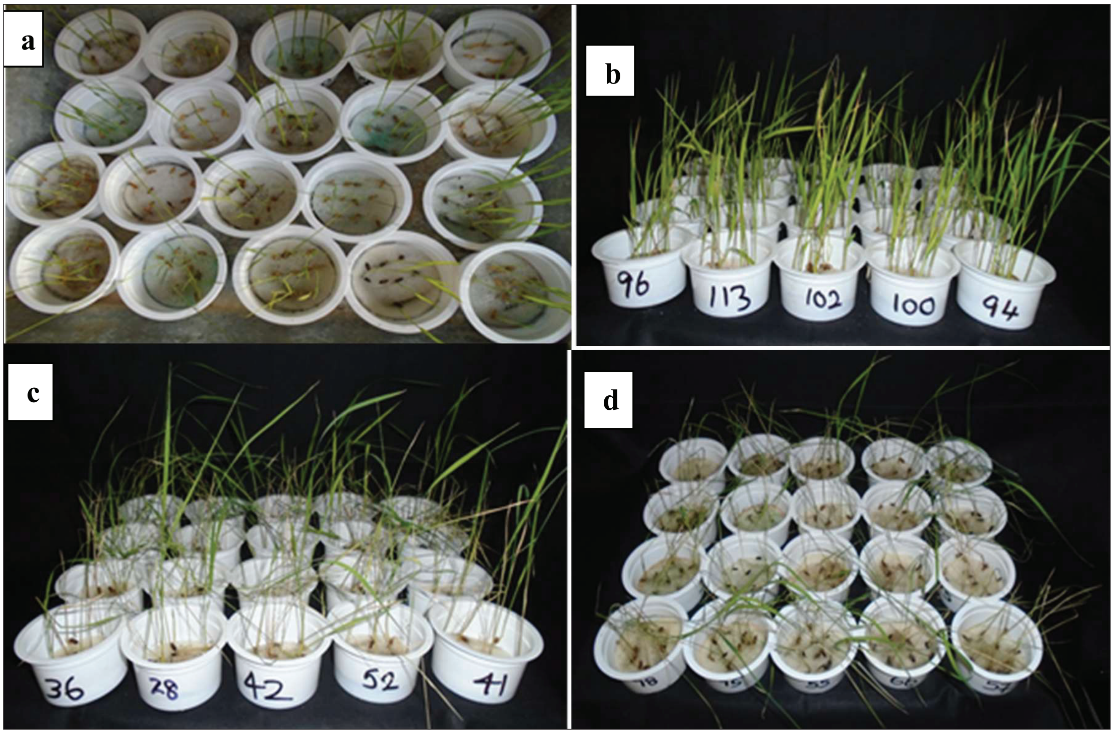
Supplementary files



Supplementary figure 1: Some different stages of testing for salinity tolerance at the seedling stage
(a): Starting stage for salinity treatment, (b): Control seedlings after sixteen days, (c): Seedlings after ten days in salinity treatment, (d) Seedlings after sixteen days in salinity treatment.

Supplementary table I: Experimental conditions used for salinity tolerant studies in rice

Materials	Tolerant genotypes	St	Salinity stress	Results	Parameters	References
Nine thousand rice germplasm	*IR29* (T) *FL478* (T)	S	EC ~10 dSm^{-1}	Identified 241 salinity-tolerant rice lines	Thirty qualitative and quantitative traits	(Krishnamurthy *et al.,* 2022)
Five rice cultivars		S	Hydroponic culture with a deep flow technique (DFT)	Hydroponic DFT is a screening technique	Agronomic characters	(Arifuddin *et al.*, 2021)
Seventy-four rice lines		S,R	Pot culture with sand six dSm^{-1} and 12 dSm^{-1}	Tolerant 13 lines- with FED 473 and IR85427	Shoot and root morpho-physiological traits	(Kakar *et al*., 2019)
Twenty-one improved rice varieties.		R	Germination, seedling and maturity stages in Petri dishes, in a hydroponic system and soil-filled pots, respectively.	At the germination stage, *Bg406* and *Pokkali* (HT) At seedling *Pokkali* (HT) *At402, Bg369* and *At354* (T)	Seed viability, growth performance, plant survival%, growth performance and grain yield reduction at maturity	(Senanayake *et al*., 2017)
Two hundred and thirty-one rice genotypes	*FL478* *NSIC Rc222* (S)	S	IRRI standard evaluation system EC ~12 dSm^{-1}	Tolerant -1.73% Moderately tolerant-18.18%	Plant damage%	(Mondal and Borromeo, 2016)
Sixteen traditional rice cultivars		G S	A Petri dish method- control, 50-, 100- and 150-mM Na^{+}	Fifteen at germination and twenty-eight at the seedling stage were salinity tolerant.		(Sakina *et al*., 2016)
Twenty germplasm-traditional and improves.	*Pokkali*		12 dS/m saline stress and five SSR markers located	*Goda Wee, At354,* and *Al Wee* varieties were highly salinity tolerant	Weighted indicator, Salinity survival index	(Dahanayaka *et al.,* 2015)
Twenty traditional rice accessions	*At354* (T) *Pokkali*	S	A hydroponic system with *Yoshida* solution EC~10 dSm^{-1}	*Sudu-Karayal* recorded the highest survival percentage	Green plant height and survival percentage	(Pradeepika *et al*., 2014)
Pokkali, Nona-Bokra and *Bicol, IR29*	*Pokkali, Nona-Bokra* and *Bicol* (T), *IR29* (S)	S	The non-destructive image-based method	The success of the technique	Total shoot area and senescent shoot area, using images.	(Hairmansis *et al*., 2014)
Five Malaysian rice varieties	*Pokkali*	V	Pot experiments EC~4-, 8-,12 dSm^{-1}	Two Malaysia varieties, *MR211* and *MR232* performed better	Plant height, leaf area, and dry matter accumulation	(Hakim *et al*., 2014a)
Japonica rice-Hyogokithanishiki and Indica rice Hokuriku-142 (Hokuriku)		S	EC solution method and MS (Murashige and Skoog) medium method	*Hyogokithanishiki* is more salt tolerant than *Hokuriku*	Green shoot length, dry matter weight and root length	(Ranawake and Nakamura, 2013)

St: Growth stage (T): Tolerant check, (S): Sensitive check, S: Seedling stage, R: Reproductive stage, G: Germination stage V: Vegetative stage, M: Tillering, panicle-initiation, heading, and harvesting stages, RILs: Recombinant inbred lines

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Materials	Tolerant genotypes	St	Salinity stress	Results	Parameters	References
Nine rice lines			EC ~5 dSm^{-1}salinized solution and let them grow in 8 days.	*Bg 250, Bg 352 and Bg 379/2* are better than others	Plant height, fresh and dry weight, survival%	(Ranawake *et al*., 2013)
Twenty-improved rice varieties			Seedling stage	*At402 (89%)*	Survival%	(Weragodavidana, *et al.*, 2012)
Eight varieties	*At354* and *Pokkali*	S	Hydroponic culture, 100 mM Na^+	*At354,* salt tolerant than *Pokkali*,	Plant growth: Leaf width fresh and dry weight, shoot and root Na^+ concentration.	(de Costa *et al*., 2012b)
One hundred and sixty-three RILs			EC~5 dSm^{-1} salinized	*Herath* and *Ranhiriyal* were salinity tolerant	Plant survival percentages	(Ranawake and Dahanayake, 2012)
Eight improved rice cultivars		S	A 50 mM NaCl and 0.2 trisodium-8-hydroxy-1,3,6-ppyrene-tri sulphonacacids (PTS)		Seedling survival%, Na^+% in shoots	(Faiyue *et a*l., 2012)
Thirty-three traditional rice cultivars		M	EC ~2-, 4-, 6-, and 8 dSm^{-1}	Salinity sensitivity among different growth stages	Plant height, biomass, harvest index, yield and yield components	(Faiyue *et al*., 2012)
Thirty rice genotypes	*Pokkali*	SR	Three levels of NaCl 0-, 60-, 100 mM at reproductive stage, EC ~12 dSm^{-1} at seedling stage		Plant growth and yield components	(Mohammadi-Nejad *et al*., 2010)
	Nona-Bokra and *Pokkali,* and *IR28* (S)*IR35657-33-2* (S)	S,R	Under controlled conditions by using the solution and pot culture techniques at EC ~12 dSm^{-1}		Shoot -length, -Na^+, Ca^{++} content and -dry weight	(Akbar *et al.,* 2008)
IR55178	*Pokkali, Nona-Bokra* and *Bicol (T) IR29* (S)	S	Primers		DNA	(Xie *et al*., 2000)
Five Malaysian rice varieties	*Pokkali*	S, VR	Standard evaluation system EC ~6 dSm^{-1} and EC ~12 dSm^{-1}	Tolerant level/score	Visual scoring system	(Gregorio *et al.,* 1997)
		S	Silica gravel culture 50-200 mol m^{-3} NaCI	Technique validation	Shoot fresh and dry weights, mortality%	(Aslam *et al.,* 1993)
		GS	EC ~10-, 15-, and 20 dSm^{-1} (5:1 NaCl and $CaCl_2$ solution)	One hundred and thirteen fairly tolerant genotypes	Germination index dry seedling weight	(Islam and Karim, 1970)

St: Growth stage (T): Tolerant check, (S): Sensitive check, S: Seedling stage, R: Reproductive stage, G: Germination stage V: Vegetative stage, M: Tillering, panicle-initiation, heading, and harvesting stages, RILs: Recombinant inbred lines