Response of selected rice varieties for salt stress at different stages of life cycle

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Introduction

Soil salinity, especially in rice growing soils is a major constraint to expand rice cultivation. The productivity of rice is greatly affected by soil salinity which is the second most widespread soil problem after drought in rice growing areas in the world. Soil salinity has the potential to reduce national rice production significantly. It affects all growth stages of rice in varying degrees starting from germination up to maturation. Though there were developed salt tolerant varieties, their level of salt tolerance and stage of salt tolerance have not been estimated properly. Therefore, the present study was carried out to identify salinity tolerance of the popular local rice varieties, which are grown in salinity affected areas in Sri Lanka to group those varieties based on their salinity tolerance level at different stages of the life cycle. Further, rice varieties were tested for their ability to sustain seed viability at germination, growth performance of seedling and plant survival, growth performance and grain yield reduction at maturity under salt stress.

Materials and methods

The research was conducted at the Rice Research and Development Institute, Batalagoda, Sri Lanka. The study was carried out over four consecutive seasons namely, *Yala* 2014, *Maha* 2014/15, *Yala* 2015 and *Maha* 2015/16. Twenty one improved rice varieties namely Bg 379-2, Bg 450, At 402, Bg 403, Bg 406, Bg 94-1, Bg 352, At 353, At 354, Bg 357, Bg 358, Bg 359, Bg 360, At 362, Ld 365, Bg 366, Bg 369, Bg 300, Bg 4-91, At 307, At 308 and check variety *Pokkali* were tested at seed germination, seedling, seedling to harvesting and booting to harvesting stages in petri dishes under hydroponic system and in soil filled pots respectively. The varieties were selected based on coverage of the saline rice lands in the country.

***** Short Communication***

Response to salt stress at seed germination stage

As proposed by Abeysiriwardena (2004), varieties were screened for their ability to sustain seed viability under high salt concentrations. The experiment was a variety (22) X salt concentrations (4) X soaking periods (2), three factor factorial laid out in a Completely Randomized Design (CRD) with 2 replications. Experiment was repeated twice to determine the consistency of results. Sodium chloride solutions were prepared having electrical conductivity (EC) levels of 0, 40, 45 and 50 dS/m and fifty seeds from each variety were soaked in the solutions for 9 and 12 days in petri dishes. Washed seeds were allowed to germinate under ambient temperature after completing the soaking period. The average temperature inside the laboratory during the study period was 27 ºC. Number of germinated seeds were counted for each variety in each replicate after 5 days.

Response to salt stress at seedling stage

The varieties were screened for salt tolerance in a hydroponic system using International Rice Research Institute (IRRI) standard protocol at seedling stage (Gregorio *et al*., 1997). Three replications were used in the experiment. The evaluation was performed using the nutrient solution proposed by Yoshida *et al*. (1976). The modified Standard Evaluation System (SES) was used in rating the visual symptoms of salt toxicity (IRRI, 1997). Initial and final scorings were performed 10 and 16 days after salinization.

Salt stress imposed at seedling stage up to harvesting

The varieties were evaluated for their tolerance to salinity in a pot experiment based on the performance of the mature plants under saline conditions. NaCl was added at the rates of 0, 6, 12 and 18 g per 5 kg soil pot to obtain the salinity levels of 0, 4, 8 and 12 dSm^{-1} respectively. Three weeks old rice seedlings of 22 varieties were planted at the rate of 3 plants per pot. Saturated moisture level was maintained in each pot throughout the growing season until maturity. The experiment was variety (22) X salinity levels (4), two factor factorial laid out in a CRD with three replications. Data were recorded for survival of plants per pot, plant height (PH), panicle length (PL), root dry weight (RDW), shoot dry weight (SDW), panicle weight (PW), panicle number per plant (PN) and grain yield per plant (GY).

Salt stress imposed at booting stage up to harvesting

The varieties were evaluated for their tolerance to salinity by using pot experiment to study the performance of the plants at booting stage under saline

conditions. Three weeks old rice seedlings of the above 22 varieties were planted as 3 plants per pot. At the booting stage NaCl was added at the rates of 0, 6, 12 and 18 g per 5 kg of soil pot to get the salinity levels of 0, 4, 8 and 12 dSm^{-1}, respectively. Saturated moisture level was maintained in each pot throughout the growing season until maturity. The experimental design was CRD with three replications. Data were recorded for survival plants per pot, PH, PL, RDW, SDW, PN, and GY.

Results and discussion

Response to salt stress at seed germination stage

Combinations of soaking periods and different salt concentrations were used to identify salinity tolerance level of 22 rice varieties at seed germination stage. Three way interaction effect of variety X soaking period X salt concentration and two way interaction effects of variety X soaking period, variety X salt concentration and soaking period X salt concentration were found to be significant at 0.01 probability levels. According to the mean separation, selected rice varieties can be categorized in to 6 groups with their response to salinity at the best combination of the 12 days of soaking and 50 dSm^{-1} salt concentrations. Highest germination percentage was observed in Bg 406 as compared to other varieties at all salt stress levels.

Response to salt stress at seedling stage

Based on the mean separation of score percentage of survival, varieties showed significant differences ($p<0.01$). According to the mean separation the varieties are categorized in to five levels of stress response. In this study of twenty two rice varieties, an improved variety At 402 was found to be highly tolerant to the 12 dSm^{-1} salt stress. It has shown 100% of survival score percentage. Also check variety, *Pokkali* and newly improved varieties, At 354 and Bg 369 were identified as salt tolerant varieties at the seedling stage according to mean separation and also showed 75% of score percentage after 10 days salinization.

Salt stress imposed at seedling stage up to harvesting

The analysis of variance showed that there is a very high significant difference among the salinity levels in to the varieties interactions for the parameters taken. The two way interaction effect of variety X salt concentration was significant with PH, PL, RDW, SDW, PW, PN, and GY. According to the cluster analysis, selected 22 rice varieties can be categorized in to six levels of tolerance. Range of the percentage reduction of the phenotypic traits at 8 dSm^{-1} and 12 dSm^{-1} salt concentrations after seedling stage up to maturity and their level of tolerance were presented in Table 1.

Salt stress imposed at booting stage up to harvesting

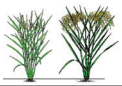
The two-way interaction effect of variety X salt concentration was significant with PH, PL, RDW, SDW, PN, GY and PS%. PH, PL, RDW, SDW, PN and GY of the tested varieties decreased with the increasing salt levels. In this experiment salinity induced at the booting stage while considering the age of the rice varieties. Influences of different salinity levels at reproductive stage on the phenotypic traits were highly significant beyond 8 dSm^{-1} salt stress. Analysis of variance indicated that the difference among varieties for the phenotypic traits were highly significant. According to the cluster analysis, selected 22 rice varieties can be categorized in to six levels of tolerance (Table 1).

Varietal Response to Salt Stress across the life cycle

According to the overall results of the varietal response in different stages of the life cycle Bg 406 is the only one newly improved variety, which is having better response for salt stress in all growth stages. As well as, At 402, Bg 369 and At 354 performed better beginning from seedling up to maturity. Therefore, those varieties can be identified as promising salinity tolerant varieties from the selected rice varieties.

The effect of salinity on rice may vary depending on the stage of its life cycle at which it is exposed to salinity. Several studies indicate that rice is tolerant to salinity during germination but young seedlings are sensitive (Flower and Yeo, 1981). Moormann and Breeman (1978) cited that the damage to the plant during transplanting increases its sensitivity to salinity. Further it is mentioned that the salt tolerance increases during tillering, but the plant again become sensitive during flowering.

Table 1. Varietal response to salt stress across the life cycle

Varieties	Salt stress imposed across the life cycle			
				
	Germination	**Seedling**	**At seedling stage up to harvesting**	**At booting stage up to harvesting**
At 307	S	HT	S	MS
At 308	S	S	S	MS
At 353	MS	MT	MS	T
At 354	MS	T	T	HT
At 362	S	S	S	HS
At 402	HS	HT	T	T
Bg 300	HS	S	HS	S
Bg 352	S	S	S	S
Bg 357	S	S	S	MS
Bg 358	MS	S	MS	S
Bg 359	S	S	MS	S
Bg 360	S	S	S	S
Bg 366	HS	S	MS	S
Bg 369	S	T	T	T
Bg 379-2	HS	MT	MS	MT
Bg 4-91	HS	S	MS	S
Bg 403	HS	MT	MS	HS
Bg 406	HT	MT	MT	T
Bg 450	MT	S	MS	S
Bg 94-1	S	S	MS	S
Ld 365	HS	S	S	S
Pokkali	T	T	HT	HT

HT T MT MS S HS

However, susceptibility to salt stress is most severe at the seedling and reproductive phases, eventually leading to significant reductions in grain yield and yield components. Zeng *et al*. (2001) found that the stage from the initiation of the third leaf to panicle initiation as the most sensitive to salinity in terms of seed yield. Thus, the spikelet number per panicle was more sensitive to salinity and it has shown a varietal variation as well. Some varieties were highly sensitive to salinity at the germination and early vegetative stages, but were tolerant at the reproductive stage. The others showed tolerance at germination but sensitivity at the subsequent stages (Heenan *et al*., 1988). However, Moradi *et al*. (2007) stated that tolerance of rice to salinity at the seedling stage is weakly correlated with tolerance at the reproductive stage.

Conclusion

According to the overall results of the varietal response in different stages of the life cycle, Bg 406 was categorized in moderately tolerant or highly tolerant throughout the life cycle. Varieties, At 402, Bg 369 and At 354 were categorized tolerant or highly tolerant after the germination stage. Therefore the varieties Bg 406, At 402, Bg 369 and At 354 can be identified as promising salinity tolerant varieties from the selected rice varieties.

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