Screening Some Modern Rice Cultivars for Submergence, Drought and Salinity Stress at Seedling Stage

PSB Weragodavidana, AL Ranawake, UGS Amarasingha, N Dahanayake
Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya

Abstract

Rice is grown in varied environmental conditions where it shows different levels of reaction to abiotic stresses, depending on the environmental conditions of origin and, cultivation. Drought and high salinity are the most important environmental factors that cause osmotic stress and dramatically limit plant growth and crop productivity. Submergence affects 15 million ha of low land rice growing areas in South and South East Asia. In Sri Lanka alone, rice lands with flash flooding exceed 25,000 - 40,000ha. In the present study 20 modern rice cultivars were evaluated for submergence, drought and salinity stress at seedling stage. An eperiment was carried out according to RCBD (Randomized complete block design) with four replicates and 20 plants per each replicate. Submergence, drought and salinity stresses were given separately at seedling stage and plant survival percentages were measured at the end of the experiment. Data were analyzed using SAS and correlation analysis was done for each pair of stress treatment. Findings of this study reveal the different levels of submergence, drought and salinity stress tolerances of these modern rice cultivars at seedling stage. The highest survival percentages at submergence (42%), drought (97%) and salinity (89%) stress were recorded by Bw 492, Bg 452, At 402 respectively. There is a positive correlation between drought and submergence tolerance and negative correlation between salinity and drought stress in modern rice cultivar at seedling stage.

Key words: At, Bg, Bw, Modern rice cultivars

Introduction

Rice has been adapted to tropical, sub tropical and temperate climates (Lattif et al. 2004). It is grown in uplands where very little water is required in seedling establishment stage like *chena* cultivation in Sri Lanka or direct sawing in southern Russia, and in low land, waterlogged soils as usually the case in lower river estuaries of south Asia. Rice cultivars affected by flooding in these areas have developed submergence tolerance. It is moderately tolerant to salinity where it is grown under seepage in coastal areas and moderately tolerant to soil acidity where it has been adapted to upper catchment areas of rivers with acidic soils developed due to excess run off, but rice is sensitive to chilling and does not acclimate to freezing (Reyes et al. 2006).

Drought is a major cause of yield loss in rain-fed rice (*Oryza sativa L.*), grown on over 40 million ha in Asia (Venupeasad et al. 2007) Rice is one of the widely cultivated cereals across diverse agroecological systems, so prone to high yield losses due to periodical droughts.

However, rice consumes about 90% of the freshwater resources in Asia used for agriculture (Bhuiyan 1992). About 80% of the world's rice is grown under irrigated (55%) and rain fed lowland (25%) ecosystems. Development of rice cultivars with less water requirement indirectly protects natural water resources.

Rice is better more drought tolerant, but this is a somewhat contradictory objective considering that rice is most commonly grown under flooded conditions.

Soil salinity constraints rice production and over 30% of the irrigated rice area in the world is affected by saline conditions due to irrational management and defective irrigation practices (Yeo and flowers 1984). Various methods such as soil reclamation, excessive irrigation, and soil drainage are used to minimize soil salinity; they are always laborious and expensive. Other strategies such as varietal improvement have to be done for constant and profitable rice production.

Almost one-third of world's rice lands are at a low elevation and rainfed, and a large proportion of it is prone to both drought and flash flooding. Submergence affects 15 million ha of low land rice growing areas in South and South East Asia. In Sri Lanka alone, rice lands with flash flooding exceed 25,000 - 40,000ha.

Considering all the factors discussed, development of abiotic stress tolerance in rice is timely needed. Evaluation of abiotic stress tolerance in some modern rice cultivars (submergence, salinity, and drought) was done in 32 traditional rice cultivars at Faculty of Agriculture, University of Ruhuna.

Materials and methods

In the present study 20 Sri Lankan modern rice cultivars were used. Those were At 303, At 306, At 307, At 308, At 353, At 354, At 362, At 401, At 402, At 405, Bg 250, Bg 38, Bg 300, Bg 305, Bg 359, Bg 379-2, Bg 360, Bw 351, Bw 364, Bw 452

Table 1: DMRT grouping of survival percentage of modern rice cultivars under submergence, salinity and drought stress

	Submergence stress	Salinity stress	Drought stress
At303	27.92 ^{abc}	58.45 ^{bcd}	16.806 ^{e}
At306	32.92 ^{abc}	54.02 ^{cd}	3.571 ^{f}
At307	7.50 ^{bc}	54.17 ^{cd}	28.532 ^{d}
At308	0	20.54 ^{e}	11.349 ^{ef}
At353	18.75 ^{bc}	19.64 ^{e}	33.194 ^{d}
At354	18.33 ^{bc}	56.39 ^{cd}	2.778 ^{f}
At362	2.5 ^{c}	47.27 ^{cde}	3.571 ^{f}
At401	8.57 ^{bc}	87.05 ^{ab}	3.125 ^{f}
At402	8.57 ^{bc}	89.45 ^{a}	9.921 ^{ef}
At405	17.50 ^{bc}	47.50 ^{cde}	74.167 ^{c}
Bg250	20.71 ^{abc}	50.00 ^{cd}	0
Bg38	40.65 ^{ab}	87.40 ^{ab}	0
Bg300	55.95 ^{a}	64.29 ^{abcd}	0
Bg305	41.67 ^{ab}	74.53 ^{abc}	0
Bg359	34.67 ^{abc}	43.82 ^{cde}	38.591 ^{d}
Bg379-2	6.25 ^{bc}	48.33 ^{cde}	7.143 ^{ef}
Bg360	0	59.24 ^{bcd}	37.351 ^{d}
Bw351	35.83 ^{abc}	69.17 ^{abc}	88.373 ^{ab}
Bw364	36.67 ^{abc}	58.4 ^{bcd}	84.276 ^{bc}
Bw452	42.22 ^{ab}	33.82 ^{de}	97.569 ^{a}

Table 2: Correlation analysis of each trait pair

Trait pair	Correlation coefficient	P value
Submergence-drought	0.1662	0.4837
Submergence-salinity	0.1117	0.6408
Drought-salinity	-03073	0.1875

Evaluation of rice cultivars for salinity tolerance

Dormancy broken (kept at 50 °C for 5 days) parental seeds were surface sterilized by dipping in 70% ethanol for 1 minute and in NaOCl solution for 1 hour, followed by washing in sterilized distilled water. Acceleration of uniform seed germination was performed by keeping surface-sterilized seeds at 35 °C for 6 days in distilled water. Germinated seeds were planted in trays (45 cm X 30 cm X 5 cm) filled with soil up to 3 cm depth according to randomized complete block design (RCBD) with 3 replicates and with 20 plants for each replicate. Equal volume (500 ml) of 5 dS/m saline solution was added to each and every tray at 2 Weeks after planting (2 WAP), 3 WAP and 4 WAP as 1st, 2nd & 3rd treatment. Electrical conductivity (EC) of soil solution was measured at each time. Equal volume of water was added to all the trays every other day. Plant survival percentage was recorded 10 days after 3rd salinity treatment. Plant survival percentage was measured at the end of the experiment.

Evaluation of rice cultivars for submergence tolerance

The experiment was carried out according to randomized complete block design (RCBD) with 4 replicates and with 20 plants for each replicate. Uniformly germinated seeds were planted in trays (60 cm X 90 cm) and maintained them under control growth conditions for 2 weeks. Two week old seedlings were subjected to incomplete submergence conditions for 14 days and control experiment was carried out all along the experiment period. In incomplete submergence conditions plants were flooded up to half of the full leaf length. After incomplete submergence plants were kept at normal growth conditions for two week period for recovery under de-submerged conditions. Plant survival percentage was recorded at the end of the experiment.

Evaluation of rice cultivars for drought tolerance

Seed dormancy was broken by keeping seeds at 50 °C for 5 days. Seed surface sterilization was done by dipping seeds in 70% ethyl alcohol for 2 minutes and dipping seeds in 5% Chlorex solution for 30 minutes. Finally seeds were washed out thoroughly by distilled water. Seed germination was done in incubator at 35 °C for 5 days under dark condition. Dormancy broken seeds were allowed to germinate at 35 °C and the germinated seeds were planted in plastic boxes (15 cm X 7.5 cm X 15 cm) filled with homogenized soil up to ¾ of the total depth according to randomized complete block design with 20 plants per replicate and four replicates for each cultivar. Water cut was done at two weeks after planting. Five days after 80% of the plants were completely withered plants were watered once again for recovery. Ten days after watering plants were evaluated according to survival percentage.

Data were analyzed using SAS. Correlation in between each pair of trait values was also analyzed.

Results and Discussion

The highest survival percentages at submergence (42%), drought (97%) and salinity (89%) stress were recorded by Bg 250, Bg 452, At 402 respectively. Among tested modern rice cultivars 5%, 20% and 60% rice cultivars recorded more than 50% survival rates under submergence, drought and salinity stress respectively. Bw 351, Bw 364, Bw 452 (all the tested Bw varieties) recorded more than 33% survival rate under each stress treatment and the same varieties were the best drought tolerant varieties (Table 1). However best submergence tolerant varieties (Bg 300, Bg 305, Bg 38) were drought susceptible according to the present study.

According to correlation analysis there was a weak positive correlation in between submergence tolerance and drought tolerance (Table 2). Recently it has been found that SUB1A mediates ABA responsiveness, thereby activating a cascade of stress responsive gene expression, thus mediating both submergence and drought tolerance through prevention of water loss from leaves and suppression of leaf elongation conserving carbohydrate reserves. This result is in agreement with our bio assay data where many cultivars those submergence tolerance were drought tolerance (except Bg 38, Bg 300, Bg 305) at the seedling stage. The pair wise correlation analysis showed 0.1662 of positive correlation in between drought tolerant and submergence tolerant rice cultivars in survival percentage but pair wise correlation of the survival percentage under submergence and salinity stress was not significant (Table 2). Controversially, the best three submergence tolerant rice cultivars (Bg 38, Bg 300, Bg 305) were drought susceptible. There was a negative correlation in between drought and salinity stress (Table 2). On the other hand the highest survival percentage under salinity stress was scored by At 402 (89.45 %). Its survival percentage under drought stress was only 9.9 % while its submergence tolerance is around 8.57%.

Findings of this study reveal the different levels of submergence, drought and salinity stress tolerances of some modern rice cultivars in Sri Lanka at the seedling stage. The level of abiotic stress tolerance and correlations of abiotic stress tolerance level reveals the presence of different abiotic stress tolerance mechanisms within different rice cultivars.

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