EVALUATION OF SALT TOLERANT CAPACITY OF SELECTED THREE RICE CULTIVARS BY PHYSIOLOGICAL CHARACTERS

Puvanitha, S[1*]. and Mahendran, S[1].
[1]Department of Agricultural Biology, Faculty of Agriculture, Eastern University, Sri Lanka
*spuvani@gmail.com

ABSTRACT

Rice is one of the most important cereal crops and is the staple food for the two-third of world population as well as in Sri Lanka. Rice is a salt–sensitive monocot in the family Poaceae. Currently, salinity is becoming a limiting environmental factor for rice production and it is more prevalent as the intensity of agriculture increases.This experiment was conducted to assess the effects of salinity on the leaf area index, relative water content and yield of selected rice cultivars. The growth of three rice cultivars namely; "Pachaiperumal", "Bg 370" and "BW 367" was evaluated for salinity tolerance. This experiment was conducted in plastic pots and was laid out in the Completely Randomized Design with two factors in a factorial arrangement. There were six treatments and each one was replicated four times. The leaf area index, relative water content and yield of the tested rice cultivars were significantly reduced by salt stress. Rice Cultivar "Pachaiperumal" showed the highest leaf area index (0.05) and relative water content (70.2%) while cultivar "Bg 370" showed the lowest leaf area index (0.01) and relative water content (48.3%) under saline condition.Salt stress has significantly reduced the yield of all the tested rice cultivars. Rice cultivar "Pachaiperumal" showed the highest yield (1.6 t/ha) and the lowest (0.6 t/ha) was recorded in "BW 367" under salt stressed condition. Hence, "Pachaiperumal'' was identified as the most salt tolerant rice cultivar among the tested ones which could be suggested for cultivation in the saline tracts of Batticaloa district.

Keywords: BG 370, BW 367, Pachaiperumal, Salt stress

INTRODUCTION

Batticaloa is one of the major rice growing areas in the Eastern Province of Sri Lanka. Farmers have been facing salt water intrusion into rice fields which causes reduction in rice production. This is largely due to the lagoon water contamination in irrigation system, global warming-induced sea level rise (IPCC, 2007) and increased evapotranspiration rates which bring greater amounts of salts to the soil surface and contribute to increased salinity levels in rice lands at present and in near future. Identification of salt tolerant varieties and development of management strategies are therefore very much essential important to reduce salinity impacts and enhance productivity from agricultural lands. This could be achieved by screening rice varieties for salinity tolerance and identification of traits associated with salt resistance which could be incorporated into breeding programmes to develop resistant varieties. The present study was aimed to investigate the effects of salt stress on the growth and yield of selected rice cultivars and to select the most salt tolerant rice cultivar among the tested ones which can thrive and produce well under saline environment.

MATERIALS AND METHODS

This experiment was conducted in the Yala 2016 on a farmer's field near to Eastern University which is located in the Batticaloa district of Sri Lanka. Rice (Oryza sativa L.) cvs. "Pachaiperumal", "Bg 360" and "BW 367" were used for this study. The certified rice seeds were collected from different sources ("Pachaiperumal" from the seed and planting material office, Vavuniya and "Bg 370" and "BW 367" from the government seed farm, Karadiyanaru). The seedlings were transplanted in plastic pots filled with soil collected from a saline tract of 'Pankudaveli' and the non-saline soil was collected from a nearby site. This experiment was carried out with six treatments and four replications and the treatments were as follows:

T_1 (S_0V_1) = "Pachaiperumal" rice cultivar grown in non - saline soil (Control).

T_2 (S_1V_1) = "Pachaiperumal" rice cultivar grown in saline soil.

T_3 (S_0V_2) = "Bg 370" rice cultivar grown in non-saline soil (Control).

T_4 (S_1V_2) = "Bg 370" rice cultivar grown in saline soil.

T_5 (S_0V_3) = "BW 367" rice cultivar grown in non-saline soil (Control).

T_6 (S_1V_3) = "BW 367" rice cultivar grown in saline soil

The experiment was laid out in the Completely Randomized Design with two factors (salinity * cultivar) in a factorial arrangement. The data were statistically analysed and the difference between treatment means was compared using DMRT.

Determination of Leaf Area Index

A number of five plants were randomly selected from each replicate of the treatments during the vegetative stage of the selected rice cvs. The leaf area was measured by a leaf area meter (Model LI-3000) and the leaf area index was calculated by using the following formula:

LAI (Leaf area index) = Leaf area / Land area

Determination of Relative Water Content (RWC)

Five leaves representing five plants were randomly collected from each replicate of the treatments of the selected rice cultivars during the vegetative stage. The RWC was determined as follows: Leaves were cut into discs (10 discs, each of one cm diameter) and were immediately weighed after the harvest to determine their fresh weight (FW). Leaf discs were immersed in distilled water in petri dishes for an hour. The discs were carefully wiped out with filter papers (What man No. 1) to remove the excess water on their surfaces. These discs were then weighed to determine the turgid weight (TW). The samples were dried at 80°C for 24 hrs to determine the dry weight (DW). RWC was calculated using the following formula:

RWC (%) = (FW-DW) / (TW-DW) x 100

Determination of Yield

Five plants were randomly selected from each replicate of the treatments of the selected rice cultivars at the end of the maturity stage. The grains were collected and their weights were recorded.

RESULTS AND DISCUSSION

Effects of salinity on the leaf area index of paddy leaves at vegetative stage

There were significant ($p<0.05$) differences between treatments in the leaf area index (LAI) of the selected rice cultivars during the vegetative stage. The LAI of the salt stressed rice cultivars were significantly lower than the control values.Rice cultivar “Pachaiperumal” showed the highest (0.05) LAI and the lowest (0.01) was recorded in “Bg 370” under saline condition. Decrease in LAI might have been due to decrease in leaf expansion in salinity stress condition. Khan et al., (2014) stated that the reduction in leaf area and leaf area index was attributed due to the increasing in leaf senescence and reduced size of leaves developed due to low turgor under saline and water stress conditions.

Table 01: effects of salt stress on the LAI of selected rice cultivars during the vegetative stage.

	Variety	Leaf Area Index
Non Saline	Pachaiperumal	0.07[a]
	Bg 370	0.04[c]
	BW 367	0.05[b]
Saline	Pachaiperumal	0.05[a]
	Bg 370	0.01[c]
	BW 367	0.02[b]
Salinity(S)		<.0001
Cultivar(V)		<.0001
Interaction (I)		<.0001

*Values with the same letter within the same column are not significant (p< 0.05) according to the Duncan Multiple Range Test at 5% significant level.

*Values are the means of 8 plants in 4 replications.

Effects of salinity on the Relative Water Content of paddy leaves at vegetative stage

There were significant ($p<0.05$) differences between treatments in the Relative Water Content (RWC) of leaves of the selected rice cultivars during the vegetative stage. In the treatments where the salt stress was imposed on plants, the RWC was significantly lower than the control values. Rice cultivar “Pachaiperumal” showed the highest (70.2%) RWC and the lowest (48.3%) was found in “Bg 370” under the saline condition. As pointed out by Munns and Tester, 2008 salinity alters plant water relations due to decreased availability of water from soil solution as a result of lowered osmotic potential. Changes in water relations of plants that are stressed by salinity could be seen in certain studies which confirmed that many plants undergo osmo-regulation when they are exposed to salt stress by increasing the negativity of the osmotic potential of the leaf sap (Rodriguez et al., 2005).

Water status is the main factor affecting the plants’ growth and development. Decreasing external water potential produces a net accumulation of solutes in cells, which lowers the cell osmotic potential necessary for maintaining the turgor pressure. Based on this observation, it could be stated that rice cultivar “Pachaiperumal” was able to maintain relatively high RWC than the other two cultivars under saline condition.

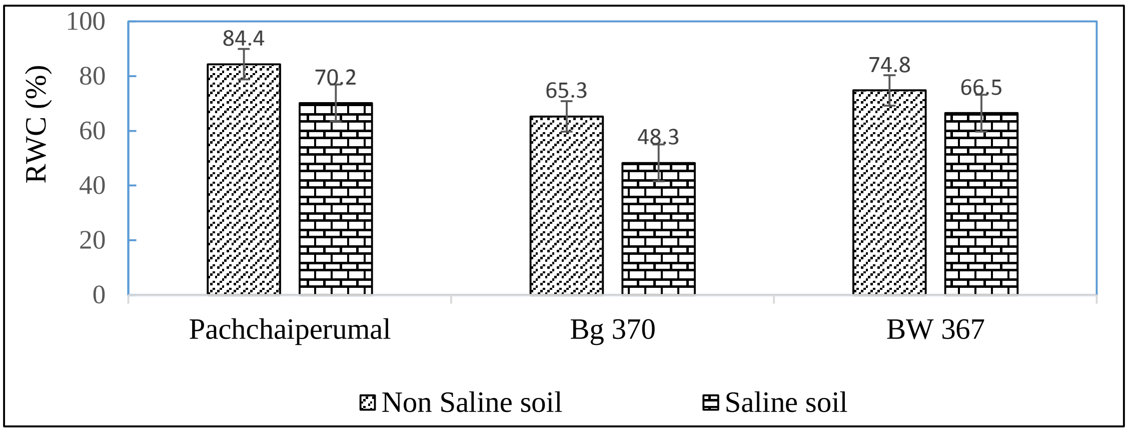

Figure 1: Effects of salinity on the RWC of selected rice cultivars during the vegetative stage

Effects of salinity on the yield of paddy at the ripening stage

Table 02: Effects of salt stress on the yield of selected rice cultivars.

	Variety	Yield (t/ha)
Non Saline	Pachaiperumal	2.2[a]
	Bg 370	1.9[b]
	BW 367	1.5[b]
Saline	Pachaiperumal	1.6[a]
	Bg 370	0.82[b]
	BW 367	0.6[b]
Salinity(S)		<.0001
Cultivar(V)		<.0001
Interaction (I)		<.0001

*Values with the same letter within the same column are not significant ($p < 0.05$) according to the Duncan Multiple Range Test at 5% significant level.

* Values are the means of 8 plants in 4 replications.

There were significant ($p<0.05$) differences between treatments in the yield of selected rice cultivars. Salinity has significantly ($p<0.05$) reduced the yield of all the tested rice cultivars. Rice cultivar "Pachaiperumal" showed the highest yield (1.6 t/ha) and the lowest (0.6 t/ha) was recorded in "BW 367" under salt stressed condition. Crop yield reduction in salt affected soils results primarily from alteration of various metabolic processes in plants under salinity stress (Eynard et al., 2005). When plants are grown under saline condition, as soon as new cell starts its elongation process, excessive salts modify metabolic activities of the cell wall causing deposition of various material which limit cell wall elasticity. Cell walls become rigid and turgor pressure efficiency in cell enlargement is decreased. The other causes for the reduction in yield could be the shrinkage of cell contents, reduced development and differentiation of tissues, imbalanced nutrition, damage of membrane and disturbed avoidance mechanism. The reduction in yield under saline condition was also due to reduced growth as a result of decreased water uptake, toxicity of sodium and chloride in the shoot cell as well as reduced photosynthesis (Ali et al., 2004). Salinity strongly reduced the tissue turgor as a result, the plant growth and development were directly inhibited, leading to low grain yield (Lauchli and Grattan, 2007). A significant reduction in grain yield per plant of rice cultivars under salt stress has earlier been reported by Nejad et al., (2010)

CONCLUSIONS

This experiment was conducted to determine the effects of salt stress on the leaf area index (LAI), relative water content (RWC) and the yield of selected rice cultivars. All the tested attributes were reduced under saline condition. Rice cultivar “Pachaiperumal” showed the LAI and RWC whereas the lowest were found in “Bg 370” under salt stressed condition. The highest yield was obtained in “Pachaiperumal” and the lowest was recorded in “BW 367” under saline condition. Hence, “Pachaiperumal” was identified as the most salt tolerant rice cultivar among the tested ones which could be suggested for cultivation in the salt prone tracts of the Batticaloa.

REFERENCES

Ali, Y., Aslam, Z., Ashraf, M.Y. and Tahir, G.R. (2004). Effects of salinity on chlorophyll concentration, leaf area, yield and yield components of rice genotypes grown under saline environment. International Journal of Environmental Science and Technology, 1 (3): 221-225.

Fabre, D., Siband, P. and Dingkuhn, M. (2005). Characterizing stress effects on rice grain development and filling using grain weight and size distribution. Field Crop Research. 92, 11-16.

IPCC (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change. 27th session of the IPCC in Valencia, Spain.

Khan, M.S.A., Al-Mamun,M.A.,Mahmud,M.A.,Bazzaz1,M.D., Hossain, A., Alam, M.S., Shamimuzzaman, M. and Karim, M.A.(2014).Effects of Salt and Water Stress on Leaf Production, Sodium and Potassium Ion Accumulation in Soybean. Journal of Plant Sciences, 2 (5): 209-214.

Lauchli, A. and Grattan, S.R. (2007). Plant growth and development under salinity stress. In: M.A. Jenks., P.M. Hasegawa and S.M. Jain (Eds.), Advances in Molecular Breeding toward Drought and Salt Tolerant Crops. pp. 1-32, Springer, Netherlands.

Munns, R. and Tester, M. (2008). Mechanisms of Salinity Tolerance, Annual Review of Plant Biology, 59: 651–681.

Nejad, G.M., Singh R.K., Arzani, A. Rezaie, A.M., Sabourid, H. and Gregono. G.B. (2010). Evaluation of Salinity Tolerance in Rice Genotypes. International Journal of Plant Production, 4:1735-8043.

Rodriguez, M., Canales, E. and Borras-Hidalgo, O. (2005). Molecular aspects of abiotic stress in plants. Biotechnology. Aplicada 22:1-10.

Zeng, L. and Shannon, M.C. (2000). Effects of Salinity on Grain and Yield Components of Rice at Different Seeding Densities. Journal of Agronomy. 92: 418-423.