International Journal of Agriculture and Nutrition
www.agriculturejournal.net
Online ISSN: 2664-6072; Print ISSN: 2664-6064
Received: 02-02-2019; Accepted: 03-03-2019; Published: 10-03-2019
Volume 1; Issue 2; 2019; Page No. 08-11

Salt tolerance screening of seven rice landraces

Muhammad Arshad Ullah[1], Muhammad Rasheed[2], Syed Ishtiaq Hyder[3], Raheel Babar[4]
[1, 3] Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan
[2] PMAS, Agronomy Department, University of Arid Agriculture, Rawalpindi. Punjab, Pakistan
[4] Forestry, Range, Watershed and Wildlife management, Baluchistan Agriculture College, Quetta, Pakistan

Abstract
Rice is grown on about one-tenth of the earth's arable land. It is the single largest source of food energy to more than half of the world population. Salinity confines the efficiency of production at the mature stage. Soil salinity decreases the plant growth rate and can harshly limit the crop production. Salinity tolerance differs extensively between species of plants and within species A pot study was conducted to evaluate the salt tolerance of rice varieties under different salinity cum sodicity levels [S_0=2.70dSm^{-1}+ 11.38 (mmol L^{-1})$^{1/2}$, S_1= 5.16dSm^{-1} +27.88 (mmol L^{-1})$^{1/2,}$ S_2= 6.15 dSm^{-1} +30.38 (mmol L^{-1})$^{1/2}$ and S_3= 6.78 dSm^{-1} +33.74 (mmol L^{-1})$^{1/2}$]. Seeds of seven rice varieties namely PB-95, SRI-12, T-05, No 1121, SRI-13, Basmati-515 and Shaheen Basmati were used for screening against salt tolerance in pots with different salinity cum sodicity combinations at green house of Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan during, 2017. Completely randomized deign was applied with three repeats. Data on grain yield were collected. This study showed significant differences in grain yield with seven rice varieties. At S_0 [2.40dSm^{-1}+ 11.38 (mmol L^{-1})$^{1/2}$] Basmati-515 rice variety gained the top position in grain yield (4.18 tha^{-1}) and the lowest position was attained by T-05 with grain yield (3.41 tha^{-1}). PB-95 produced the highest paddy yield (3.18tha^{-1}) and Shaheen Basmati attained grain yield (3.06tha^{-1}). All other rice under S_1 [5.106dSm^{-1}+27.88 (mmol L^{-1})$^{1/2}$] showed the lowest grain yield. Under S_2 [6.15dSm^{-1} +30.38 (mmol L^{-1})$^{1/2}$] PB-95 rice variety attained the highest grain yield (2.16 tha^{-1}). Rice line 1121 also received the least position (1.66tha^{-1}) in this salinity level. % decrease at S_2 over S_0 was indicated salt tolerance of rice varieties. PB-95 rice variety attained the lowest % decrease at S_2 over S_0 (45.17). PB-95 rice variety attained the highest grain yield (1.08tha^{-1}) at S_3 [6.78dSm^{-1} +33.74 (mmol L^{-1})$^{1/2}$]. Rice line 1121 also received the least position (0.62tha^{-1}) in this salinity level. % decrease at S_3 over S_0 was indicated salt tolerance of rice varieties. PB-95 rice variety attained the lowest % decrease at S_3 over S_0 (72.58). Therefore, this variety had the maximum salt tolerance than other rice varieties under this experiment.

Keywords: rice, PB-95, Sri-12, t-05, no 1121, sri-13, basmati-515, Shaheen basmati, saline- sodic, and grain yield

Introduction

Due to rapidly increasing population globally in every passing year will demand to attain 87% more production than today particularly rice, wheat, soybean and maize by 2050 [1]. Salt tolerance in rice is mainly determined by plant vigor [2]. Das *et al.* [3] found that rice plants control the salts transport initially through selective uptake with root cells and ions entering into the root along with water by symplastic and apoplastic routes. Rice production needs to continue increase in future decades to convene food demands due to population raise [4]. Slowly and steadily increasing sea levels are another promising basis of flood risk and areas ambient to estuaries receive more salts causing stresses for the crops especially rice [5, 6, 7]. Salinity resistance of rice is a necessary alternative to increase the food production as food demand being agricultural land is a limited source [8].

Anther culture, protoplast fusion and culture, leaf culture, root culture, immature embryo culture and mature seed culture are tissue culture techniques that are too important techniques for induction variations in plants [9, 10]. Plants respond to salinity in two phases. Growth inhabitation of young leaves is in first phase i.e. osmotic phase and second phase boosts senescence of mature leaves [11, 12, 13]. Salt Injury Score (SIS) was linked with sodium contents in shoot, not in the root, but the potassium contents in both shoot and root were not allied with (SIS). Therefore, leaves did not directly damage due to high potassium contents [14]. Endogenous proline accretion in plants with raised levels is associated with improved salt tolerance [15], and modulating antioxidant enzymes activities provoke oxidative stress tolerance [16].

Components of antioxidant defense systems in plants are affected by salt stress [80]. Accumulation of NACL in older leaves is due to longer salinity disclosure [17] which significantly affects the photosynthesis rate. It too disturbs the largely plant metabolism and repartees it [18, 19]. Rivero *et al.* [20] also stated that there are visual symptoms of salt toxicity in tomato plant when salinity stress is combined with heat stress. There are different screening methods for different stages of growth. Early seedling stage manifest on the first leaf, followed by the second, and finally on the growing leaf. Salinity suppresses leaf elongation and formation of new leaves [21, 22]. Salinity besides reduces growth parameters e.g. panicle length, number of primary branches and spikelets per panicle as well as production traits i.e. fertility and panicle weight and grain yield [23]. Still in some tolerant varieties, some spikelets are distorted or dropped off before good spikelets fertile [24].

Growth inhibition and production loss due to salinity induce both biochemical and physiological changes in rice crop [25]. Ansari *et al*. [26] found that sodium uptake is inversely proportional to potassium at higher salinity.

Materials and methods

A pot study was conducted to evaluate the salt tolerance of rice varieties under different salinity cum sodicity levels [S_0=2.70dSm^{-1}+ 11.38 (mmol L^{-1})$^{1/2}$, S_1= 5.16dSm^{-1} +27.88 (mmol L^{-1})$^{1/2,}$ S_2= 6.15 dSm^{-1} +30.38 (mmol L^{-1})$^{1/2}$ and S_3= 6.78 dSm^{-1} +33.74 (mmol L^{-1})$^{1/2}$].Seeds of seven rice varieties namely PB-95, SRI-12, T-05, No 1121, SRI-13, Basmati-515 and Shaheen Basmati were used for screening against salt tolerance in pots with different salinity cum sodicity combinations at green house of Land Resources Research Institute, National Agricultural Research Centre, Islamabad, Pakistan during, 2017. 10 Kg soil was used to fill each pot. 10 seeds of Ricet (*Oryza sativa*) were sown in each pot. Fertilizer was applied @65-55-45 NPK Kg ha^{-1}. Completely randomized deign was applied with three repeats. Data on grain yield were collected. Collected data were statistically analysed and means were compared by LSD at 5 % [29].

Results and disussions

Rice is grown on about one-tenth of the earth's arable land. It is the single largest source of food energy to more than half of the world population [2]. Rice genotypes show wide variations in salinity tolerance due to additive gene effects [3]. The effect of salinity on rice is many fold, leading to inhibition of germination, difficulties in crop area establishment, leaf area development, decrease in dry matter production, delay in seed set and also even sterility can occur [5]. Data presented in table-1 depicted significant differences in grain yield with seven rice varieties. At S_0 [2.40dSm^{-1}+ 11.38 (mmol L^{-1})$^{1/2}$] Basmati-515 rice variety gained the top position in grain yield (4.18 tha^{-1}) and the lowest position was attained by T-05 with grain yield (3.41 tha^{-1}). Salinity delays heading in rice, which negatively affects a number of yield components [14]. Salinity stress affects seed germination, seedling growth, leaf size, shoot growth, shoot and root length, shoot dry weight, shoot fresh weight, number of tillers per plant, flowering stage, spikelet number, percent of sterile florets and productivity [29].

PB-95 produced the highest paddy yield (3.18tha^{-1}) and Shaheen Basmati attained grain yield (3.06tha^{-1}). All other rice under S_1 [5.106dSm^{-1}+27.88 (mmol L^{-1})$^{1/2}$] showed the lowest grain yield. Table-1 also depicted very interesting data in % decrease at S_1 over S_0. The least % decrease in grain yield (18.68) was attained in SRI-13 rice variety which was very close to PB-95 showing the % decrease (19.28), therefore these two rice varieties showed minimum loss due to toxic effects of salinity cum sodicity. Increasing salinity and sodicity affected inverse on grain yield of these rice varieties as indicated in table-1. High salinity can lead to osmotic stress similar to physiological drought, and high salt deposition in soils makes plants increasingly difficult to acquire water and nutrients [26]. Growth differences among various genotypes in response to salinity are dependent on the salt concentration and the degree of salt tolerance [6.

Under S_2 [6.15dSm^{-1} +30.38 (mmol L^{-1})$^{1/2}$] PB-95 rice variety attained the highest grain yield (2.16 tha^{-1}). Rice line 1121 also received the least position (1.66tha^{-1}) in this salinity level. % decrease at S_2 over S_0 was indicated salt tolerance of rice varieties. PB-95 rice variety attained the lowest % decrease at S_2 over S_0 (45.17). Therefore, this variety had the maximum salt tolerance than other six oat varieties under this experiment. It has been well documented that the effect of salinity on seedling growth, seedling establishment, grain yield components such as spikelet number, tiller number has successively lead to a reduction in grain yield [5].

PB-95 rice variety attained the highest grain yield (1.08tha^{-1}) at S_3 [6.78dSm^{-1} +33.74 (mmol L^{-1})$^{1/2}$]. Rice line 1121 also received the least position (0.62tha^{-1}) in this salinity level. % decrease at S_3 over S_0 was indicated salt tolerance of rice varieties. PB-95 rice variety attained the lowest % decrease at S_3 over S_0 (72.58). Therefore, this variety had the maximum salt tolerance than other rice varieties under this experiment. Studies indicated that rice is more resistant at reproductive and grain filling than at germination and vegetative stages as well as low levels of salinity can increase the resistance of rice to higher and lethal salinity levels [9]. Grain yield of rice in salt affected soils is much lower because of its high sensitivity to salt stress [30]. Grain yield and shoots, 100 seeds weight, tiller number, root dry weight and K^+ uptake in seeds and shoot significantly decreased with increasing salinity [24].

Table 1: Screening of rice (*Oryza sativa*) varieties/ advance lines in saline- sodic soil (Grain yield tha^{-1})

Varieties /lines	S_0	S_1	%decrease at S_1over S_2	S_2	%decrease at S_2over S_0	S_3	%decrease at S_3 over S_0
PB-95	3.94ab	3.18a	19.28	2.16a	45.17	1.08a	72.58
SRI-12	3.69de	2.85c	22.76	1.95abc	47.15	0.86bc	76.69
T-05	3.41e	2.64c	22.58	1.81cd	46.92	0.77bcd	77.41
1121	4.06ab	1.94d	57.21	1.66e	59.11	0.62d	84.72
SRI-13	3.64cd	2.96b	18.68	1.91bc	47.52	0.84ab	76.92
Basmati-515	4.18a	2.05d	50.95	1.68de	59.85	0.65cd	84.44
Shaheen Basmati	3.91bc	3.06ab	21.73	2.68ab	46.80	0.91ab	76.22
LSD	0.24	0.16	--------	0.13	-----	0.21	-------

S0= [2.4 dSm-1 +11.38(mmol L-1)1/2] S1= [5.16 dSm-1 + 27.88(mmol L-1)1/2] S2= [6.15 dSm-1 +30.38 (mmol L-1)1/2] S3= [6.78 dSm-1 +33.74(mmol L-1)1/2]

Conclusion

PB-95 rice variety received the highest position in three salinity level. % decrease at all salinity levels showed the least among other varieties. PB-95 rice variety showed the maximum salt tolerance.

References

1. Kromdijk J, Long SP. One crop breeding cycle from starvation? How engineering crop photosynthesis for rising CO_2 and temperature could be one important route to alleviation. Proc Royal Soc B: Biol Sci. 2016; 283:2015-2578.
2. Platten JD, Egdane JA, Ismail AM. Salinity tolerance, Na+ exclusion and allele mining of *HK*T1;5 in Oryza sativa and O. glaberrima: Many sources, many genes, one mechanism? BMC Plant Biol, 2013; 13:32.
3. Das P, Nutan KK, Singla-Pareek SL, Pareek A. Oxidative environment and redox homeostasis in plants: Dissecting out significant contribution of major cellular organelles. Front Environ Sci. 2015; 2:70.
4. Ziska LH, Gealy DR, Burgos N, Caicedo AL, Gressel J, Lawton-Rauh, AL, *et al*. Weedy (Red) rice: an emerging constraint to global rice production. Chapter Three-Weedy (Red) Rice: An Emerging Constraint to Global Rice Production," Advances in Agronomy, 2015; 129:181-228.
5. Smajgl A, Toan TQ, Nhan DK, Ward J, Trung NH, Tri LQ, Tri V PD, Vu PT. Responding to rising sea levels in the Mekong Delta, Nature Climate Change. 2015; 5(2):167-74.
6. Dang LE, Bruwer J, Nuberg. Farmers' perceptions of climate variability and barriers to adaptation: lessons learned from an exploratory study in Vietnam, Mitigation and adaptation strategies for global change. 2014; 19(5):531-48.
7. Conway D, Mustelin J. Strategies for improving adaptation practice in developing countries, Nature Climate Change. 2014; 4(5):339-42.
8. Laik R, Sharma S, Idris M, Singh AK, Singh SS, Bhatt BP. Integration of conservation agriculture with best management practices for improving system performance of the rice–wheat rotation in the Eastern Indo-Gangetic Plains of India, Agriculture, Ecosystems & Environment. 2014; 195:68-82.
9. Zinnah KMA, Zobayer N, Sikdar SU, Liza LN, Chowdhury MAN, Ashrafuzzaman M. In vitro regeneration and screening for salt tolerance in rice (*Oryza sativa* L.). Int Res J Biol Sci. 2013; 2:29-36.
10. Chachar NA, Chachar SD, Chachar Q, I Keerio MI, Shereen A, Chachar MH. Screening for salt tolerant rice (*Oryza sativa* L.) genotypes at early seedling stage, Journal of Agricultural Technology. 2014; 10(1):265-75.
11. Campbell MT, Kencht AC, Berger B, Brien CJ, Wang D, Walia H. Integrating image-based phenomics and association analysis to dissect the genetic architecture of temporal salinity responses in rice," Plant physiology. 2015; 168(4):1476-89.
12. Bac-Molenaar JA, Vreugdenhil D, Granier C, Keurenties JJ. Genome-wide association mapping of growth dynamics detects time-specific and general quantitative trait loci," Journal of experimental botany. 2015; 66(18):5567-5580.
13. Brown TB, Riyan C, Xavier RRS, Tepsuda R, Kevin DM, Martin T, Robert TF, Murray B, Barry JP, Justin OB. Trait Capture: genomic and environment modelling of plant phenomic data, Current opinion in plant biology. 2014; 18:73-9.
14. Oosterhuis, DM, Loka DA, Kawakami EM. The physiology of potassium in crop production, Advances in Agronomy. 2014; 126:203-33.
15. Sripinyowanich S, Klomsakul P, Boonburapong B, Bangyeekhun T, Asami T, Gu HY, *et al.* Exogenous ABA induces salt tolerance in indica rice (*Oryza sativa* L.): The role of *OsP5CS1* and *OsP5CR* gene expression during salt stress tolerance in indica rice (*Oryza sativa* L.). Environ Exp Bot. 2013; 86:94-105.
16. Saeedipour S. Relationship of grain yield, ABA and proline accumulation in tolerant and sensitive wheat cultivars as affected by water stress. Proc Natl Acad Sci USA. 2013; 83(3):311-315.
17. Hasanuzzaman M, Alam MM, Rahman A, Hasanuzzaman M, Nahar K, Fujita M. Exogenous proline and glycine betaine mediated upregulation of antioxidant defense and glyoxalase systems provides better protection against salt-induced oxidative stress in two rice (*Oryza sativa* L.) varieties. Biom Res Int, 2014, 1-17.
18. El Mokhtar SM, Abdoulaye S, Abdallahi OM, Ali OMSB, Taleb KOD. Effect of different levels of salinity on germination and early seedling growth of three rice varieties cultivated in Mauritania, International Journal of Agriculture and Crop Sciences. 2015; 8(3):346.
19. Deinlein U. Plant salt-tolerance mechanisms, Trends in plant science. 2014; 19(6):371-9.
20. Bhusan D, Debasish KD, Mahmud H, Yoshiyuki M, Md. AH. Improvement of salt tolerance in rice (*Oryza sativa* L.) by increasing antioxidant defense systems using exogenous application of proline, Australian Journal of Crop Science. 2016; 10(1):50.
21. Fan W, Deng G, Wang H, Zhang H, Zhang P. Effect of different potassium levels on the growth and photosynthesis of sweet sorghum seedlings under salt stress, Advances in Energy, Environment and Materials Science: Proceedings of the International Conference on Energy, Environment and Materials Science (EEMS 2015), Guanghzou, PR China, August, 2015, 25-26.
22. Rivero RM, Mestre TC, Mittler R, Rubio F, Garcia-Sanchez F, Martinez V. The combined effect of salinity and heat reveals a specific physiological, biochemical and molecular response in tomato plants, Plant, cell & environment. 2014; 37(5):1059-73.
23. Arsa I, Ariffin GB, Aini N, Lalel HJD. Evaluation of Grain Yield and Aroma of Upland Rice (Pare Wangi Var.) as Response to Soil Moisture and Salinity, Current Agriculture Research Journal. 2016; 4(1):35-46.
24. Céccoli G, Bustos D, Ortega LI, Senn ME, Vegetti A, Taleisnik E. Plasticity in sunflower leaf and cell growth under high salinity, Plant Biology. 2015; 17(1):41-51.
25. Thitisaksakul M. *et al.* Effects of timing and severity of salinity stress on rice (*Oryza sativa* L.) yield, grain composition, and starch functionality, Journal of agricultural and food chemistry. 2015; 63(8):2296-2304.
26. Sánchez B, Rasmussen A, Porter JR. Temperatures and the growth and development of maize and rice: a review, Global change biology. 2014; 20(2):408-17.

27. Ali MN, Ghosh B, Gantait S, Chakraborty S. Selection of rice genotypes for salinity tolerance through morpho-biochemical assessment. Rice Sci. 2014a; 21:288-298.
28. FAO. Extent of salt affected soils. http://www.fao.org/ soils-portal/soil-management/management-of-someproblem-soils/salt-affected-soils/more-information-on-salt- affected-soils/en/ [last accessed 03 December 2014].
29. Analysis of Experiments (5th Ed.) John Willey and Sons, New York, USA, 2001, 64-65.
30. Gupta B, Huang B. Mechanism of salinity tolerance in plants: Physiological, biochemical, and molecular characterization. Int J Genom. 2014; (1):1-18.