RESEARCH ARTICLE

EVALUATION OF RICE GENOTYPES FOR TOLERANCE AGAINST SOIL SALINITY IN-VITRO

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ARTICLE DETAILS

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ABSTRACT

The research conducted in the laboratory includes four different types of concentration of salt. The highest germination percentage was recorded with Gorakhnath followed by Jyoti Ankur and Paddy Jk with almost all solution. The highest dry weight shoot was observed on Paddy Jk and on Gorakhnath at treatment level 10gm and Jyoti Ankur and Ramdhan showed negligible growth. The highest fresh root weight was observed on Paddy Jk at all treatment level while Ramdhan showed lowest fresh weight. At dry weight of root, Paddy Jk and Gorakhnath showed highest dry weight while Sabitri and Ramdhan showed negligible growth at treatment 10gm of salt solution. And at last at root shoot ratio the highest growth was observed on treatment level 10gm salt solution because at stress condition root performs better. Thus, this reveals the germination performance of Rice (*Oryza sativa*) seedlings in saline condition was better with Gorakhnath followed by Paddy Jk variety while seedlings growth and development with Ramdhan was seen to be lowest. Similarly, the better performance was observed on control condition while the least performance on treatment 10gm of salt solution.

KEYWORDS

Rice, Salinity, Germination, Root and shoot.

1. INTRODUCTION

Rice, a monocot, is normally grown as an annual plant, although in tropical areas it can survive as a perennial and can produce a Ratoon crop for up to 30 years (IRRI, 2009). Rice is considered as a most important food grain crops under a wide range of climatic, geographic and edaphic growth condition. Rice is the seed of grass species *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). Out of total arable land area rice dominates the country's crop sector accounting for over 42.5% (168,047) under food grains and shares 51.6 percent in total food grain production (MOAD, 2017). Rice is a cereal grain which is most widely used as staple food for more than 3.5 billion people in the world (CGIAR, 2016). The approximate annual production of rice (milled) is 480 million mt with India and China accounting to produce half of it (Muthayya et al., 2014). Rice can be grown practically anywhere, even on a steep hill or mountain area with the use of water-controlling terrace systems.

Rice is not only a key source of food but also a major employer and source of income for the Nepalese people with its dietary contribution of about 50% (Prasai et al., 2013). Out of total cultivated land, 1.55 million ha comes under rice with production of 5.23 million ton and average productivity of 3.36 t/ha making about 16.33% contribution in AGDP (MoAD, 2017). Rice is the agricultural commodity with the third-highest worldwide production (FAOSTAT, 2018). Traditional farming, lack of proper irrigation system, lack of transport and market, poor economic condition, lack of research activities are the main reasons for low production of rice in Nepal. Researches carried out in rice have clearly revealed that its production in Nepal is lower as compared to other developed countries.

Various factors are witnessed to limit rice production in Nepal such as gender conflicts, lack of resources, shortage of labor, environmental extremes, biotic stress and edaphic differences (Basnet, 2017). Among various factors, edaphic stress is also an important one especially salinity. Rice is grown several coastal regions of world affected by salt stress (Mass et al., 1986).

Soil salinity is a measure of the minerals and salts that can be dissolved in water (Artiola, 2019). Salinity is the saltiness or amount of salt dissolved in a body of water, called saline water. Soil salinity is the term used to designate a condition in which the soluble salt content of the soil reaches a level harmful to crops (Childs & Hanks, 1975). Soil salinity is the salt content in the soil; the process of increasing the salt content is known as salinization (SADM). Salinity can be caused by natural processes such as mineral weathering or by the gradual withdrawal of an ocean. It can also come about through artificial processes such as irrigation and road salt. Soil salinity levels vary widely from one environment to another (Paul, 2017). Soil salinity is a major concern to agriculture all over the world because it affects almost all plant functions that limit agriculture production (Chowdhury, 2019).

A saline soil is generally defined as one in which the electrical conductivity of the saturation extract in the root zone exceeds 4 dSm⁻¹ (approximately 40 mM NaCl) at 25 °C and has an exchangeable sodium of 15%. Soil salinity can be measured in terms of its electrical conductivity (EC); the SI unit of which is decisiemens per meter (dSm⁻¹). The yield of most crop plants is reduced at this EC, though many crops exhibit yield reduction at lower EC (Munns, 2005; Jamil et al., 2007). Soil salinity is one of the abiotic stresses

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that constrain crop growth in the extensive coastal regions (Paliwal, 2018). The influence of initial soil salinity on crop growth depended upon the crop type and irrigation management (Childs, 1975). High concentrations of soluble salts lower the pH and may limit plant growth, in some cases by more than 90%. (D. Kalev, 2018).

Salinity from irrigation can occur over time wherever irrigation occurs, since almost all water (even natural rainfall) contains some dissolved salts (ILRI, 1989). The total global area of salt affected soils has recently been estimated to be 830 million hectares of which about 20 % salt affected are those of irrigated lands. Salinity often reduces shoot growth more than root growth. Soil salinity is the most severe factor that affects the growth of plants. Rice is one of the most salt sensitive field crops including sign of stress, wilting, and dull leaves. Rice grown under saline soils show reduction in growth, morphological characteristics and production. Soil salinity changes the fertile land to unproductive land, which ultimately results in economic loss (Imadi, 2016). Its height, root length, emergence of new roots, and dry matter decrease significantly at EC (electrical conductivity) 5-6 dSm⁻¹ (Pearson et al., 1966, Akbar & Yabuno, 1974). Rice genotypes of varying tolerance (tolerant, semi-tolerant and sensitive) were screened in saline soil. Vegetative growth events were less affected by both the stresses in comparison to reproductive stage (Rathore, 2008). Soil salinity can have a major effect on the structure of soils (Sparks, 2003).

2. MATERIALS AND METHODS

The experiment entitled "Evaluation of rice genotypes for tolerance against soil salinity in-vitro" was carried out at the laboratory of NPI from July 14, 2019 in the petri-disc to know the germination characteristics of rice on different germination media. The materials and methodology used in the study are described below:

2.1 Seed collection

Five different varieties of rice were collected from Institute of Agriculture and animal science, Rampur.

Table 1: Seven different varieties	
S.N.	Variety
1.	Jyoti Ankur
2.	Paddy JK
3.	Sabitri
4.	Ram dhan
5.	Gorakhnath

2.2 Research design

The experiment was conducted in Complete Randomized Block Design with Four treatments and three replications. The Four treatments were the application of three different concentration of salt solution and one in controlled condition:

- 0
- 42mmol/l
- 84mmol/l
- 168mmol/l

2.3 Calculations

Firstly, distilled water was taken, and solutions of various concentrations were prepared. For preparing 42mmol/l solution of sodium chloride 2.5gm of NaCl was mixed with 1000 ml of distilled water. Similarly, to make 84mmol/l solution 5gm of NaCl was mixed in 1000ml of distilled water and at last to make 168mmol/l solution 10gm of NaCl was mixed with 1000ml of distilled water. And this mixed solution was kept left for 1 day and the other next day we made a solution of 1000ml and kept in a flask for regular use. According to the design of the experiment, 9 cm diameter Petri disc was filled with two germination papers to retain the moisture for germination of the rice seeds of respective varieties. 30 seeds of each variety were placed in each petri dish according to the treatment and replication. 10 ml of the prepared salt solution was applied to each Petri disc in each day according to the treatment. Seeds were allowed to germinate in each Petri disc. Number of seeds germination were:

$$GE (\%) = \frac{\text{number of germinated seeds}}{\text{Total number of seed tested}} \times 100$$

Total number of seed tested

2.4 Research Detail

Different varieties of rice were treated with common salt (NaCl) in different beaker for about 10 minutes then thoroughly washed many times using distilled water spread over the blotting paper to absorb the moisture. The 60-petri plate were taken and washed them. The filter papers were cut and placed it in each petri plate of their size. 20 petri plate were arranged in each replication tray on complete randomized design. Seeds were filled in petri plate on July12, 2019. Solution of Sodium chloride and distilled water had given once a day throughout the research period via test tube. The solution was sprayed at the date of July14, 2019. Observation was taken in each seed of every treatment and replication. The data were collected on different parameters during research period. The Parameters are Germination percentage (%), Stem length(cm), root length(cm), Shoot weight(gm), Root weight(gm), Shoot dry weight(gm), Root dry weight(cm).

3. RESULT AND DISCUSSION

In this experiment we obtained variable results for different level of salinity induced by application of salt. Different varieties responded variably to the applied levels of salinity. Table below gives the overall performance of varieties in the experiment and the level of significance for varieties. Also, it presents the germination and parameters of different varieties for early establishment of varieties in given conditions.

Table 2: Performance of varieties in the experiment and the level of significance for varieties							
Varieties	Germination %	Root weight	Root Dry weight	Shoot weight	Shoot Dry Weight	Root length	Shoot length
Jyoti Ankur	80 ^b	0.36 ^a	0.19 ^{ab}	0.32 ^a	0.26 ^a	3.66 ^a	3.13 ^a
Paddy Jk	76.66 ^b	0.53 ^a	0.24 ^{ab}	0.30 ^a	0.83 ^b	3.52 ^a	3.06 ^a
Sabitri	73.33 ^b	0.49 ^a	0.33 ^a	0.30 ^a	0.37 ^a	1.60 ^b	2.73 ^a
Ram dhan	40 ^c	0.42 ^a	0.09 ^b	0.32 ^a	0.17 ^{ab}	2.23 ^{ab}	3.13 ^a
Gorakhnath	90 ^a	0.38 ^a	0.07 ^b	0.32 ^a	0.08 ^b	2.82 ^{ab}	3.13 ^a
Mean	21.9	0.43	0.17	0.31	0.17	2.77	3.04
CV	12.61	47.21	103.49	47.09	102.3	66.52	19.58
LSD	2.27					1.52	0.49
SEM	7.63	0.04	0.03	0.02	0.03	3.39	0.35
F-stat	***	Ns	Ns	Ns	*	***	Ns

Note: SEM= Standard Error of Mean, LSD= Least Significant Difference, CV%=Percentage of Coefficient of Variance.

The above table explained about the mean obtained from the different varieties. The research revealed the fact that the effects of different germination on the germination percentage to be highly significant. Highest germination percentage was seen on the Gorakhnath and lowest germination percentage was seen on Ramdhan. Similarly, the effect of root weight was obtained to be non-significant. Highest root weight was seen on Paddy Jk and lowest root weight was obtained in Jyoti Ankur. Highest root dry weight was recorded in Sabitri and lowest root dry weight was seen in Ramdhan and the result was non-significant. And in another parameter Shoot weight highest value was obtained in Gorakhnath and Jyoti Ankur and lowest have found in Sabitri. Highest shoot dry weight was obtained in Paddy Jk and lowest was obtained in Gorakhnath and the result was significant. In next parameter i.e Root length, highest value was obtained in Jyoti Ankur and lowest was seen in Sabitri and the result was to be significant. And the highest shoot length was recorded in Gorakhnath and in Jyoti Ankur and lowest was obtained in Sabitri.

3.1 Germination percentage (GE%)

Figure 1: Effect of salinity stress on germination energy (%) of different rice varieties

Percentage of seed germinating in a given period of time is known as germination and energy. Germination percentage was taken after 3DAS and above figure shows there was reduction in germination energy with an increase in salt concentration. At controlled condition varieties i.e. Jyoti Ankur, Paddy Jk, Sabitri and Gorakhnath showed higher germination energy and Ramdhan showed lower germination growth. And at salinity level of 2.5gm, the other four varieties showed higher germination percentage while Ramdhan showed lower germination percentage. And at salinity level i.e. 5gm, again Gorakhnath showed higher germination percentage and Ramdhan showed lower germination percentage. At salinity level i.e. 10gm, Gorakhnath showed higher germination percentage while Ramdhan showed lower germination percentage. These results are matched with the work of Karim, (1992) and Khan, (1997) who described germination process delays with salinity. Folkard, (2001) reported that salinity delayed germination in rice with increasing salt stress.

3.2 Radicle length

Figure 2: Effect of salinity stress on radicle length of different rice varieties.

Radicle lengths of all the rice varieties were decreasing in order which is clearly shown by figure 3. Radicle length was recorded after 12 days of germination. At control condition, paddy Jk had longer radicle length with less difference to Jyoti Ankur while Sabitri showed lesser radicle length. At salinity condition i.e. 2.5 gm, Jyoti Ankur had longer radicle length than all other varieties. At salinity condition i.e. 5gm, longer radicle length was observed in Gorakhnath and Jyoti Ankur was observed to have lowest radicle length. At salinity condition i.e. 10gm, longer radicle length was observed in Ramdhan with less difference with other varieties. At all treatments level, the shortest radicle length was observed in Sabitri. From this above figure, we can say that Paddy Jk and Jyoti Ankur is salt tolerant variety on the basis of radicle length. Jamil, observed that radicle length was decreased with increasing salt stress in his experiment 'Response of transgenic rice at germination and early seedling growth under salt stress (Jamil, 2007).

3.3 Plumule length

Figure 3: Effect of salinity on plumule length (cm) of different rice varieties

Plumule length of all the varieties decreased with the increase in salinity level as shown in figure. The effects of each treatment was observed in each variety. At control condition, the longest plumule length was observed in Jyoti Ankur with less difference with Gorakhnath and the shortest shoot length was observed in Sabitri. At salinity level i.e. 2.5gm, Paddy Jk showed longest shoot length and shortest shoot length was observed in Sabitri. At salinity level i.e. 5gm, longest shoot length was recorded in Gorakhnath while shortest shoot length was observed in Jyoti Ankur. At salinity level i.e. 10gm, Ramdhan showed higher longest shoot length with less significant differences with others varieties. Reduction of

seedling height is commonly observed for most of the plants grown in saline condition (Hakim et al., 2009; Anbumalarmathi et al., 2013).

3.4 Root shoot ratio

Figure 4: Variation in root/shoot ratio of Rice varieties under saline condition

Mean comparison of the root shoot ratio of the different varieties is shown above in the figure. Above figure shows that the treatment 10gm showed the highest root shoot ratio because at salt stress condition root performs a better result. At control condition, Paddy Jk showed highest root shoot ratio which is followed by Gorakhnath. At saline condition, i.e. 2.5gm Paddy Jk showed highest root shoot ratio while Ramdhan showed lowest root shoot ratio. At saline condition i.e. 5gm, again Paddy JK showed highest root shoot ratio followed by Gorakhnath while Ramdhan showed lowest root shoot ratio. At saline condition i.e. 10gm, Gorakhnath showed highest root shoot ratio followed by Paddy Jk and Jyoti Ankur with lowest root shoot ratio.

3.5 Shoot Fresh Weight

Figure 5: Mean fresh shoot weight of different rice varieties under different treatments

Fresh shoot weight is a weight of plant when you harvest it immediately. Fresh weight was observed after the plant is harvested and the shoot parts were separated from its root parts. At controlled condition, Ramdhan showed highest weight with less difference with other variety while Sabitri was recorded least shoot weight. At salinity condition i.e. 2.5gm, Sabitri showed highest shoot weight while lowest shoot weight was recorded in Jyoti Ankur and in Ramdhan. At salinity condition i.e. 5gm, Sabitri showed highest shoot weight while Jyoti Ankur and Paddy Jk showed lowest shoot weight. At salinity condition i.e. 10gm, Gorakhnath showed highest fresh shoot weight while lowest was observed in Jyoti Ankur with less difference with Ramdhan. From this above figure we can say that Gorakhnath has salt resistance tolerance than other varieties.

3.6 Shoot Dry Weight

Figure 6 : Mean dry weight of shoot of different rice varieties under different treatments

Dry weight is the actual weight without any water content on particles. The weight of any plant part after all its water content has been removed by drying is called Dry weight. This method is typically used to estimate a plant yield but it is also an accurate measure of plant biomass. From the above figure, at control condition highest dry weight was observed in Jyoti Ankur with less difference with Sabitri while lowest dry weight was observed in Ramdhan. At salinity condition i.e. 2.5gm, highest dry weight was observed in Sabitri and lowest dry weight in Ramdhan. At salinity condition i.e. 5gm, highest dry weight of shoot was observed in Sabitri and Gorakhnath showed lowest weight of dry shoot. At salinity condition i.e. 10 gm, highest shoot dry weight was observed in Paddy Jk while lowest shoot dry weight was observed in Sabitri and negligible growth in Jyoti Ankur and in Ramdhan.

3.7 Root Fresh Weight

Figure 7: Mean fresh root weight of different rice varieties under different treatments

Root weight is the most important parameter for determining the tolerance level of varieties under saline condition. Above figure shows the mean fresh root weight of different varieties. Root fresh weight recorded immediately after the plant is harvested. At control condition, highest root weight was observed in Paddy Jk while least fresh root weight was observed in Jyoti Ankur. At salinity condition i.e. 2.5gm, Paddy Jk weight showed highest root weight and lowest root weight was observed in Ramdhan. At salinity condition i.e. 5gm, highest fresh root weight was observed in Paddy Jk while lowest fresh root weight was observed in Jyoti Ankur and in Ramdhan. At salinity condition i.e. 10gm, highest fresh root weight was observed in Paddy Jk and lowest fresh shoot weight was observed in Ramdhan. So here, Paddy Jk have highest salt tolerant among other varieties.

3.8 Root Dry Weight

Figure 8: Mean Dry root weight of different rice varieties under different treatments

Mean comparison of the root dry weight of the different varieties is shown in figure. Above figure shows at control condition Paddy Jk showed highest dry root weight while Ramdhan showed least dry root weight. At salinity condition i.e. 2.5gm, highest dry root weight was observed in Paddy JK and Sabitri and least dry root weight was observed in Ramdhan. A salinity condition i.e. 5gm, Paddy Jk showed highest dry root weight while Ramdhan showed least dry root weight. At salinity condition i.e. 10gm, highest dry root weight was observed in Gorakhnath while least dry root weight was seen in Jyoti Ankur. And Ramdhan and Sabitri showed negligible value.

4. CONCLUSION

Salinity is one of the major problems causing huge loss in Rice crop production. The present study was focus to identify the best variety among different treatments and to produce healthy and viable seedlings of rice.

This experiment showed that with increased concentration of salt there was reduction in germination, root and shoot biomass and their length whereas root/shoot ratio was increased. Lowest speed of germination, plumule and radicle length, root shoot weight was at highest level of salt concentration for all the varieties. Among the tested varieties Gorakhnath and Paddy Jk showed comparatively higher salt tolerance.

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REFERENCES

- Akbar, M., Yabuno, Y., 1974. Breeding for saline-resistant varieties of rice. II. Comparative performance of some rice varieties to salinity during early developing stages. *Jap. J. Breed.*, 25, Pp. 176-181.
- Anbumalaramathi, J., Mehta, P., 2013. Effect of salt stress on germination of indica rice varieties. In: www.ejarr.com/volumes/vol6/EJBS_6_01.pdf.
- Basnet, B.S., 2017. Rice and food security: Serious constraints. *The Himalayan Times* (Daily edition), 26 June [online]. Available at: <https://thehimalayantimes.com/opinion/rice-food-security-serious-constraints/>.
- CGIAR, 2016. The global staple. <http://ricepedia.org/rice-as-food/the-global-staple-rice-consumers>
- Childs, S.W., 1975. Soil salinity effects on crop growth. *Alliance of crop, soil and environment science societies*
- Chowdhury, S., 2019. Organic Amendments For Mitigating Soil. *Research in Agriculture, livestock and fisheries*.
- FAOSTAT. 2018. Food and Agriculture Organization, Corporate Statistical Database (FAOSTAT). Retrieved December 1, 2019.
- Folkard, A., Wopereis, M.C.S., 2001. Responses of field-grown irrigated rice cultivars to varying levels of floodwater salinity in a semi-arid environment. *Field Crop Res*, 70, Pp. 127-137
- ILRI. 1989. Effectiveness and Social/Environmental Impacts of Irrigation Projects: a Review, In: *Annual Report 1988 of the International Institute for Land Reclamation and Improvement (ILRI)*, Wageningen, The Netherlands, Pp. 18-34.
- Imadi, S.R., 2016. Phytoremediation of Saline Soils for Sustainable Agricultural Productivity.
- IRRI. 2009. "The Rice Plant and How it Grows". International Rice Research Institute.
- Jamil, M., 2007. Response of transgenic rice at germination and early seedling growth under salt stress. *Pak. J. Biol. Sci.*, 10, Pp. 4303-4306.
- Kalev, S.D., 2018. The components of soils and Sediments.
- Khan, M.S.A., Hamid, A., Karim, M.A., 1997. Effect of sodium chloride on germination and seedling characters of different types of rice (*Oryza sativa* L.). In: *J. Agron. Crop Sci.*, 179, Pp. 163-169.
- Maas, E.V., Hoffman, G.J., Chaba, G.D., Poss, J.A., Shannon, M.C., 1986. Salt sensitivity of corn at various growth stages. In: *Irrigation Sci.*, 4, Pp. 45-57.
- MoALD. 2017. Statistical Information on Nepalese Agriculture. Government of Nepal, MoALD, Agri-Business Promotion and Statistics Division, Singhdurbar, Kathmandu, Nepal.
- Muthayya, S., Sugimoto, J.D., Montgomery, S., Maberly, G.F., 2014. An overview of global rice production, supply, trade, and consumption. *Annals of the New York Academy of Sciences*, 1324 (1), Pp. 7-14.
- Paliwal, A., 2018. Salinity stress detection in rice crops using time series MODIS VI data. *International journal of remote sensing*.

Paul, B.K., 2017. Climatic hazard in coastal bangladesh. Salinity Intrusion and Impacts.

AK Gautam, D Gauchan, AR Ansari, JD Ranjit, R Shrestha and B Sapkota eds). National Maize Research Program, Rampur, Chitwan, Pp. 18-20.

Prasai, H.K., Kushwaha, U.K.S., Sharma, S., Joshi, B., 2013. Varietal Improvement of Upland and Normal Rice for Far Western Hills of Nepal. In: Proceeding of the 27th National Summer Crops Workshop (Giri YP, YG Khadka, BN Mahato, BP Sah, SP Khatiwada, MR Bhatta, BK Chhetri,

Rathore, P.S., 2008. Reproductive stage tolerance to salinity and alkalinity stresses in rice genotype.

Sparks, D.L. 2003. Effects of soil salinity on soil structure. The Chemistry of saline and Sodic soils.