Khulna University Studies Volume 14 (1 & 2) : 49-57 : January-December 2017

LIFE SCIENCE

SALT STRESS ON GERMINATION AND SEEDLING GROWTH OF INDIGENOUS AMAN RICE (*Oryza sativa*)

Toushick Ahmed Sarkar, Md. Ashruf Ali, Debesh Das*, Md. Yasin Ali and Rahima Nusrat Remme

Agrotechnology Discipline, Khulna University, Khulna 9208, Bangladesh

KUS: 16/23: 060616

Manuscript submitted: June 06, 2016 Accepted: July 28, 2017

Abstract: The factorial experiment was conducted during June, 2014 to March, 2015 which consists of two factors i.e. ten indigenous Aman rice variety and four salt solutions (0, 5, 10 and 15 dS m^{-1}). The experiment was laid out in Completely Randomized Design (CRD) with three replications. Data were collected on some selected parameters and statistical analysis was performed by using MSTAT-C program. The interaction effect between variety and salinity on germination and growth parameters of indigenous Aman rice varieties varied significantly ($P < 0.05$). All of the germination and seedling growth parameters of indigenous Aman rice were significantly ($P < 0.05$) affected by salt stress. All of the germination and seedling growth parameters were decreased sharply with increasing soil salinity. The rice variety named Lily, Khakshail, Tal mugur, Harisankar, Bholanath and Swarna showed better germination performance and can tolerate salinity up to 10 - 15 dS m^{-1}. The variety of Lily, Khakshail, Tal mugur, Swarna, Harisankar, and Bholanath are superior to others variety considering their germination and seedling growth attributes of indigenous rice.

Keywords: Germination energy, germination capacity, germination speed, seedling growth, Seedling vigor index

---

Introduction

Rice (*Oryza sativa* L.) is one of the most important annual cereal crops of the world which belongs to Poaceae family. It is the most extensively consumed staple food for more than one third of world's population, especially in Asia. In Bangladesh, rice is the principal source of food and people greatly depend on it for accomplish their daily dietary scheme. The annual cultivated area of rice is 15.03 million hectares and the annual production are 33.83 million metric tons in Bangladesh (BBS, 2015). Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh. The production of rice is directly affected by different types of hazard such as drought, flooding, salinity etc. In saline soil, pH remains below 8.5 (7.0 to 8.5), electrical conductivity remains greater than the 4 dS m^{-1} at 25 ^{0}C and sodium absorption ratio (SAR) found to be less than 15 (Gupta and Abrol, 1990). Saline condition influences the water uptake that results osmotic stress to plants. This creates toxic condition and accumulation of Na and Cl ions in tissue of seed that may reduce the rate of seed germination (Murillo-Amodor *et al.*, 2002; Shokohhifard *et al.*, 1989).

*Corresponding author: <debeshdasat@gmail.com>

DOI: https://doi.org/10.53808/KUS.2017.14.1and2.1623-L

Rice production has significantly increased because of rapid and wide acceptance of high yielding varieties with improvement of irrigation, fertilizer application as well as farming technique (Israt *et al.*, 2016). A large number of landrace have been lost by the spread of the elite varieties but these indigenous rice cultivars possess a wide diversity in morphological, physiological and ecological characteristic. Some of the indigenous varieties also have the capacity to tolerate environment stresses such as drought, flooding and salinity (Kashem, 2013). For preserving genetic, these landraces need to be collected and evaluated. Therefore, it is necessary to identify the sensitivity and tolerance level of these indigenous varieties at early seedling stage and period of vegetative as well as reproductive growth for successful crop production. The present experiment was conducted to screen out the salt tolerant indigenous *aman* rice varieties based on germination and seedling growth performance

Materials and Methods

Experimental setup: The experiment was conducted in Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Bangladesh during June 2014 to March 2015. This experiment consists of two factors i.e four different concentrations of salt solution (control, 5, 10, 15 dS m^{-1}) and ten indigenous Aman rice varieties (V_1 = Lily, V_2 = Harisanker, V_3 = Khakshail, V_4 = Satin, V_5 =Mura bajal, V_6 = Mulagathi, V_7 =Bholanath, V_8 = Tal mugur, V_9 =Swarna, V_{10}= Kalomota. The experiment was carried out in a Completely Randomized Design (CRD) with three replications. Salt solutions of definite level of salinity were prepared by using required amounts of salt (NaCl) dissolving in distilled water (Table 1). The germination was conducted by petridish method using distilled water and saline soil solution of different concentrations.

Table 1: Salinity levels with corresponding amount of salt (NaCl)

Treatments	Water salinity level (EC) dSm-1	NaCl (g) added in *per* liter of distilled water
S_0	0 (control)	0.0
S_1	5	3.20
S_2	10	6.40
S_3	15	9.60

Data Collection: The data were collected on germination energy (%), germination capacity (%), germination speed (%), seedling vigor index, shoot length (cm) and root length (cm). Five seedlings were taken randomly from each petridis to measure root and shoot length.

Germination energy: Percentage of seeds germinated at 72 h (Bam *et al.*, 2006)

Germination capacity: Percentage of seeds germination at 168 h (Bam *et al.*, 2006)

$$\text{Speed of gemination (\%)} = \frac{\text{Number of seeds germinated at 72 h}}{\text{Number of seeds germinated at 168 h}} \times 100$$

Seedling vigor index (SVI): According to Abdul and Anderson (1973) seedling vigor index can be expressed by the following equation:

Seedling vigor index = (average shoot length+ average root length) × germination percentage

***Statistical analysis*:** The recorded data were analyzed statistically using MSTAT-C statistically software. Analysis of variance (ANOVA) technique was employed to test the overall significance of the data. The mean differences were adjudged by Duncan's New Multiple Ranges Test (Gomez and Gomez, 1984).

Results and Discussion

***Effect of variety on germination and seedling growth parameters of indigenous Aman rice*:** The effect of variety on the germination energy (%), germination capacity (%), seedling vigor index (%), root length (cm) and shoot length (cm) have been shown in Table 2. All the studied parameters *viz*, germination energy, germination capacity, seedling vigor index, root length, shoot length in the tested varieties differed significantly among the variety. The highest germination energy (93.00%) was observed in *Khakshail* which was statistically similar ($P > 0.05$) with *Talmugur* (91.00%), Lily (88.17%), *Harisanker* (86.17%), *Bholanath* (85.17%), *Murabajal* (86.67%), *Swarna* (85.83%). The lowest germination energy (70.67%) was observed in *Kalomota* which was statistically similar ($p > 0.05$) with *Mulagathi* (77.08%).

Table 2: Effect of variety on germination and seedling growth parameters of indigenous *Aman* rice

Variety	Germination energy (%)	Germination capacity (%)	Germination speed (%)	Seedling vigor index	Root length (cm)	Shoot length (cm)
Lily	88.17ab	99a	88.93ab	777.47bc	4.92b-d	2.29d
Harisanker	86.17ab	95bc	90.61ab	886.1bc	5.8bc	4.55a
Khakshail	93a	96.67a-c	96.17a	1156a	7.73a	4.09ab
Satin	84bc	94.83c	88.52b	970.8ab	6.39ab	3.82a-d
Mura bajal	86.67ab	96a-c	90.22ab	873.9bc	5.38b-d	3.68a-e
Mulagathi	77.08cd	95.5a-c	80.78c	724.4bc	4.12d	3.47b-e
Bholanath	85.17ab	96.33a-c	88.41b	887.1bc	5.52b-d	3.71a-e
Tal mugur	91ab	98.67ab	92.24ab	1147a	7.59a	4.03a-c
Swarna	85.83ab	96a-c	89.46ab	688.6c	4.34c-e	2.83e
Kalomota	70.67d	98.5a-c	71.71d	636.1c	3.33e	3.11c-e
LS.	**	**	**	*	**	**
CV (%)	6.31	2.64	5.74	19.92	19.53	17.83

Means with the same letter in the column do not differed significantly, ** = Significant at 1% level of significance * = Significant at 5% level of significance, CV (%) = Co-efficient of variation; LS. = Level of significance

Sarker T.A., Ali M.A., Das D., Ali M.Y and Remme R.N. (2017). Salt stress on germination and seedling growth of indigenous aman rice (oryza sativa). *Khulna University Studies* Volume 14 (1 & 2): 49-57

	Treatment combinatio n	Germination energy (%)	Germina-tion capacity (%)	Germination speed (%)	Seedling vigor index	Root length (cm)	Shoot length (cm)
	Swarna	94ab	96	97.92ab	914.52e-j	4.70f-l	4.83b-f
	Kalomota	94ab	98.66	95.28ab	889.59g-k	3.95h-l	4.04d-i
5	*Lily*	98a	100	98ab	815g-k	5.20e-k	2.95g-k
	Harisanker	88.66a-d	95.33	92.97a-c	752.46g-l	6.12d-i	6.12a-c
	Khakshail	94ab	94.66	99.32ab	1332.13bc	9.55ab	4.45c-h
	Satin	91.33ab	94.66	96.53ab	1222.68b-e	7.66b-e	5.24b-d
	Mura bajal	92ab	94.66	97.07ab	1060.55c-g	5.86d-j	5.16b-e
	Mulagathi	90ab	94.66	95.08ab	997.02e-j	5.54e-j	4.24d-i
	Bholanath	90.66ab	96	94.47ab	965.36e-i	5.62e-j	4.45c-h
	Tal mugur	93.33ab	99.33	93.95a-c	1308.17bc	8.62a-d	4.55c-g
	Swarna	95.33ab	95.33	100a	832.68g-j	5.66f-j	3.04d-j
	Kalomota	86a-e	98.66	87.19a-e	678.34h-n	3.37i-l	3.49e-j
10	*Lily*	94.66ab	98.66	95.51ab	771.52g-k	5.16e-k	2.66i-k
	Harisanker	88.66a-d	92.66	95.65ab	838.84g-j	6.04d-i	3g-k
	Khakshail	94ab	97.33	96.53ab	861.84g-j	5.45e-j	3.16f-j
	Satin	75.33d-g	92.66	81.21c-g	822.28g-j	5.87d-j	3g-k
	Mura bajal	89.33a-c	95.33	93.73a-c	765.79g-k	4.49g-l	3.53e-j
	Mulagathi	74efgh	94.66	78.08d-g	732.85g-m	4.24g-l	3.50e-j
	Bholanath	91.33ab	98	93.24a-c	791.92g-k	5.45e-j	2.62i-k
	Tal mugur	88.66a-d	98	90.46a-c	975.1d-h	6.79c-h	3.16f-j
	Swarna	82.66b-f	96.66	85.61b-f	995.36j-n	3.99h-l	2.16jk
	Kalomota	69.33f-h	98	70.63gh	682.25h-n	4.12g-l	2.79h-k
15	*Lily*	60.66hi	97.33	62.39hi	648.21i-n	4.66f-l	2jk
	Harisanker	71.33f-h	92.33	75.85e-g	672.43k-n	3.20i-l	1.79jk
	Khakshail	86.66a-e	95.33	90.87a-d	746.60g-l	5.04e-k	2.70ijk
	Satin	76c-g	92.33	79.73d-g	624i-n	4.54g-l	2jk
	Mura bajal	68.66gh	95.33	72.12gh	663.86h-n	5.08e-k	1.91jk
	Mulagathi	52.33i	96.66	54.11i	369.86n	2.53kl	1.28k
	Bholanath	66.66gh	95.33	70.02gh	585.4j-n	4.07g-l	2.08jk
	Tal mugur	86a-e	97.33	88.38 a-e	786.60g-k	4.70f-l	2.08jk
	Swarna	71.33f-h	96	74.31f-h	412.021-n	2.99j-l	1.29k
	Kalomota	33.33j	98.66	33.76j	394.34mn	1.871	2.12jk
LS..		**	NS	**	*	**	**
CV(%)		6.31	2.46	5.74	19.92	19.53	17.83

Means with the same letter in the column do not differed significantly

** = Level of significance at 1% level; * = Level of significance at 5% level; LS (%) = Level of Significance; CV.(%) = Co-efficient of variation . Where, S_0 = Control (Distilled water); S_1 = 5 dS m^{-1}; S_2 = 10 dS m^{-1} ; S_3 = 15 dS m^{-1}

germination percentage was recorded in Kalomota (33.33%) at S_3. It was found that all of the variety showed better performance (approximately 70% germination) upto S_2 (10 dS m^{-1}) except Kalomota (33.33%) (Table 3). Salinity might be included numerous effects in germination energy. Firstly it reduces the imbibition of water because of lower osmotic potential of the saline solution. Secondly it causes mineral imbalance and ion toxicity which affect on germination energy. Similar findings also predicted by Munns and Tester (2008) and Rajendran *et al.* (2009).

***Germination capacity*:** The highest germination capacity was recorded in Lily (100%) at control and S_1 (5 dS m^{-1}) *Talmugur* produced highest result (100%) at control. The lowest germination capacity (92.33%) was produced in *Harisanker* and *Satin* at S_3 (15 dS m^{-1}) (Table 3). High concentrations of salts, particularly sodium chloride (NaCl) can inhibit the germination of seeds due to osmotic and toxic effects. The low external potential can inhibit the enzymatic activity of seeds and delay the release and development of the radicle. The Na+ absorption has toxic effects on seed germination, primarily by the disruption of the movement of Ca^{+2} Na^{+} In the cell wall which could disrupt its synthesis and, therefore, prevent the growth of rootlets (Zidane *et al.*, 1991; Xue *et al.*, 2004; Martinez- Ballesta *et al.*, 2004). NaCl also affects the permeability of the plasma membrane by increasing the influx of external ions and efflux solutions cytosol (Allen *et al.*, 1995).

***Germination speed*:** The interaction of variety to salinity on germination speed (%) was statistically significances and the ranged of germination speed from 33.76% to 100%. The maximum germination speed was *Swarna* (100%) and the minimum was *Kalomota* (33.76%) (Table 3).

***Seedling vigor index*:** The range was from 369.86 to 1681.83. The highest seedling vigor index was found *Khakshail* (1681.83) in control which was produced better result 1332 at S_1. *Harisanker* produced better result 1480.84 in control and *Talmugur* also produced relatively better result in Control and S_1 which was 1494 and 1311.92 respectively. The lowest seedling vigor index was recorded in *Mulagathi* (369.86) at S_3 (Table 3). It was found that decreasing the growth of young seedlings by increasing salinity, was because of the most decreasing of water absorption by radicle and subsequently by accumulation of soluble salts in cells. (Cramer, 1993).

***Root length*:** The highest root length was found in *Khakshail* (10.87 cm) in control which was also showed better result (5.04 cm) at S_3. The lowest root length was recorded in *Kalomota* (1.87 cm) at S_3.

***Shoot length*:** The shoot length ranged from 1.28 cm to 7.28 cm. The highest shoot length was found in *Harisanker* (7.28 cm) in control and followed by *Khakshail*, *Satin*, *Talmugur*, *Bholanath*. Another variety *Khakshail* produced better result (6.04 cm) in control. The lowest shoot length was recorded in *Mulagathi* (1.28 cm) at S_3 which was approximate five times lower of *Harisankar* at control.

Conclusion

Germination and seedling growth of Indigenous *Aman* rice are significantly affected by salt stress. Germination percentage (%), germination energy (%), germination capacity (%), germination speed (%), root length (cm), shoot length (cm), seedling vigor index were gradually deceased with increasing salinity but sharply decline after 12 dS m^{-1}. The response of variety to salinity is variable. The tolerance level of salinity is varied from variety to variety. The variety named *Lily*, *Khakshail*, *Talmugur*, *Murabajal*, *Mulagathi* were considered as superior to others variety based on their germination and seedling growth performance.

Acknowledgement

The authors would like to thank Agrotechnology Discipline for the logistic support and especial thanks to the Ministry of Education, Bangladesh for financial support throughout the period of experiment. The authors would like to thank Md. Samsol Alam, Md. Taohiduzzaman, Nevanon Kumar Roy, Dhiman Adhikary, Md. Habibur Rahman for their technical assistance.

References

Abdul, B. A.A. & Anderson, J. D. (1973) Vigor Determination in Soybean Seed by Multiple Criteria. *Crop Science*, 1(3): 630-633

Allen, J, Muir SR. & Sanders, D. (1995). Release of Ca^{2+} from individual plant vacuoles by Both Ins P_3 and cyclic ADP- ribose. *Plant Biology*, 268:735-737

Anbumalarmathi, J. & Mehta, P. (2013). Effect of Salt Stress on Germination of indica Rice Varieties. *European Journal of Biological Sciences,* 6(1):1-5.

Bam, R. K., Kumaga, F., Kofori, K. & Asieudu, E. A. (2006). Germination, Vigor and Dehydrogenase Activity of Naturally Aged Rice (*Oryza sativa* L.) Seeds Soaked in Potassium and Phosphorous Salts. *Asian Journal of Plant Sciences,* 5: 948-955.

BBS. (2015). Agricultural Statistic in Bangladesh. Bangladesh Bureau of Statistics, Agriculture Wing. Website: <www.bbs.gov.bd> – Accessed on February 5, 2015.

Bewley, J. D. & Black, M. (1994). Seeds: Physiology of development and germination. New York: Plenum Press.

Cramer, G.R. (1993). Response of maize (*Zea mays* L.) to salinity. In: Handbook of Plant and Crop Stress, New York, pp. 449-459.

De Oliveira, F. A., De- Campos, T.G.S. & Oliviera, M. (1998). Effect of saline Subtract on germination, vigor and growth of herbaceous cotton. Engenharia Agricola, 18:1-10.

Gomez, K.A. & Gomez, A. A. (1984). Statistical procedures for agricultural research. John Wiley & Sons.

Gupta, R.K. & Abrol, I.P. (1990). Salt-affected soils: their reclamation and management for crop production. In Advances in soil science (pp. 223-288). Springer, New York.

Hakim, M.A., Juraimi, A.S., Begum, M., Hanif, M.M., Ismail, M.R. & Selamat, A. (2010). Effect of salt stress on germination and early seedling growth of rice (Oryza sativa L.). *African Journal of Biotechnology*, 9(13): 1911-1918.

Horie, T., Karahara, I. & Katsuhara, M. (2012). Salinity tolerance mechanisms in glycophytes:An overview with the central focus on rice plants.*Rice*, 5(1): 11.

Islam, M.Z., Baset Mia, M.A., Islam, M.R. & Akter, A. (2007). Effect of different saline levels on growth and yield attributes of mutant rice. *Journal of Soil and Nature*, *1*(2): 18-22.

Israt, J. S., Misuzu, T.N., Mana, K.N., Mohammad, S. H. & Yoshiaki, I. (2016). Rice Cultivation in Bangladesh: Present Scenario, Problems, and Prospects. *Journal of International Cooperation for Agricultural Development,* 14: 20–29

Jamil, M., Lee, D.B., Jung,K. Y., Ashraf, M., Lee, S.C. & Rha, S.E. (2006). Effect of salt (NaCl) stress on germination and early seedling growth of four Vegetable species. *Journal of Central European Agriculture.* 7(2): 273-282.

Kashem, M. A. (2013) Challenges in Higher Agricultural Education in Bangladesh. *Progressive Agriculture,* 24: 61–68

Martinez, B.M.C., Martinez, V. & Carvajal, M. (2004). Osmotic adjustment, water connections and gas exchange in pepper plants grown under NaCl or KCl. *Botany & Environment,* 52: 161-174.

Munns, R. & Tester, M. (2008). Mechanisms of salinity tolerance. *Annual Review of Plant Biology,* 59: 651-681.

Murillo, A, B., Polez, A. R., Kaya, C., Larringa, M.J. & Flores, H.A. (2002). Comparative affect of NaCl and polyethylene glycol on germination emergence and seedling growth of cowpea. *Journal of Agronomy & Crop Science*, 188: 235-247

Rajendran, K., Tester, M. & Roy, S. J. (2009). Quantifying the three main components of salinity tolerance in cereals. *Plant, Cell & Environment*, 32(3): 237-249.

Roy, S.K., Patra, S.K. & Sarkar, K. K. (2002). Studies on the effect of salinity stress on rice (Oryza sativa L.) at seedling stage. *Journal of Inter academicia.* 6(3): 254-259.

Shokohifard, G., Sakagami, K., Hamada, R. & Matsumoto, S. (1989). Effect of amending materials on growth of radish plant in salinized soil. *Journal of plant nutrition,* 12(10): 1195-1214.

Sun, Z. & Henson, C.A. (1991). A quantitative assessment of the importance of barleyseed a- amylase, P- amylase, debranching enzyme, and a- glucosidase in starch degradation. *Arch Biochem & Biophysics*, 284: 298-305.

Xue, Z., Zhid, D., Xue, L., Zhang, H., Zhao, Y. & Xia, G. (2004). Enhanced salt tolerance of transgenic wheat (*Triticum aestivum* L.) expressing a vacuolar Na+ / H+ antiporter gene with Improved Grain Yields in saline soils in the year has fioed Reduced level of leaf Na+. *Plant Science*, 167: 849-859.

Zidane, I., Azaizeh, H. & Neumann, P.M. (1991). Does salinity reduce growth of maize root epidermal cells by inhibiting their capacity for cell wall acidification. *Journal of Plant Physiology,* 93: 7-11.