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Germination and seedling growth of indigenous aman rice under salt stress

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Abstract

The experiment was conducted at the Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Khulna to determine the effect of salt stress on germination and seedling growth of indigenous Aman rice varieties during June, 2015 to December, 2015. The salt tolerant landraces will be used as genetic resource for variety development program in future. The factorial experiment consists of two factors such as ten indigenous Aman rice varieties and four levels of salt solutions *viz* EC (dS m^{-1}) of 5, 10 and 15 with control (distilled water). The experiment was laid out in Completely Randomized Design (CRD) with three replications. The interaction effects between variety and salinity on germination and seedling growth parameters of indigenous Aman rice varieties were varied significantly. It was found that germination capacity, energy, speed, seedling vigor index, root length and shoot length of rice were decreased gradually with increasing salinity. The germination energy and germination speed of most varieties were drastically reduced at 10 dS m^{-1} or higher salinity levels. The germination capacity of Hatibazor, Boushohagi, Shadagotal and Moinamoti were recorded 97.66 %, 99.33%, 98.0 % and 97.33%, respectively at 15 dS m^{-1} water salinity in laboratory condition. The results revealed that the indigenous Aman rice varieties named Boushohagi, Shadagotal, Hatibazor, Moinamoti, Motha were performed better over other varieties considering of germination and seedling growth parameters.

Introduction

Rice (*Oryza sativa* L.) is the principal source of food for more than one third of the world's population. It is the second most important crop in the world after wheat, more than 90 per cent of which is grown in Asia. In Bangladesh, rice is the most important leading cereal crop. The annual cultivated area of rice is 15.03 million hectares and the annual production about 38.34 million metric tons in Bangladesh (BBS, 2016). Rice production is affected by different biotic and abiotic factors flooding, salinity drought, pest and pathogen. Salinity and drought are the most serious challenges to crop production in the world today, particularly in developing countries (Zhou *et al*. 2007). The higher levels of salt concentration in the germinating media build up the high osmotic pressure of the solution that prevent intake of water for germination. Higher salinity delayed and reduced germination percentage (Ramaden, 1986). Salinity decreased germination percent, root length, coleoptile length and seedling growth (Lallu and Dixit, 2005 and Agnihotri *et. al.,* 2006).

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. A large number of landraces 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 environmental stresses such as salinity during germination and seedling stage. However, there was a little attention to preserve these land races which might be used as valuable genetic resources for variety improvement program in future. It is necessary to identify the salt tolerant indigenous varieties for successful crop production. In these circumstances, the research was undertaken to determine the effect of salt stress on germination and seedling growth of indigenous Aman rice varieties

Material and Methods

The experiment was conducted at Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Bangladesh during June 2015 to October 2015. This factorial experiment consists of two factors such as four different concentrations of salt solutions (0, 5, 10, 15 dS m^{-1}) and ten indigenous Aman rice varieties (V_1 = Gopalvog, V_2 = Hatibazor, V_3 = Lalmota, V_4 = Hamai, V_5 = Khejurchari, V_6 = Barjomuri, V_7 = Boushohagi, V_8 = Shadagotal, V_9 = Moinamoti, V_{10} = Motha. 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 tests were conducted at petridishes using distilled water and salt solutions of different concentrations. The recorded data were analyzed statistically with the help of computer package program MSTAT-C and the mean differences were adjudged by Duncan's New Multiple Ranges Test (Gomez and Gomez, 1984).

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

Salinity stress	Water salinity level (EC) dS m^{-1}	NaCl (g) added 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:

Germination energy**:** Percentage of seeds germinating 3 days after sowing (Bam *et al.,* 2006.)

Germination capacity*:* Percentage of seeds germinating 7 days after sowing (Bam *et al.,* 2006.)

Speed of germination: According to Krishnaswamy & Seshu (1990) speed of germination was measured by using following formula:

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

Seedling vigor index (SVI): According to Abdul and Anderson (1973) seedling vigor index was measured by the following equation:

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

Root and shoot length: Five seedlings were sampled randomly from each petridish to measure root and shoot length.

Results and Discussion

Effect of variety on germination and seedling growth parameters of indigenous Aman rice

All the studied parameters viz, germination energy, germination capacity, seedling vigor index, root length (cm) and shoot length (cm) in the tested varieties differed significantly. The highest germination energy was found in Boushohagi (97.83%) which was statistically similar to Motha (96.50%) whereas the lowest was recorded in Gopalvog (56.67%). The highest germination capacity was found in Barjomuri (99.83%) and Boushohagi (99.83%) which was statistically similar to Shadagotal (99.33%), Motha (99.5%), Hatibazor (99%), Lalmota (98%), and Moinamoti (97.5%) but the lowest germination capacity (90.33%) was observed in Khejurchari which was statistically similar to Hamai (91.67%) (Table 2).

Germination speed was differed significantly among the varieties. The Germination speed ranged from 58.99% to 97.99%. The variety Boushohagi (97.99%) showed highest germination speed whereas the lowest was found in Gopalvog (58.99%) (Table 2).

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)
Gopalvog	56.67g	95.33b	58.99e	447.2d	2.02d	2.6 cd
Hatibazor	72.83de	99a	73.34cd	423.4d	1.52d	2.74 b-d
Lalmota	68.33ef	98ab	69.52d	631.8c	3.16c	3.25 a-c
Hamai	65.17f	91.67c	70.44cd	434.1d	1.98d	2.72b-d
Khejurchari	67ef	90.33c	73.40cd	279.3e	1.13d	1.91d
Barjomuri	81.17c	99.83a	81.22b	879.5a	5.09b	3.7 ab
Boushohagi	97.83a	99.83a	97.99a	854.3ab	5.04b	3.51a-c
Shadagotal	76.83cd	99.33a	77.45bc	719.7bc	4.24bc	3.01bc
Moinamoti	91b	97.5ab	93.31a	1004a	6.72a	3.58a-c
Motha	96.50ab	99.5a	96.96a	885.2a	4.76b	4.12 a
LS.	**	**	**	**	**	**
CV. (%)	6.35	2.19	6.43	16.81	24.04	21.94

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

Means are the average of all parameters derived from ten cultivars with three replications

The seedling of Moinamoti (1004) is highly vigor which was followed by Motha (885.2), Barjomuri (879.5), Boushohagi (854.3), Shadagotal (719.7), Lalmota (631.8) whereas the Khejurchari (279.3) was poorly vigor. The variation in germination parameters among varieties may be due to variation of genetype. The results obtained from this experiment were supported and coincides with Anbumalarmathi and Metha (2013), Hakim *et al*. (2010).

The shoot and root length of tested rice varieties differed significantly. The root length ranged from 1.13 cm to 6.13 cm. The highest root length was observed in Moinamoti (6.72 cm) but the lowest root length was found in Khejurchari (1.13 cm) (Table 2).

The shoot length of the tested variety varied from 1.91 cm to 4.12 cm. The highest shoot length was recorded in Motha (4.12 cm) which was statistically similar to Barjomuri (3.7 cm), Moinamoti (3.58 cm), Boushohagi

(3.51 cm) and Lalmota (3.25 cm) whereas, the lowest shoot length was noticed in Khejurchari (1.91 cm) (Table 2). From the present investigation it was observed that the variation in germination parameters among different varieties might be due to genetic diversity which were supported by the experimental findings of Horie *et al.* (2012) and Hossain (2014).

Effect of salinity on germination and seedling growth parameters of indigenous Aman rice

There were significant effects of salt stress on germination and seedling growth parameters of rice. Germination parameters showed downward tendency with increasing salinity level. It was found that highest germination energy (%), germination capacity (%) and germination speed were observed at control which was decreased gradually with increasing salinity upto 15 dS m^{-1} (Fig. 1). The figure indicates that the germination energy and germination speed at control is approximately double from those of the highest salinity level (15 dS m^{-1}).

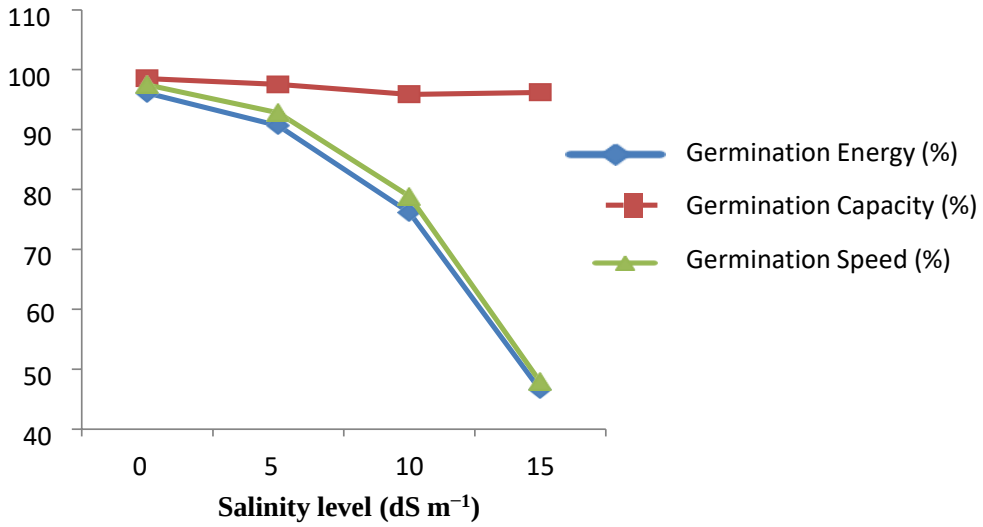

Fig. 1. Effect of salinity on germination parameters of indigenous Aman rice varieties

The effect of salt stress on root and shoot length was highly significant. The root length of the tested varieties ranged from 2.83 cm to 4.06 cm under different salinity levels. The highest root length (4.06 cm) was observed at control but the lowest (2.83 cm) was found at S_3 (15 dS m^{-1}). The highest shoot length (4.1 cm) was observed at control which was approximately double of the shoot length (2.12 cm) at S_3 (15 dS m^{-1}) (Fig. 2). The figure indicates that shoot length was more affected by salinity than root length. During germination of most seeds reserves are degraded by amylases, phosphorylases and glucosidase and much of the hydrolysis products are transported to the embryo for growth (Sun and Henson, 1991). This mobilization of simple sugar is affected by salt stress. High concentrations of NaCl showed strong inhibition of germination, root length as well as shoot length in compare to lower concentrations. The results of this experiment coincided by Theerakulpisut *et al.* (2005) and they stated that the dry weight of shoots and roots were highly correlated with the salinity.

Interaction effect between variety and salinity on germination and seedling growth parameters of indigenous Aman rice

Germination energy

Germination energy (%) varied from 12.67% to 100% due to the interaction between variety and different levels of salinity. The highest germination energy was found in Boushohagi (100%) at control but the lowest germination energy was found in Gopalvog (12.67%) at 15 dS m^{-1}. The germination energy were significantly ($P<0.01$) reduced with increasing salinity and drastically reduced at 10 dS m^{-1} and higher (Table 3).

Germination capacity

Germination capacity (%) ranged from 86% to 100.00%. The variety Hatibazor (100.00%), Barjomuri (100.00%), Boushohagi (100.00%), Shadagotal (100.00%), Motha (100.00%) showed cent percent germination at control. The germination capacity of most varieties were significantly ($P< 0.01$) reduced at 5 dS m^{-1} and higher (Table 3).

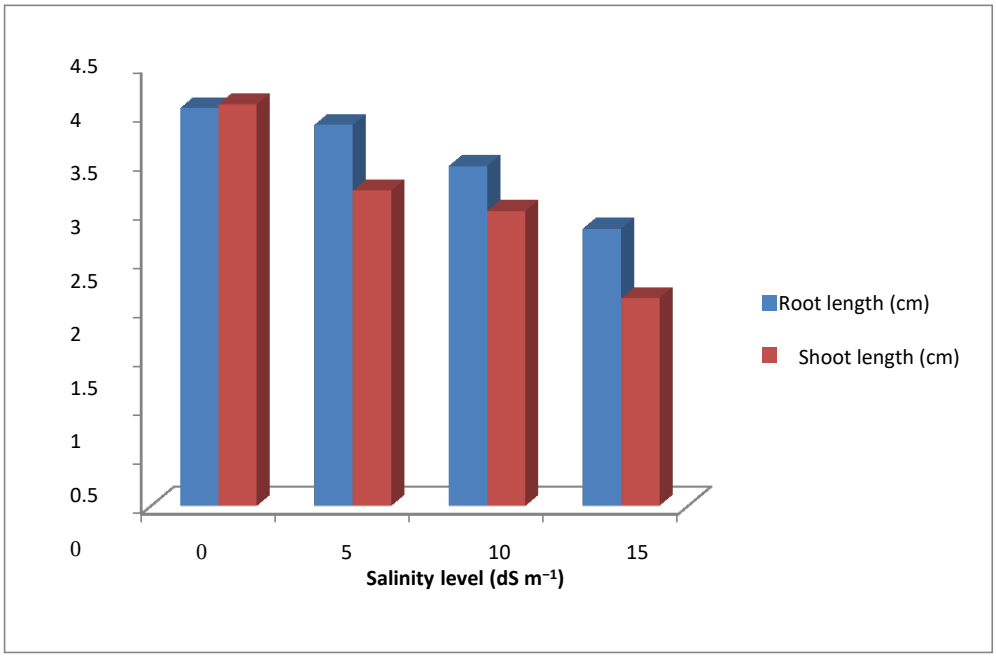

Fig. 2. Effect of salinity on root and shoot length of indigenous Aman rice varieties

Germination speed

The interaction effect between variety and salinity on germination speed was varied significantly and ranged from 13% to 100%. The maximum speed of germination was Boushohagi (100%) at control and 5 dS m^{-1} salinity level but the minimum was Gopalvog (13%) at 15 dS m^{-1}sanity level (Table 3).

Seedling vigor index

The seedling vigor index of different rice varieties were varied significantly. It was found that the variety of Motha was highly vigor followed by Barjomuri, Moinamoti, Boushohagi, Shadagotal but the variety khejurchari was poorly vigor (Table 3). The variation of seedling vigor might be due to genotypic differences which was supported by Hasegawa *et al.* (2000) and stated that salt stress and tolerance in several species including rice might be due to the expression of specific genes or completely suppress the expression of others.

Root length

The root length of tested varieties was varied from 0.5 cm to 7.91 cm. The highest root length was recorded in Moinamoti (7.91 cm) and followed by Motha, Gopalvog, and Boushohagi at control whereas the lowest root length was noticed in Hatibazor (0.5cm) at 15 dS m^{-1}. It was found that root length was adversely affected by salinity and reduction of root length was more prominent than shoot (Table 3). Our findings were supported by Akhtar and Azhar (2001) and stated that root lengths of 11 varieties were affected considerably in comparison with their shoot lengths, also shown that root length is the most sensitive part of plant under salt stress.

Shoot length

The shoot length obtained from the interaction effect between variety and salinity varied from 1.46 cm to 5.29 cm. The highest shoot length was found in Boushohagi (5.29 cm) at control but the lowest shoot length was noticed in Khejurchari (1.46 cm) at 15 dS m^{-1} (Table 3). It was found that the adverse effect of salinity on the root and shoot length might be due to the lower uptakes of water and nutrients from the growing media. The growing media possesses higher concentration of salts which may causes imbalances in osmotic pressure. The reduced growth under salt stress might be due to inhibition of transport of essential nutrient to the shoot (Tarmatt and Munns, 1986) Dagar *et.al.*, 2004.

Table 3. Interaction effect between variety and salinity on germination and seedling growth parameters of indigenous Aman rice

Treatment Combination		Germination	Germination	Germination	Seedling	Root length	Shoot length
Salinity (dSm^{-1})	Variety	energy (%)	capacity (%)	speed (%)	vigor index	(cm)	(cm)
	Gopalvog	97.33a-c	99.33ab	97.99a	872.3a-e	5.2c-g	3.58
	Hatibazor	98.67ab	100a	97.99a	553.3f-j	2.37i-p	3.16
	Lalmota	94.67a-c	99.33ab	95.33ab	770.9d-g	3.82e-m	3.93
	Hamai	88.67a-d	94b-e	94.37ab	445.1e-i	2.74h-p	4.12
0	khejurchari	91.33a-d	95.33a-e	95.78ab	492.9g-k	2.3k-p	2.83
	Barjomuri	99.33a	100a	99.33a	841b-e	6.83a-c	4.08
	Boushohagi	100a	100a	100.0a	1004a-d	4.75c-h	5.29
	Shadagotal	96a-c	100a	96.00ab	920.8a-e	4.62c-j	4.58
	Moinamoti	95.33a-c	98a-c	97.27a	1260.28a	7.91a	4.95
	Motha	99.33a	100a	99.33a	845.7b-e	5.66b-f	4.5
	Gopalvog	75.33e-g	96.67a-d	78.08c-e	359i-l	1.16op	2.54
	Hatibazor	88a-d	99.33ab	88.63a-c	525.2f-j	2.37j-p	2.91
	Lalmota	90.67a-d	98.67a-c	91.83ab	758.4d-h	4.1e-l	3.56
	Hamai	85.33b-e	93.33c-f	91.39ab	403i-l	1.45n-p	2.84
5	khejurchari	84.67c-e	91.33e-g	92.72ab	226.9kl	0.7p	1.79
	Barjomuri	96a-c	100a	96.00ab	926.3a-e	5.37b-g	3.89
	Boushohagi	99.97a	100a	100.0a	1014a-d	6.79a-c	3.34
	Shadagotal	91.33a-d	100a	93.18ab	807c-f	5.16c-g	2.91
	Moinamoti	96a-c	97.33ac	98.63a	1112.48a-c	7.44ab	3.99
	Motha	98.67ab	100a	98.67a	908a-e	4.41d-k	4.66
	Gopalvog	41.43j	88gh	46.97g	260.3j-l	0.7p	2.25
	Hatibazor	70.67f-g	99.33ab	71.10d-f	344.7j-l	0.83p	2.96
	Lalmota	58i	96a-e	60.35f	525.4f-j	2.26k-p	3.18
	Hamai	62.67hi	91.33d-g	68.68ef	387.6i-l	2.02l-p	2.21
10	khejurchari	64.67g-i	88.67f-h	73.23de	198.2l	0.69p	1.55
	Barjomuri	91.33a-d	100a	91.33ab	982.7a-d	5.04c-g	3.78
	Boushohagi	99.33a	100a	99.33a	849.3b-e	5.08c-g	3.41
	Shadagotal	87.33a-e	99.33ab	87.95a-c	642.1e-i	3.87e-m	2.58
	Moinamoti	92a-d	97.33a-c	94.51ab	1105.4a	6.54a-d	3.79
	Motha	94a-c	98.67a-c	95.19ab	975.6a-d	5.04c-g	4.21
	Gopalvog	12.67m	77.33 i-j	16i	297.1j-l	1p	2.04
	Hatibazor	34j-l	97.66 a-c	34.95gh	270.3j-l	0.5p	1.94
	Lalmota	30j-l	88gh	34.55h	472.5h-l	2.48i-p	2.33
	Hamai	24l	88gh	27.33 h	300.7j-l	1.7m-p	1.71
15	khejurchari	27.33kl	76jk	31.87h	197.8l	0.84p	1.46
	Barjomuri	38jl	89.33f-h	38.23gh	768.1d-g	4.64c-i	3.08
	Boushohagi	92a-d	99.33ab	92.63ab	550.2f-j	3.54f-n	1.99
	Shadagotal	32.67j-l	98 a-c	33.33h	513.52f-j	3.29g-o	1.95
	Moinamoti	80.67d-f	93.33a-c	82.84b-d	640.2e-i	4.99c-h	1.58
	Motha	84 c-e	87.33gh	94.64ab	811.5c-f	3.95 e-m	3.13
LS.		**	**	**	**	**	NS
CV (%)		6.35	2.19	6.43	16.81	24.04	21.94

Means with the same letter in the column do not differed significantly; ** = Level of significant at 1% level; * = Level of significant at 5% level; LS (%) = Level of Significance; CV.(%) = Co-efficient of variation; Where, S_0 = Control; S_1 = 5 dS m^{-1}; S_2 = 10 dS m^{-1}; S_3 = 15 dS m^{-1}

Means are the average of 40 treatments combination derived from ten cultivars and four salinity stresses with three replications

Conclusion

Germination and seedling growth of indigenous Aman rice were significantly affected by salt stress. Germination percentage (%), germination energy (%), germination capacity (%), germination speed (%), root length (cm), shoot length (cm), seedling vigor index were declined gradually with increasing salinity. The variable response was found by the interaction between varieties to salinity. The variety named Boushohagi, Shadagotal, Hatibazor, Moinamoti, Motha were might be considered as superior to others variety based on their germination and seedling growth performance.

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