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SCREENING OF TOSSA JUTE (*CORCHORUS OLITORIUS*) VARIETIES AGAINST SALT STRESS

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ABSTRACT

Nine *tossa* jute (*Corchorus olitorius*) varieties, viz. JRO632, JRO204, S19, JRO524, IRA, JRO8432, JRO128, JRO2407 and CP58 were selected to test their tolerance to salinity stress under laboratory condition. Twenty five seeds of each of the selected variety were allowed to germinate in petri-dish under five levels of salt stress imposed by 0, 100, 160, 240, and 300 mM NaCl solution. Maximum inhibition of seed germination due to salinity was observed in jute variety S 19 (by 14% at 100 mM and 38% at 160 mM NaCl) and minimum inhibition in variety JRO 128 (no inhibition at 100 mM and 18% inhibition at 160 mM NaCl). Seed germination and seedling growth of all the jute varieties, however, were completely inhibited at 300 mM NaCl. Salt tolerance index of 10 days old seedling grown at 160 mM NaCl was 77.5% for variety S 19 and 30% for variety JRO 632. The study revealed that salinity stress has inhibitory effect on both seed germination and seedling growth of *tossa* jute and the jute varieties differed significantly in their tolerance to this salinity stress.

KEY WORDS
Corchorus olitorius
Germination
Salt tolerance index
Salinity stress

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INTRODUCTION

Jute is an important bast fibre producing cash crop which belongs to the family Tiliaceae and genus *Corchorus*. This cash crop is the source of highly versatile environment friendly natural fibre, and is the second only to cotton in terms of production and variety of uses (Islam *et al.* 2013).Jute fibre is mainly used for manufacture of sacs, carpets, wrapping materials, etc. and it is also a potential source of different grades of paper pulp. Apart from fibres, two cultivated species of jute, viz. *Corchorus capsularis* (*Deshi* jute) and *Corchorus olitorius* (*Tossa* jute) are most frequently grown as green leafy vegetable (Imbamba, 1973). Tossa jute is rich in beta-carotene, iron, calcium, and vitamin C along with its antioxidant activity with a significant α-tocopherol equivalent Vitamin E (Leung *et al.,* 1968) and consumed as vegetable by people of eastern India during hot summer.

Salt stress is an important abiotic stress in major jute growing countries like India and Bangladesh. In India total salt affected soils including saline and sodic soils is 6.7 million hectares, out of which 1.47 million hectares salt affected soils constituted jute growing states. But 0.75 million hectares pertain to salinity and 0.72 million hectares owing to sodicity (Mandal *et al.,* 2010). About 70% of cultivable land of Bangladesh suffered from different degrees of salinity (Haque, 2006). Moreover, recent cyclone like *Aila* in India and Bangladesh has converted vast non-saline crop lands to salt affected areas and this salinity developed in soils is still increasing day by day due to raise in sea level because of global warming (www.savebd.com). About 80% jute growing areas of India situated in West Bengal. This state has a vast coastal area where climate is suitable for jute cultivation but high salinity in soils is unsuitable which lead to mono-cropping of rice in kharif season. It has been recently reported that jute can grow readily in saline soils (Ma *et al.*, 2011). Identification of jute varieties tolerant to the salinity can extend the jute cultivation to the salt affected soils in eastern India in which cultivation is generally not practiced. This, in one hand, will increase jute areas and fibre production to meet the increasing demands of jute fibres and, in other, it will meet nutrition to the poor people of coastal area. Therefore, high yielding jute varieties either need to be screened from the existing varieties or breeding of new variety is required.

Seed germination and seedling growth are two important and vulnerable stages in the early life cycle of terrestrial angiosperms and responses to the salt stress at this stages are used to screen salt tolerant species. Purhpan and Rangasamy, 2002 observed that seed germination is adversely affected by the increase in salinity. Crop plants show reduction in dry matter accumulation and grain yield under salt stress which is invariably accompanied with pronounced changes in their ionic composition. Relative reduction in germination and growth have earlier been used for assessing salt tolerance of jute in China (Ma *et al*, 2011) and for *C. capsularis* in India (Naik *et al.*, 2015). The present study was conducted to assess nine *tossa* jute (*C. olitorius*) varieties for their tolerance to salinity stress.

MATERIALS AND METHODS

The experiment was conducted under laboratory conditions. Factorial randomized block design was used keeping nine *C.olitorius* varieties (JRO-632, JRO-204, S-19, JRO-524, IRA, JRO-8432, JRO-128, JRO-2407 and CP-58) and four salt concentrations (0, 100, 160, 240 and 300 mMNaCl). Each treatment was replicated thrice.Twenty five representative seeds of each variety were sown on a filter paper held in 9 cm petridish. One set of 45 petridishes was considered as one replication. Petridish containing 8ml of double distilled water (control) or 8mL of 100, 160, 240 and 300 mM NaCl concentration are at room temperature (27ºC ± 2).The seed germination was observed after every 12 hours. Seed germination was considered when there was radical protrusion through the seed coat.The lengths of root and shoot of the germinated seeds and fresh and dry weight of seedling were measured and recorded five and ten days after sowing. Five seedlings were randomly selected from each Petridish and their average root and shoot length were measured by using measuring scale. Fresh biomass weight was measured by using an analytical weighing balance and the samples were dried in a hot air oven at 65±2ºC for 24 hours to acquire their dry biomass weight (Seghatoleslami, 2010). The germinated seeds were counted every day and the germination rate was calculated by using the following mathematical formula (Pieper, 1952).

$$GR = \frac{(n1 \times t1) + (n2 \times t2) + (n3 \times t3)........ (ni \times ti)}{T}$$

where,

GR: Germination rate (days),n1, n2, n3,....ni: 1st, 2nd, 3rd,...ith number of days for each counting of germinated seeds, t1, t2, t3,...ith: 1st, 2nd, 3rd,...ithnumber of germinated seeds in each counting day and T: Total number of germinated seeds.More the value of GR, more time is required for the germination.

Salt Tolerance Index (STI) was calculated for 10 days old seedling according formula given by Bagci *et al.,* (2003) as total plant (shoot to root) dry weight obtained from 5 seeds (Kagan *et al.,* 2010) grown on different salt concentrations compared to total plant dry weight obtained on normal concentration.

STI = (TDW at S_x/TDW at S_1) x 100]

where,TDW = total dry weight, S_1 = control, S_x = x treatment.

RESULTS AND DISCUSSION

Germination is a vital stage to begin lifecycle of plant and this also the most sensitive to any kind of stress. During the process of germination salt stress generally becomes fatal to most of the agricultural crops. Salt tolerance at this stage is crucially important for the establishment of the plants growing in such environments. In our experiment, jute seed germination in general reduced with the increasing level of salinity in all the selected nine tossa jute varieties (Table 1), similar result was also reported in castor crop (Raghavaiah *et al.,* 2006). The reduction of germination percentage ranges between 0 (JRO 128) and 14% (S 19) in 100 mM NaCl concentration and between 18% (JRO 128) and 38% (S 19) with the increase of the NaCl concentration from 100 to 160 mM. However, at all the different NaCl concentrations, the reductions of germination percentage among the varieties were statistically non-significant. JRO 632, JRO128 and IRA had higher germination percentages,more than 70% even at the 160 mM NaCl concentration, while JRO204 and S19 had lower germination percentages at the same NaCl concentration (Table 1). Even though salt tolerance during germination differs from that at later stages of plant development (Hongyu *et al.,* 2011), good germination under salinity stress conditions is essential because it is the first stage of plant growth. Also NaCl may be inhibitory to the activities of some enzymes that may play critical roles in seed germination and seedling growth (Basha *et al.,* 2010).

The time course of seed germination measured by germination rate (days) significantly increased with the increasing NaCl concentrations irrespective of the selected nine *tossa* jute varieties, it was observed highest at control. Later it decreased by reducing the NaCl concentration levels. Among all the nine varieties best performer in terms of germination rate is JRO 632, followed by JRO 128 and IRA and the least performer was found to be JRO-2407 at 160 mM NaCl (Table 1).Salt tolerance index (STI) based on seedling dry weight (10 days old) indicated a wide difference in salt tolerance among the jute varieties, but statistically it was non-significant (Table 1). The reduction of STI from 0 mM NaCl ranged between 12.5% (IRA) and 42.5% (S 19) at 100 mM NaCl, and between 30% (JRO 632) and 77.5% (S 19) at 160 mM NaCl. Similar with the

Table 1: Effect of salinity stress on germination percentage, germination rate and Salt tolerance index of selected *C. olitorius* varieties

Varieties	Germination (%) NaCl (mM)					Germination rate (days) NaCl (mM)					Salt tolerance index (%) NaCl (mM)				
	Control	100	160	240	300	Control	100	160	240	300	Control	100	160	240	300
JRO 632	98.0	94.0	78.0	0.00	0.00	1.60	1.78	2.05	0.00	0.00	100.0	80.0	70.0	0.00	0.00
JRO 204	92.0	83.0	60.0	0.00	0.00	1.20	2.43	2.29	0.00	0.00	100.0	67.5	35.0	0.00	0.00
S 19	98.0	84.0	60.0	0.00	0.00	1.19	1.83	2.42	0.00	0.00	100.0	57.5	22.5	0.00	0.00
JRO 524	92.0	84.0	62.0	0.00	0.00	1.13	1.96	2.30	0.00	0.00	100.0	67.5	32.5	0.00	0.00
IRA	94.0	86.0	72.0	0.00	0.00	1.36	1.75	2.13	0.00	0.00	100.0	87.5	50.0	0.00	0.00
JRO 8432	94.0	82.0	60.0	0.00	0.00	1.10	1.85	2.40	0.00	0.00	100.0	77.5	45.8	0.00	0.00
JRO 128	94.0	94.0	76.0	0.00	0.00	1.49	1.83	2.12	0.00	0.00	100.0	77.5	52.5	0.00	0.00
JRO 2407	98.0	86.0	68.0	0.00	0.00	1.39	1.94	2.52	0.00	0.00	100.0	75.0	62.5	0.00	0.00
CP 58	94.0	84.0	62.0	0.00	0.00	1.230	1.98	2.44	0.00	0.00	100.0	70.5	50.0	0.00	0.00
SEm+ 3.50						SEm+ 0.08					SEm+ 6.88				
LSD (p=0.05) = N.S						LSD (p=0.05) = N.S					LSD (p=0.05) = N.S				

Table 2: Effect of salinity stress on root length of *C. olitorius* varieties at 5 and 10 DAS

Varieties	Root length (cm) at 5 DAS					Root length (cm) at 10 DAS				
	Control	100 mM	160 mM	240 mM	300 mM	Control	100 mM	160 mM	240 mM	300 mM
JRO 632	3.60	1.28	0.00	0.00	0.00	4.85	1.99	0.69	0.00	0.00
JRO 204	2.71	1.18	0.00	0.00	0.00	3.71	1.84	0.48	0.00	0.00
S 19	3.24	1.20	0.00	0.00	0.00	4.31	1.66	0.46	0.00	0.00
JRO 524	3.36	0.99	0.00	0.00	0.00	4.32	1.61	0.44	0.00	0.00
IRA	3.51	1.25	0.00	0.00	0.00	4.03	1.83	0.59	0.00	0.00
JRO 8432	3.11	1.10	0.00	0.00	0.00	4.47	1.42	0.50	0.00	0.00
JRO 128	3.52	1.25	0.00	0.00	0.00	4.60	1.93	0.60	0.00	0.00
JRO 2407	3.19	1.20	0.00	0.00	0.00	4.59	1.85	0.57	0.00	0.00
CP 58	2.84	1.19	0.00	0.00	0.00	4.01	1.77	0.47	0.00	0.00
SEm+ 0.21						SEm+ 0.24				
LSD (p=0.05) = N.S						LSD (p=0.05) = N.S				

*DAS = Days after sowing

Table 3: Effect of salinity stress on shoot length of *C. olitorius* varieties at 5 and 10 DAS

Varieties	Shoot length (cm) at 5 DAS					Shoot length (cm) at 10 DAS				
	Control	100 mM	160 mM	240 mM	300 mM	Control	100 mM	160 mM	240 mM	300 mM
JRO 632	1.94	1.04	1.07	0.00	0.00	2.23	1.72	1.07	0.33	0.00
JRO 204	1.46	0.77	0.65	0.00	0.00	1.97	1.39	0.65	0.00	0.00
S 19	1.40	0.92	0.73	0.00	0.00	1.74	1.63	0.73	0.00	0.00
JRO 524	1.44	0.57	0.66	0.00	0.00	1.68	1.52	0.66	0.00	0.00
IRA	1.43	0.95	0.90	0.00	0.00	1.82	1.68	0.89	0.26	0.00
JRO 8432	1.61	0.86	0.87	0.00	0.00	1.84	1.50	0.87	0.00	0.00
JRO 128	1.91	1.01	0.90	0.00	0.00	2.03	1.69	0.90	0.00	0.00
JRO 2407	1.89	0.93	0.85	0.00	0.00	1.99	1.65	0.85	0.00	0.00
CP 58	1.88	0.95	0.59	0.00	0.00	1.92	1.67	0.59	0.00	0.00
SEm+ 0.13						SEm+ 0.11				
LSD (p=0.05) = N.S						LSD (p=0.05) = N.S				

Table 4: Effect of salinity stress on fresh weight of *C. olitorius* varieties

Varieties	Fresh Weight (mg) at 5 DAS					Fresh Weight (mg) at 10 DAS				
	Control	100 Mm	160 mM	240 mM	300 mM	Control	100 mM	160 mM	240 mM	300 mM
JRO 632	63.5	48.0	0.00	0.00	0.00	76.0	65.0	55.5	48.5	0.00
JRO 204	46.5	42.0	0.00	0.00	0.00	69.0	64.0	45.5	0.00	0.00
S 19	44.5	38.0	0.00	0.00	0.00	67.0	63.5	47.5	25.0	0.00
JRO 524	46.5	35.5	0.00	0.00	0.00	67.5	63.5	35.5	0.00	0.00
IRA	60.0	44.5	0.00	0.00	0.00	64.0	64.0	50.5	24.5	0.00
JRO 8432	52.0	37.5	0.00	0.00	0.00	63.5	56.5	40.0	0.00	0.00
JRO 128	60.0	44.5	0.00	0.00	0.00	69.0	65.0	54.0	0.00	0.00
JRO 2407	52.0	42.0	0.00	0.00	0.00	65.0	61.0	48.5	0.00	0.00
CP 58	54.0	37.5	0.00	0.00	0.00	65.5	61.0	41.0	0.00	0.00
SEm+ 2.92						SEm+ 2.80				
LSD (p=0.05) = N.S						LSD (p=0.05) = N.S				

germination percentage and germination rate, reduction of STI is lesser in case of JRO 632, IRA and JRO 128 than the other varieties except of JRO 2407 which showed 37.5% reduction of STI just after JRO 632 (30% redction) at 160 mM NaCl. Among the nine tossa varieties, the reduction of STI is highest incase of S 19 variety at both 100 mM and 160 mM NaCl concentration which may be due to thin cell wall of the variety. Kagan *et al.* (2010) and Khatun *et al.* (2013) also found in their experiment that salt tolerance index decreased with increasing with NaCl salinity stress.

There were no significant differences between varieties in terms of root and shoot lengths. Root and shoot length was higher in control then other salt concentration levels, but later on showed a declining trend at higher levels of salinity and a perfect negative correlation with increasing levels of NaCl (Table 2 and 3). Shoot length and root length of 10 days old seedlings were found to be affected due to salinization. It was observed higher root and shoot length in varieties JRO 632, JRO-128 and IRA. The decrease in root and shoot elongation starting from the 100 mM NaCl concentration was considered an indicator that root and shoot growth was affected more quickly compared with the control (Abass and Latif,2005). No root growth was found at 160, 240, 300 mM NaCl concentrations but smaller shoot growth was found at 160 mM NaCl concentrations. Varieties JRO-632 and IRA produced smaller shoot even at 240 mM NaCl concentrations. High concentrations of salts to disturb the capacity of roots to extract water and high salts within the plant itself can be toxic, resulting

Table 5: Effect of salinity stress on dry weight of *C. olitorius* varieties

Varieties	Dry weight (mg) at 5 DAS					Dry weight (mg) at 10 DAS				
	Control	100 mM	160 mM	240 mM	300 mM	Control	100 mM	160 mM	240 mM	300 mM
JRO 632	6.00	4.50	0.00	0.00	0.0	4.00	4.00	4.00	0.00	0.00
JRO 204	5.00	4.00	0.00	0.00	0.0	4.50	3.50	1.50	0.00	0.00
S 19	5.00	4.00	0.00	0.00	0.0	4.50	3.00	1.00	0.00	0.00
JRO 524	4.00	3.00	0.00	0.00	0.0	4.50	3.00	1.50	0.00	0.00
IRA	5.00	4.50	0.00	0.00	0.0	4.00	3.50	2.00	0.00	0.00
JRO 8432	4.50	3.50	0.00	0.00	0.0	3.50	3.50	1.50	0.00	0.00
JRO 128	5.50	4.50	0.00	0.00	0.0	4.50	4.00	2.00	0.00	0.00
JRO 2407	5.00	3.50	0.00	0.00	0.0	4.00	2.50	1.50	0.00	0.00
CP 58	5.00	3.50	0.00	0.00	0.0	3.50	3.00	1.50	0.00	0.00
SEm + 0.26						SEm + 0.27				
LSD (p=0.05) = N.S						LSD (p=0.05) = N.S				

in an inhibition of many physiological and biochemical processes (Jaiswal *et al*., 2014) such as nutrient uptake and assimilation. Both together, these effects reduce plant growth, development and survival (Munns and Tester, 2008). Stimulation of root and shoot length with increasing salt levels has been documented in fibre species, including *Hibiscus sabdariffa* (Moosavi *et al*., 2013). Moreover, saline condition disturbs water uptake by seed, resulting in the reduction of plant hormones and enzymes production which consequently inhibits seedling's growth.

Fresh weight and dry weight (Table 4 and 5) was observed higher in JRO 632 both at 5 and 10 days after sowing. Shoot and root lengths did not always relate to shoot and root weights. Although some varieties had long shoots and roots, thin and unbranched, they could not produce sufficient dry weight. For this reason, when length and dry weight are considered as selection criteria, we advise that dry weight be the primary selection criterion. It is anticipated that in addition to higher dry weight, longer and stronger root and shoot development will allow more successful selection for high salt tolerance. However, as selection criteria, the length and weight measurements taken from single plants can be considered appropriate only when there is a high germination percentage. For these reasons, germination percentage and total dry weight, was determined to be a more reliable selection criterion in this study. Salt damage to the crops has been attributed to combination of several factor including osmotic stress and the accumulation of toxic ions. Abass and Latif (2005) also agree with this observation. In addition, Ghazizade *et al*. (2012) showed a significant reduction of seedling length, fresh weight and dry weight was observed due to salt stress for all of the studied varieties.

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