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Effect of salinity on germination and early seedling growth of maize

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Abstract

An incubation experiment was conducted at the Department of Soil Science, Patuakhali Science and Technology University during *Rabi* season 2015 to investigate the effects of different levels of salinity on germination and early seedling growth of maize. There were ten treatments consisting of different concentrations of salinity viz. 0, 20, 40, 80, 120, 160, 200, 240, 280 and 320 mM NaCl. The germination experiment was conducted in petri dish lined with a layer of cotton consisting ten ml of each test solution. Germination percentage gradually decreased with the increase of concentration of salt. Up to 80 mM concentration was found safe for maize seed germination. Salinity caused delay in germination. Highest seedling height was found at 40 mM NaCl concentration (21.51 cm) and root length (23.61 cm) was found in 20 mM NaCl concentration. In 320 mM NaCl concentration roots were abnormal, deformed and twisted. The 0 to 80 mM NaCl concentration gave statistically similar shoot fresh weight. Compared to control treatment 20 mM NaCl concentration gave 0.55 % higher fresh weight and at 80 mM NaCl concentration shoot fresh weight reduced by only 6.9 %. The 80 mM NaCl concentration was found acceptable for germination and early seedling growth of maize.

Key words: Coastal Bangladesh, sodium chloride, speed of germination, salinity, vigor index

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Introduction

Salinity is a major environmental constraint to crop productivity throughout the arid and semi-arid regions of the world (Foolad and Lin, 1997). In Bangladesh, there are approximately 2.85 million ha of coastal land of which about one million ha are seriously affected by varying degrees of salinity (SRDI, 2010). About 30-50% of net cropped areas remains fallow in rabi and *Kharif-1* seasons, mainly due to soil and water (irrigation) salinity. The salinity increases in dry months showing a peak in March-April and decreases in wet months with the minimum in July-August.

Annual precipitation does not exceed evapotranspiration, soluble salts tend to accumulate and build-up in the soil of coastal regions, instead of being leached, and can reach the levels inhibitory to plant growth and development (Roychoudhury and Chakraborty, 2013). The prevailing salinity intrusion due to climate change is severely affecting the crop productivity in the saline regions of Bangladesh (Haque *et al*., 2014). The situation calls an urgent need to improve crop productivity. Introduction of new crops and/or crop varieties in the fallow lands of the coastal regions might be the scholastic technique for improvement of system productivity. Maize is one of the most important food grains in the world as well as in developing countries like Bangladesh.

The food produced in Bangladesh is not adequate to meet domestic requirements. Seed germination is a major factor limiting the establishment of plants under saline conditions (Carpıcı *et al*., 2009). Salinity may cause significant reductions in the rate and percentage of germination, which in turn may lead to uneven stand establishment and reduced crop yields (Foolad *et al*., 1999).

Salt tolerance at germination stage is important factor, where soil salinity is mostly dominated at surface layer. High concentration of salt has detrimental effects on germination of seeds (Rahman *et al*., 2000; Sharma *et al*., 2004; Saboora and Kiarostami, 2006; Shila *et al.,* 2016). Plant growth is ultimately reduced by salinity stress (Haque *et al*., 2008, 2014; Sikder *et al*., 2016). It is very important to know what extent of salinity a maize variety can tolerate at germination and early seedling growth stage. This information will help to identify salt tolerant varieties and/or genotypes and to develop saline soil management strategies. An experiment is therefore needed to investigate the effects of different levels of salinity on germination and early seedling growth of maize.

Materials and methods

The experiment was conducted at the laboratory of the Department of Soil Science, Patuakhali Science and Technology University, Dumki, Patuakhali during the period from January to February 2015.The experiment was designed at completely randomized design (CRD) with three replications. There were ten treatments consisting different levels of salinity. The treatments were 0, 20, 40, 80, 120, 160, 200, 240, 280 and 320 mM NaCl concentration. The germination experiment was conducted in petri dishes of 12 cm diameter lined with a thin layer of cotton. Bangladesh Agricultural Research Institute (BARI) developed “BARI Hybrid Maize 7” was used in the experiment. Twenty five seeds were placed on cotton bed in a circle pattern. Ten milli litre of treatment solutions of different salinity concentrations were poured in each Petri dish to immerse the seeds partially for ensuring proper aeration. Three replications were maintained for each salinity concentration. The petri dishes were placed on a table in the laboratory. The seeds were allowed to germinate at room temperature (25±2°C). A 100 w power bulb was fixed using a stand on the petri dishes. Required amount of distilled water was added to each petri dish every day to maintain same level of water as in initial date. Seeds were considered germinated when radicles measured 2 mm size.

The number of seeds germinated was recorded starting from 2 days after sowing (DAS) to 12 DAS. The results obtained in each day were converted into percentage. Shoot length was recorded at 7, 9, 11 and 13 DAS. Observation was made on germination percentage, fresh and dry weight of shoot and root, moisture content of root and shoot, seedling height, speed of germination and vigor index .Vigor index (VI) was worked out according to the formula.
VI= Germination% × (Root length in cm + Shoot length in cm) and

speed of germination was calculated as follows:

$$SG = \frac{Number\ of\ germinated\ seeds}{Days\ of\ first\ count} + \cdots + \frac{Number\ of\ germinated\ seeds}{Days\ of\ final\ count}$$

Data were statistically analyzed following F-test and the mean comparisons were made at 0.05 probability level by DMRT as outlined by Gomez and Gomez (1984).

Results and Discussion

Germination percentage: Germination percentage data was recorded starting from 3 DAS to 12 DAS. In 3 and 4 DAS some treatments had zero percent germination, thus statistical analysis was not performed in that days. In other days germination percentage was significantly influenced by different levels of salinity. Table 1 show that at 3 DAS 0 and 40 mM NaCl concentration had only 4 and 1.3 % germination, respectively. After 1 day (at 4 DAS) more than 20% germination was found at 0, 20, 40 and 80 mM NaCl concentration. At 5 DAS control treatment had 37.3% germination. The 20, 40, 80 and 120 mM concentration had identical germination percentage both at 5 (33.3 %) and 6 DAS

(41.3 %). With the passes of days the trend of germination was changed. All the days control treatment had highest germination and most of the days it was statistically similar with germination percentage obtained at 20 mM NaCl concentration. At all the sampling dates 20 and 40 mM concentration had statistically similar germination percentage. More than 80% germination percentage was found only at 0, 20 and 40 mM concentration, which attained at 10, 11, and 12 DAS, respectively. Other concentrations had lower than 80% germination and were gradually decreased with the increase of concentration of salt in growth medium. The 80 mM NaCl concentration had 73.3% germination. Beyond this concentration the germination percentage was very poor. At 12 DAS 7.4 and 8.9 % reduction in germination percentage was recorded at 20 and 40 mM NaCl concentration, respectively. The 80 mM NaCl concentration reduced germination percentage by 17.9 %. Thus upto 80 mM NaCl concentration could be identified as acceptable for maize seed germination. Similar result was also found in rapeseed (Andalibi *et al*., 2005) and in sunflower (Shila *et al*., 2016). Ratnakara and Raib (2013) reported that though the lower concentrations of NaCl (upto 40 mM) did not affect percentage germination, the germination was found to be delayed in *Triginella foenum-graecum*. At higher salinity levels, inhibitory effect on germination was recorded to an extent that seeds did not germinate at 80 mM and above concentrations of NaCl in *Triginella foenum-graecum*.

Table 1. Effects of different levels of salinity on germination percentage of maize (*Zea mays* L.)

Salt concentration	Germination percentage										Speed of germination
	3 DAS	4 DAS	5 DAS	6 DAS	7 DAS	8 DAS	9 DAS	10 DAS	11 DAS	12 DAS	
T_1: 0 mM NaCl (Control)	4.0	28.0	37.3a	46.7a	57.3a	62.7a	74.7a	84.0a	84.0a	89.3a	20.9a
T_2: 20 mM NaCl	0.0	22.7	33.3a	41.3ab	46.7b	57.3ab	62.7b	74.7b	80.0a	82.7ab	17.9b
T_3: 40 mM NaCl	1.3	21.3	33.3a	41.3ab	46.7b	57.3ab	61.3b	76.0b	78.7a	81.3b	17.9b
T_4: 80 mM NaCl	0.0	21.3	33.3a	41.3ab	45.3b	50.7b	58.7b	66.7c	66.7b	73.3c	16.6b
T_5: 120 mM NaCl	0.0	18.7	33.3a	41.3ab	45.3b	50.7b	58.7b	64.0c	65.3b	68.0c	16.2b
T_6: 160 mM NaCl	0.0	12.0	24.0b	34.7b	36.0c	37.3c	42.7c	46.7d	48.0c	54.7d	12.1c
T_7: 200 mM NaCl	0.0	4.0	9.3c	16.0c	21.3d	29.3cd	32.0de	40.0e	44.0c	52.0d	8.0d
T_8: 240 mM NaCl	0.0	1.3	13.3c	18.7c	22.7d	30.7cd	38.7cd	40.0e	46.7c	49.3de	8.5d
T_9: 280 mM NaCl	0.0	1.3	10.7c	13.3c	22.7d	32.0cd	34.7cd	38.7e	41.3cd	42.7ef	7.7 de
T_{10}: 320 mM NaCl	0.0	0.0	4.0d	12.0c	17.3d	24.0d	25.3e	30.7f	34.7d	38.7f	5.8e
% CV			12.9	14.09	12.13	12.31	10.34	6.24	8.59	7.89	8.66
Significance level			***	***	***	***	***	***	***	***	***
SE (±)			1.738	2.494	2.530	3.070	2.921	2.022	2.921	2.860	0.659

Common letters in a column are not significantly different at 5% level by DMRT

Speed of germination: Speed of germination was significantly influenced by different levels of salinity. Speed of germination ranged from 5.8 to 20.9, highest being in control and lowest in 320 mM NaCl concentration (Table1). The second highest position was ranked by the 20 mM NaCl concentration which was statistically similar with 40, 80 and 120 mM NaCl concentration. Due to use of increasing rate of salt concentration, speed of germination reduced by 14.15 to 72.16 %.

Seedling height: Seedling height data was recorded at 7, 9, 11, 13 and 15 days after sowing (DAS). In all the data recording day seedling height was significantly influenced by different levels of salinity. At 7 DAS highest seedling height was found in control treatment (2.17 cm) and it was statistically similar with that obtained at 20 mM NaCl (2.04 cm). With the increase of the concentration of solution seedling height was gradually decreased (Table 2). At 9 DAS the seedling height pattern was slightly changed. This day highest height was further found at control treatment and it was statistically similar with 20 and 40 mM NaCl concentration. In other concentrations, seedling height gradually decreased with increasing concentration of solution. At 11 DAS highest seedling height was found at control treatment (10.81 cm) and it was statistically similar with 20 (10.47), 40 (10.39 cm) and 80 (10.32 cm) mM NaCl concentration. At 13 DAS similar trend was observed. The result clearly indicates that up to 80 mM NaCl concentration, salinity is not harmful for maize seedling height. However, at 20, 40 and 80 mM NaCl concentration had better performance compared to control. The results further showed that with the increase of concentration of salt, plant takes longer time for their growth and development15 DAS.

Shoot elongation rate: Shoot elongation rate was calculated at 7, 9, 11, 13 and 15 DAS, and was significantly influenced by salinity. At 7, 9, 11, 13 and 15 DAS shoot elongation rate ranged from 0.13 to 3.10, 0.96 to 7.78, 1.10 to 9.83, 1.26 to 11.10 and 1.89 to 13.58 mm/day, respectively (Table 3).

Table 2. Effects of different levels of salinity on seedling height of maize

Salt concentration	7 DAS		9 DAS		11 DAS		13 DAS		15 DAS	
	Seedling height (cm)	% decrease over control	Seedling height (cm)	% decrease over control	Seedling height (cm)	% decrease over control	Seedling height (cm)	% decrease over control	Seedling height (cm)	% decrease over control
T_1: 0 mM NaCl (Control)	2.17a	-	7.00a	-	10.81a	-	14.43a	-	20.16a	-
T_2: 20 mM NaCl	2.04ab	5.99	6.87a	1.90	10.47a	3.11	14.08a	2.43	20.37a	-1.03
T_3: 40 mM NaCl	1.94b	10.75	6.84a	2.29	10.39a	3.85	14.19a	1.69	21.51a	-6.71
T_4: 80 mM NaCl	1.71c	21.04	6.33b	9.52	10.32a	4.53	14.07a	2.47	20.50a	-1.69
T_5: 120 mM NaCl	1.31d	39.78	5.37c	23.33	8.84b	18.22	11.97b	17.07	18.05b	10.48
T_6: 160 mM NaCl	1.09e	49.92	3.93d	43.90	6.93c	35.86	9.49c	34.26	13.31c	33.99
T_7: 200 mM NaCl	0.34f	84.49	1.49e	78.67	3.23d	70.15	5.13d	64.43	7.79d	61.34
T_8: 240 mM NaCl	0.22 fg	89.86	1.19ef	82.95	1.86e	82.82	2.67e	81.47	5.28e	73.81
T_9: 280 mM NaCl	0.17 fg	92.32	1.14ef	83.71	1.77ef	83.66	2.71e	81.20	4.72ef	76.59
T_{10}: 320 mM NaCl	0.09g	95.70	0.86f	87.71	1.21f	88.78	1.63e	88.68	2.84f	85.93
% CV	11.51		6.84		4.94		7.15		8.83	
Significance level	***		***		***		***		***	
SE (±)	0.0730		01623		0.1680		0.3733		0.6856	

Common letters in a column are not significantly different at 5% level by DMRT

At 7 DAS highest elongation rate was found at control treatment. In this date second (2.91 mm/day) and third position (2.77 mm/day) was ranked by 20 and 40 mM NaCl concentration. At 9 DAS highest position was further ranked at control treatment, second (7.63 mm/day) and third position was recorded by 20 and 40 mM NaCl concentration, respectively. At 11 DAS highest position was ranked at control treatment, second (9.52 mm/day) and third position was recorded by 20 and 40 mM NaCl concentration, respectively. At

13 DAS highest position was ranked at control treatment, second (10.91 mm/day) and third position was recorded by 40 and 20 mM NaCl concentration, respectively. At 15 DAS the highest position was ranked by 40 mM NaCl concentration, the 20 mM NaCl concentration and control had the second and third position, respectively. Table 3 further shows that increasing salt concentration reduced the shoot elongation rate at every sampling date. Elongation rate in different salt concentrations also varied in different sampling dates. At lower concentration higher elongation rate was found at initial dates but it was gradually delayed with the increase of salt concentration. Shila *et al.* (2016) also noticed similar results in sunflower.

Table 3. Effects of different levels of salinity on shoot elongation rate of maize (*Zea mays* L.)

Salt concentration	7 DAS		9 DAS		11 DAS		13 DAS		15 DAS	
	Shoot elongation rate	% decrease over control	Seedling height (cm)	% decrease over control	Seedling height (cm)	% decrease over control	Seedling height (cm)	% decrease over control	Seedling height (cm)	% decrease over control
T_1: 0 mM NaCl (Control)	3.10a		7.78a		9.83a		11.10a		13.44a	
T_2: 20 mM NaCl	2.91ab	5.99	7.63a	1.93	9.52a	3.14	10.83a	2.43	13.58a	-1.03
T_3: 40 mM NaCl	2.77b	10.75	7.60a	2.31	9.45a	3.88	10.91a	1.69	14.34a	-6.71
T_4: 80 mM NaCl	2.45c	21.04	7.04b	9.55	9.38a	4.56	10.83a	2.47	13.67a	-1.69
T_5: 120 mM NaCl	1.87d	39.78	5.96c	23.36	8.04b	18.25	9.21b	17.07	12.03b	10.48
T_6: 160 mM NaCl	1.55e	49.92	4.36d	43.92	6.30c	35.88	7.30c	34.26	8.87c	33.99
T_7: 200 mM NaCl	0.48f	84.49	1.66e	78.67	2.93d	70.16	3.95d	64.43	5.20d	61.34
T_8: 240 mM NaCl	0.31fg	89.86	1.33ef	82.96	1.69e	82.83	2.06e	81.47	3.52e	73.81
T_9: 280 mM NaCl	0.24fg	92.32	1.27ef	83.72	1.61ef	83.66	2.09e	81.20	3.15ef	76.59
T_{10}: 320 mM NaCl	0.13g	95.70	0.96f	87.72	1.10f	88.78	1.26e	88.68	1.89f	85.93
% CV	11.45		6.89		4.97		7.13		8.83	
Significance level	***		***		***		***		***	
SE (±)	0.1049		0.1817		0.1713		0.2858		0.4572	

Common letters in a column are not significantly different at 5% level by DMRT

Root length: Ten different levels of salinity had significant effect on root length of maize. The root length ranged from 2.85 cm to 23.61 cm (Table 4). The highest root length (23.61 cm) was found in 20 mM NaCl concentration which was 5.6 % higher than the control treatment; although it was statistically similar with control treatment (22.36 cm). Beyond 20 mM NaCl concentration the root length was found reduced gradually and ultimately in the highest concentration root length was the lowest. In the experiment 12.3% root length reduction was found in 80 mM NaCl concentration, beyond this level root length was reduced drastically and in 320 mM NaCl concentration root length reduced by about 87%. In fact in this concentration roots were lean and thin.

***Root fresh weight*:** There was a significant effect of salinity on root fresh weight of maize. Root fresh weight was ranged from 0.415 to 4.168 g over different levels of salinity (Table 4). Highest of 4.168 g fresh root was found at 0 mM NaCl concentration. Second highest root weight was found in 20 mM NaCl concentration. There was found a decreasing trend of root fresh weight, with the increasing of the concentration of the solution. In the experiment 20 mM NaCl concentration had 7.88% decrease over control, beyond this concentration a drastic reduction was observed. At 240 mM NCl concentration more than 80% reduction in root fresh weight was observed. At 320 mM NaCl concentration root fresh weight reduced by 90.1%.

***Root dry weight*:** Root dry weight was significantly influenced by different levels of salinity. Root dry weight ranged from 0.038 g in 320 mM NaCl concentration to 0.403 g in 0 mM NaCl concentration (control) (Table 4). Second highest (0.360 g) result was obtained in 20 mM NaCl concentration which had 10.6 % reduction over control. In the experiment 40 mM NaCl concentration had less than 20 % reduction in root dry weight. However, with the increase of salt concentration root dry weight was drastically reduced. About 90.6% reduction in root dry weight was observed due to use of 320 mM NaCl concentration.

***Shoot fresh weight*:** Different levels of salinity had significant effect on shoot fresh weight of maize. Shoot fresh weight ranged from 0.661 g in 320 mM NaCl concentration to 5.478 g in 20 mM NaCl concentration (Table 4). Highest of 5.478 g shoot fresh weight in 20 mM NaCl concentration was statistically similar with 0, 40 and 80 mM NaCl concentration. Beyond 20 mM NaCl concentration, with the increase of the concentration of the solution shoot fresh weight was reduced gradually. Compared to control treatment 20 mM NaCl concentration gave 0.55 % higher fresh weight and upto 80 mM NaCl concentration shoot fresh weight reduced by only 6.9 %. After this concentration the reduction rate increased very fast. In the experiment 320 mM NaCl concentration had 87.9 % reduction in shoot fresh weight. Thus upto 80 mM NaCl concentration was found acceptable for production of shoot fresh weight.

***Shoot dry weight*:** Shoot dry weight was significantly influenced by different levels of salinity. The lowest dry weight of 0.092 g was found in 320 mM NaCl concentration and was highest of 0.515 g in 0 mM NaCl concentration (Table 4) .In the experiment 0, 20, 40, 80 and 120 mM NaCl concentration gave statistically similar shoot dry weight. Although not significant but 20, 40, 80, and 120 mM NaCl concentration gave 1.42, 0.84, 5.95 and 9.58 %, respectively lower shoot dry weight than control treatment. The result announces that upto 120 mM NaCl concentration maize can tolerate salinity. In the experiment 320 mM NaCl concentration had highest of 82% reduction.

***Shoot and root moisture content*:** Shoot moisture content was significantly influenced by different levels of salinity. Table 4 shows that highest of 90.7% moisture content was recorded by the treatment 20 mM NaCl, however, it was statistically similar to the treatment 0, 40 and 80 mM NaCl concentration. Beyond 80 mM NaCl concentration increasing salt concentration reduced shoot moisture content. In other word, increasing salt concentration increase dry matter accumulation by reducing water uptake by the plant. Root moisture content was less affected by salinity compared to shoot moisture content. It was also significantly influenced by different levels of salinity. Root moisture content varied between 90.7 to 85.7 % at salt concentration of 0 - 320 mM NaCl concentration. It indicates that under this range salinity has no effect on root moisture content.

***Vigor index*:** Salinity effect on vigor index was significant. Vigor index value ranged from 2.2 to 38.1 over the different concentration of solution (Table 4). The control had highest vigor index (38.1). Second highest value (36.4) was recorded at 20 mM NaCl concentration. Increasing concentration of salt gradually decrease the vigor index. When vigor index value were compared with control treatment it was found that the 20 and 40 mM NaCl concentration had 4.53 and 9.98 % decrease, rspectively. As high as 94.2% decrease in vigor index was found at highest concentration of 320 mM NaCl.

Table 4. Effects of different levels of salinity on different growth parameters of maize

Salt concentration	Root length (cm)	Root fresh weight	Root dry weight	Shoot fresh weight	Shoot dry weight	Shoot moisture content (%)	Root moisture content(%)	Vigor index
T_1: 0 mM NaCl (Control)	22.36ab	4.168a	0.403a	5.448a	0.515a	90.5 a	90.3 ab	38.1a
T_2: 20 mM NaCl	23.61a	3.840b	0.360b	5.478a	0.508a	90.7a	90.6a	36.4a
T_3: 40 mM NaCl	20.75bc	3.263c	0.330c	5.369a	0.511a	90.5a	89.9ab	34.3a
T_4: 80 mM NaCl	19.60c	2.978d	0.309d	5.074a	0.484a	90.4a	89.6ab	29.4b
T_5: 120 mM NaCl	16.06d	2.600e	0.277e	4.408b	0.466a	89.4a	89.3ab	23.2c
T_6: 160 mM NaCl	11.82e	2.147f	0.232f	3.468c	0.343b	90.1a	89.2ab	13.7d
T_7: 200 mM NaCl	7.74f	1.184g	0.143g	1.537d	0.191c	87.6b	87.7bc	8.0e
T_8: 240 mM NaCl	4.75g	0.821h	0.124h	0.889e	0.177c	80.1d	84.9d	4.9ef
T_9: 280 mM NaCl	4.63g	0.777h	0.111i	0.804e	0.123d	84.5c	85.7cd	4.0f
T_{10}: 320 mM NaCl	2.85g	0.415i	0.038j	0.661e	0.092d	86.1bc	90.7a	2.2f
% CV	10.40	7.60	9.12	9.72	6.04	1.19	1.62	11.44
Significance level	***	***	***	***	***	***	***	***
SE (±)	0.8056	0.0966	0.0002	0.1862	0.018	0.6069	0.8307	1.283

Common letters in a column are not significantly different at 5% level by DMR

Conclusion

Salinity reduced germination percentage of maize and the extent of reduction increased with the increase in the concentration of salinity in the growth medium. NaCl concentration up to 80 mM was found as safe for maize seed germination. NaCl upto 40 mM favors plant growth which otherwise indicates the necessity of NaCl in lower concentration for plant growth and development. At higher concentration like 320 mM NaCl, root was more affected than shoot. Further study is needed to test the performance of different maize genotypes at varying degree of salt stress.

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References

Andalibi B, Zangani E, Nazari AH (2005). Effects of water stress on germination indices in six rapeseed cultivars (*Brassica napus* L.). Iranian Journal of Agricultural Sciences 36: 457-463.

Carpıcı EB, Celık N, Bayram G (2009). Effects of salt stress on germination of some maize (*Zea mays* L.) cultivars. African Journal of Biotechnology, 8(19): 4918-4922.

Foolad MR, Hyman JR, Lin GY (1999). Relationships between Cold and Salt Tolerance During Seed Germination in Tomato: Analysis of Response and Correlated Response to Selection. Plant Breeding, 118: 49-52.

Foolad MR, Lin GY (1997). Genetic Potential for Salt Tolerance during Germination in Lycopersicon Species. Horticultural Science, 32: 296-300.

Gomez KA, Gomez AA (1984). Statistical Procedures for Agricultural Research, John Wiley and Sons, New York.

Haque MA, Jahiruddin M, Hoque MA, Rahman MZ, Clarke D (2014). Temporal variability of soil and water salinity and its effect on crop at kalapara upazila. Journal of Environmental Science & Natural Resources, 7(2): 111-114.

Haque MA, Jharna DE, Hoque MF, Uddin MN, Saleque MA (2008). Soil solution electrical conductivity and basic cations composition in the rhizosphere of lowland rice in coastal soils. Bangladesh Journal of Agrcultural Research, 33(2): 243-250.

Rahman M, Kayani SA, Gul S (2000). Combined Effects of Temperature and Salinity Stress on Corn Sunahry Cv., Pak. J. Biological Sci., 3(9): 1459-1463.

Ratnakara A, Raib A (2013). Effect of sodium chloride salinity on seed germination and early seedling growth of *trigonella Foenum-graecum* L. Journal of Environmental Research, 1(4): 304-309.

Roychoudhury A, Chakraborty M (2013). Biochemical and molecular basis of varietal difference in plant salt tolerance. Annual Review & Research in Biology, 3(4): 422-454.

Saboora A, Kiarostami K (2006). Salinity (NaCl) Tolerance of Wheat Genotypes at Germination and Early Seedling Growth. Pak. J.Biological Sci., 9(11): 2009-2021.

Sharma AD, Thakur M, Rana M, Singh K (2004) Effect of Plant Growth Hormones and Abiotic Stresses on Germination, Growth and Phosphatase Activities in *Sorghum bicolor* (L.) Moench Seeds. Afr. J. Biotechnol., 3: 308-312.

Shila A, Haque MA, Ahmed R, Howlader MHK (2016). Effect of different levels of salinity on germination and early seedling growth of sunflower. World Research Journal of Agricultural Sciences, 3(1): 048-053.

Sikder MU, Haque MA, Jodder R, Kumar T, Mondal D (2016). Polythene mulch and irrigation for mitigation of salinity effects on maize (*Zea mays* L.) The Agriculturists, 14(2): 01-13.

SRDI (2010). SRMAF Project. Soil Resource Development Institute. Ministry of Agriculture GoB.