SALINITY (NACL) TOLERANCE OF FOUR VEGETABLE CROPS DURING GERMINATION AND EARLY SEEDLING GROWTH

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Abstract

In order to study salinity stress on four vegetable crops including radish (*Raphanus sativus* L.), cabbage (*Brassica oleracea* capitata L.), mustard (*Brassica juncea*) and water spinach (*Ipomoea aquatica*), a laboratory experiment as completely randomized design was conducted with three replications in the Department of Soil Science, University of Chittagong, Bangladesh. To create salinity stress, sodium chloride (NaCl) at five levels of 0 (as control), 2, 4, 8 and 16 dS m^{-1} were used. In the present study, indices such as germination percentage, germination rate, reduction of germination percentage, seed viability index, seedling and root length, seedling and root fresh weight of four vegetable crops were measured. Statistical results revealed that the effect of salt levels on investigated parameters was significant ($P< 0.01$)). Means comparison for these parameters showed that the application of 8 and 16 dS m^{-1} salinity resulted in the loss of germination percentage, germination rate, seed viability index, seedling and root length, seedling and root fresh weight of four vegetable crops, as compared to control treatment (0 ds m^{-1} salinity). In total, it can be concluded that salinity stress significantly decreased germination and growth parameters of seedlings of four vegetable crops.

Keywords: Salinity, seed germination, seedling growth, vegetable crops

I. Introduction

Salinization of soil is one of the major factors limiting crop production particularly in arid and semi-arid regions of the world (Ahmed, 2009). Salt stress leads to suppression of plant growth and development at all

growth stages, however, depending upon plant species, certain stages such as germination, seedling or flowering stage could be the most critical stages for salts stress (Khoshsokan *et al*., 2012). Germination and seedling establishment are critical stages in the plant life cycle. In crop production, stand establishment determines plant density, uniformity and management options (Cheng and Bradford, 1999). Seed germination is first critical and the most sensitive stage in the life cycles of plants (Ahmed, 2009) and the seeds exposed to unfavorable environmental conditions like salts and drought stresses may have to compromise the seedlings establishment (Albuquerque and Carvalho, 2003).

Plant growth is ultimately reduced by salinity stress but plant species differ in their salinity tolerance (Munns and Termaat, 1986).The major inhibitory effect of salinity on plant growth and development has been attributed to osmotic inhibition of water availability as well as the toxic effect of salt ions responsible for salinization (Hakim *et al*., 2009). Jamil *et al*. (2006) stated that salinity caused a significant reduction in germination percentage, germination rate, and root and shoots length and weights of four vegetable species. Despite the importance of seed germination under salt stress (Ungar, 1995), the mechanism (s) of salt tolerance in seeds is relatively poorly understood, especially when compared with the amount of information currently available about salt tolerance physiology and biochemistry in vegetative plants (Hu *et al*., 2005; Garthwaite *et al*., 2005; Kanai *et al*., 2007). The aim of this study was to evaluate the effects of salinity level on final germination percentage, germination rate, reduction of germination percentage, seed viability index, seedling and root length, seedling and root fresh weight of four vegetables species (radish, cabbage, mustard and water spinach).

Ii.Materials and Method

This experimental study was carried out under laboratory conditions in the Department of Soil Science, University of Chittagong, Bangladesh in a completely randomized design with three replications. This study consists of experiment on seed inoculation with salinity as NaCl at concentrations of 0 (distilled water as control), 2, 4, 8 and 16 dS m^{-1} on germination and early growth of four vegetable crops. Seeds of radish (*Raphanus sativus* L.), cabbage (Brassica oleracea capitata L.), mustard (Brassica juncea) and water spinach (Ipomoea aquatica) differing in salt tolerance, were used in this investigation. The seeds were surface sterilized with 5% NaOCl (sodium hypo chloride) for 5 min to avoid fungal invasion, followed by washing with distilled water. For each plant species, 10 seeds for each of the five NaCl treatments were used. Seeds were allowed to germinate in laboratory condition on filter paper (Whatman No. 2) in sterilized 9 cm petri dishes

soaked in a solution of the respective salt concentration. The number of germinant seeds was counted every day up to 10 days and the seeds were considered germinated when the radical emerged.

Final germination percentage, germination rate and reduction of germination Percentage (Azizi et al. 2011) were calculated as follows:

Final germination percent = S/T×100

Germination rate = N1/D1+N2/D2+ ... +Ni/Di

Where S is the number of germinated seeds, T is the total number of seeds and Ni number of germinated seeds, per day (Di).

Reduction of germination Percentage = (1-The number of germinated seeds conditions salinity/the number of germinated seeds conditions control)×100

At the end of tenth day, 5 seedlings were randomly selected and seedling and root length with their fresh weight were measured.

Also, seed viability index was determined by the following equation (Seghatoleslami, 2010):

Seed viability index =Final germination percentage × average seedling length (mm) / 100

Analysis of variance of data was performed with Microsoft Excel and MINITAB (Minitab, 1996) program and means were compared using Tukey's Multiple Range Test (TMRT).

III. Result

The results revealed that the final germination percentage and rate, reduction of germination percentage, seed viability index, seedling and root length, seedling and root fresh weight of radish, cabbage, mustard and water spinach were strongly affected (P<0.05) by all salt treatments (**Table 1-4**).

Salts stress on final germination percentage and germination rate:

The results of seed germination showed that, germination percentage and rate reduced with increasing salt concentration. Strong reduction was observed mainly at the higher level of salt concentration compared to control. Lowest mean germination percentage was observed in case of mustard (61 %) while the highest mean value was measured in radish (83%) (**Table 1**). The germination rate of the four vegetables species under observation showed marked differences in the timing of initiation and completion of germination (**Table 1**). In all seeds species except radish highest germination rate is related to the control treatment and the lowest rate is in the salt concentration of 16 dS m^{-1}. Germination response of radish at 2 dS m^{-1} was not significantly different from control. At higher salinity level (16 dS m^{-1}) the lowest germination rate was observed in mustard and water spinach while highest was observed in radish.

Salts stress on reduction of germination percentage and seed viability index:

Average reduction of germination percentage in different seed species showed the greatest reduction in salt concentration with 16 dS m^{-1} (**Table 2**). However at 16 dS m^{-1} salinity this reduction was more prominent in radish (47%) and cabbage (47%) than mustard (42%) and water spinach (37%). Means comparison showed that the application of 8 and 16 dS m^{-1} salinity resulted in the loss of seed viability index of four seeds species as compared to control treatment (0 dS m^{-1} salinity) (**Table 2**). Seed viability index of radish at 2 dS m^{-1} was not significantly different from control.

Salts stress on seedling and root length:

The continuous increase in length of seedling and root was observed in frequent hours of germination in four vegetable species in control as well as salt treatments. The data on the average length (**Table 3**) of seedling and root revealed that radish, cabbage, mustard and water spinach showed a strong inhibition with the increasing level of salt solution particularly at high salt levels (8 and 16 dS m^{-1}). The great reduction of seedling growth and particularly in root growth occurred with NaCl treatments in cabbage, mustard and water spinach compared to control. No significant difference was observed in seedling and root length of radish at 2 dS m^{-1} then control. Decrease in length of seedling was more prominent in radish than cabbage, mustard and water spinach. Although mustard, cabbage and water spinach showed sign of great affects on root length; great inhibition was recorded in radish. In contrast, seedling and root length of water spinach was less affected (**Table 3**).

Salts stress on fresh weight of seedling and root:

Statistical analysis showed that there were highly significant differences among all the vegetable species for seedling and root fresh weight. The fresh weight of seedling and root of all four species was strongly affected by all salinity levels. Seedling and root fresh weight were significantly reduced at high salinity levels (8 and 16 dS m^{-1} NaCl), whereas fresh seedling weight was reduced more as compared to fresh root weight. This trend was more prominent in radish than cabbage, mustard and water spinach at all salt levels except 2 dS m^{-1} NaCl. Highest seedling and root fresh weight of radish were recorded at 2 dS m^{-1} and was significantly different from control. However mustard showed less reduction. On the other hand fresh root weight of cabbage was strongly inhibited by all salinity treatments as compared to radish, mustard and water spinach. But this decrease was less in mustard (**Table 4**).

IV. Discussion

Salinity slowed the germination rate and at low concentrations the only effect was on germination rate and not total percentage of seeds (Shannon and Grieve, 1999). Generally, the decreases in the germination and seedling growth, due to the increase in the environment's salt concentration, are caused by physicochemical effects or by osmotic-toxic salts which exist in saline solutions. In fact, increasing the osmotic pressure (more negative osmotic pressure) resulted from the increased environment's salinity, on one hand disrupts the seed hydration, and on the other hand, the high concentrations of cations and anions (especially Na^+ and Cl^-) in the environment impede the seed germination by imposing toxicity in seeds (Rajabi and Postini, 2005, Atak *et al*., 2006). The adverse effect of salinity on plants can be caused by the loss of osmotic potential of root medium, specific ion toxicity and the lack of nutritional ions (Nabizadeh, 2002). Also stated that salinity imposes other stresses such as ion toxicity on plants, as a result of ion entry in excess of appropriate concentrations and nutrient imbalances, as commonly seen in the displacement of potassium by sodium (Khoshsokan *et al*. 2012). The reduction in seedling and root development may be due to toxic effects of the NaCl used as well as unbalanced nutrient uptake by the seedlings. The ability of the root system to control entry of ions to the shoot is of crucial importance to plant survival in the presence of NaCl (Hajibagheri, 1989). In addition, high salinity may inhibit seedling and root elongation by slowing down the water uptake by the plant (Werner and Finkelstein 1995).

V. Conclussion

In the present study, salt stress adversely affected the final germination percentage, germination rate, reduction of germination percentage, seed viability index, seedling and root length, seedling and root fresh weight of the four vegetables species. It can be concluded that salinity stress significantly decreased all studied seed germination and growth parameters of four vegetable crops and this information should be taken into consideration when crops grown under saline condition.

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Table1: Effect of salt (NaCl) stress on the final germination percentage (%) and germination rate (per day) in four vegetable crops.

Variables	Salinity level (ds m^{-1})	Radish	Cabbage	Mustard	Water spinach
Final germination percentage (%)	0	100 a	100 a	86.67 a	80 a
	2	100 a	83.33 b	60.0 b	66.67 b
	4	86.67 b	66.67 c	56.67 b	63.33 b
	8	73.33 c	56.67 c	53.33 b	60.0 b
	16	53.33 d	53.33 c	50.0 b	50.0 c
	Mean	82.67	72.0	61.33	64.0
Germination rate (per day)	0	5.0 a	4.75 a	3.50 a	2.42 a
	2	5.0 a	3.75 b	2.25 b	1.83 b
	4	4.08 b	2.75 c	1.75 b	1.75 b
	8	3.08 c	2.08 cd	1.33 b	1.50 c
	16	2.33 d	1.50 d	1.25 b	1.25 d
	Mean	3.90	2.97	2.02	1.75

Means followed by the same letter (s) in column (s) are not significantly different at $P<0.05$.

Table2. Effect of salt (NaCl) stress on the reduction of germination percentage (%) and seed viability index (mm) in four vegetable crops.

Variables	Salinity level (ds m^{-1})	Radish	Cabbage	Mustard	Water spinach
Reduction of germination percentage (%)	0	0 d	0 c	0 c	0 c
	2	0 d	16.67 b	30.80 b	16.67 b
	4	13.33 c	33.33 a	34.64 a	20.83 b
	8	26.67 b	43.33 a	38.49 a	25.0 b
	16	46.67 a	46.67 a	42.33 a	37.50 a
	Mean	17.33	28.0	29.25	20.0
Seed viability index (mm)	0	5.25 a	4.25 a	4.72 a	1.90 a
	2	5.76 a	2.97 b	2.26 b	1.16 b
	4	3.95 ab	2.15 c	1.92 b	0.79 c
	8	2.54 bc	1.23 d	1.64 bc	0.71 cd
	16	1.10 c	0.56 e	0.46 c	0.51 d
	Mean	3.72	2.23	2.20	1.02

Means followed by the same letter (s) in column (s) are not significantly different at $P<0.05$.

Table 3. Effect of salt (NaCl) stress on the seedling and root length (mm) in four vegetable crops.

Variables	Salinity level (ds m^{-1})	Radish	Cabbage	Mustard	Water spinach
Seedling length (mm)	0	5.25 a	4.25 a	5.42 a	2.37a
	2	5.76 a	3.55 b	3.77 b	1.74 b
	4	4.60 a	3.23 b	3.38 bc	1.25 c
	8	3.47 ab	2.17 c	3.08 cd	1.18 c
	16	2.07 b	1.07 d	0.93 d	1.03 c
	Mean	4.23	2.85	3.32	1.52
Root length (mm)	0	6.43 ab	4.67 a	6.66 a	3.15 a
	2	7.0 a	2.92 b	5.63 b	2.60 b
	4	4.13 bc	2.63 b	4.05 c	2.13 c
	8	4.07 c	2.47 b	3.35 c	1.03 d
	16	1.37 d	1.87 b	3.15 c	0.63 e
	Mean	4.60	2.91	4.57	1.91

Means followed by the same letter (s) in column (s) are not significantly different at $P<0.05$.

Table 4. Effect of salt (NaCl) stress on the fresh weight of seedling and root (mg) in four vegetable crops.

Variables	Salinity level (ds m^{-1})	Radish	Cabbage	Mustard	Water spinach
Fresh weight of seedling (mg)	0	0.46 b	0.31 a	0.21 a	0.58 a
	2	0.69 a	0.26 b	0.16 b	0.37 b
	4	0.37 bc	0.20 c	0.13 c	0.30 bc
	8	0.23 cd	0.17 cd	0.10 d	0.24 c
	16	0.10 d	0.15 d	0.07 e	0.19 c
	Mean	0.37	0.22	0.13	0.34
Fresh weight of root (mg)	0	0.07 b	0.19 a	0.12 a	0.18 a
	2	0.14 a	0.13	0.09 ab	0.12 b
	4	0.05 bc	0.10 c	0.08 b	0.09 bc
	8	0.04 cd	0.05 d	0.05 c	0.07 cd
	16	0.02 d	0.03 d	0.03 c	0.05 d
	Mean	0.06	0.10	0.08	0.10

Means followed by the same letter (s) in column (s) are not significantly different at $P<0.05$.