INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 5, No. 1, p. 37-48, 2014

RESEARCH PAPER OPEN ACCESS

Effect of salinity on germination, growth and yield of radish (*Raphanus Sativus* L.) varieties

Paromita Ghosh[1], Prosanta Kumar Dash[1*], Rituraj Sarker[2], Md. Abdul Mannan[1]

[1] *Agrotechnology Discipline, Life Science School, Khulna University, Khulna-9208, Bangladesh*

[2] *Agricultural Extension Officer (AEO), DAE, Bangladesh*

Key words: Germplasm, salinity, germination, variety, treatment.

http://dx.doi.org/10.12692/ijb/5.1.37-48 Article published on July 02, 2014

Abstract

The laboratory and pot experiments were conducted at Molecular Horticulture Lab and Germplasm Centre, Khulna University, Khulna during December 2012 to March 2013 to assess the effect of salinity on germination parameters, growth and yield contributing characters of three radish varieties viz. V_1 = Tasakisan Mula-1 (BARI Mula-1), V_2 = Druti (BARI Mula-3) and V_3 = Red Bombay. Four salinity levels control (0.66 dS m^{-1}), 4, 8 and 12 dS m^{-1} respectively were used as treatment in the experiments. The experiments were laid out in a factorial Completely Randomized Design (CRD) with three replications. Germination test was done in the laboratory following pertidish method. There was wide variation in germination parameters and growth parameters among the varieties due to different level of salt applications. In all the germination and growth parameters Tasakisan Mula-1 (BARI Mula-1) was found superior. Red Bombay was inferior regarding germination and growth parameters. Number of leaf per plant, leaf fresh weight (g), leaf length (cm), leaf width (cm), leaf dry weight (g), root fresh weight (g), root dry weight (g), root length (cm), root diameter (cm) and yield (g/plant) progressively decreased with the increasing salinity level as compared to control. Tasakisan Mula-1 (BARI Mula-1) showed better performance in the above mentioned morphological parameters and yield attributes. Druti (BARI Mula-3) was found intermediate. Red Bombay showed the lower value of those parameters. Among the varieties Tasakisan Mula-1 (BARI Mula-1) was the best tolerant to salinity at 12 dS m^{-1} followed by Druti (BARI Mula-3) at final harvest. Considering all the parameters observed in the experiment Tasakisan Mula-1 (BARI Mula-1) was found the best.

* **Corresponding Author:** Prosanta Kumar Dash ✉ pro.shanto@yahoo.com,

Introduction

Radish (*Raphanus sativus* L.) is a popular and important cruciferous vegetable crop in Bangladesh (Rashid *et al.,* 1983). Radish is popular for its pungency and taste. This crop can withstand so diversified climate that the crop is grown in tropical, subtropical and even in temperate countries. China and India are supposed to be its native (Katyal and Chandha, 1985). Radish is grown for its young tender tuberous roots which is eaten raw as salad and cooked as vegetables. The young leaves are also eaten as vegetables. It is a good source of protein, carbohydrate, Ca, K, P and ascorbic acid (Larry, 1977). Tender leaf is a good source of protein and vitamin C (Eguchi, 1979). The pungent flavor characteristics of radish are due to the presence of volatile isothiocyanates (trans-4-methyl-thiobutenyl isothiocyanate) (Srinivas and Naik, 1990). Pink skinned radish is generally richer in vitamin C than the white skin one. Vitamin C content of radish roots is greatly influenced by light condition (Jamil *et al.,* 2005).

Radish contain 17 mg (Pink cultivar) vitamin C and 5.0 I.U. of vitamin A (Gopalan and Balasubramanium, 1966). The radish root contains protein 0.7 g, fat 0.3 g, minerals 0.9 g, carbohydrate 6.8 g, calcium 50 mg, phosphorus 22 mg, thiamine 0.06 mg, riboflavin 0.02 mg, nicotinic acid 0.5 mg and fiber 0.8 g per 100 g of edible portion. Further, it has some medicinal values (Bose and Som, 1986).The radish has the cooling effect on human body and is thought suitable for patient suffering from liver troubles and jaundice and juice of fresh leaves is used as diuretic and laxative (Katyal and Chandha, 1985). In South Africa, the giant radish of Japan has shown much promise as a fodder crop yielding more than 60 t/ha of roots and 12-25 t/ha of leaves (Kolbe and Voss, 1952).

Now a days radish enjoys the popularity among all classes of people, rich or poor, urban and rural. If grown in hot weather small rooted varieties produces and extremely pungent roots, so they should be harvested at till young and small rather than allowed to reach the edible size (Sonneveld *et al.,* 1995). Radish classified as a crop which yield is moderately sensitive to salinity (Maas and Hoffman, 1977), but sometimes it is a crop of low sensitivity (Sonneveld, 1988). Although salinity may reduce growth, raising the salinity in the root zone is also used as a method to enhance the quality of some vegetables including radish (Mizrahi and Pasternak, 1985).

Considering the area and production radish stands as one of the major vegetables crop of Bangladesh (Anonymous, 1989) but the production is quite low as compared to the national requirement. Although it is mainly a winter vegetable crop, it becomes available in Bangladesh market as early as September and last as May. However, now a days it can be grown any time of the year in Bangladesh (Rashid *et al.,* 1983). Total vegetable production in Bangladesh is about 3.47 million tons per year of which 83.09% produced in winter and 16.91% in summer season (Anonymous, 2010). The present per hectare yield of radish is far below the levels attainable in the developed countries of the world (Shahidullah *et al.,* 1991). In Bangladesh, radish is cultivated in an area of 25.5 thousand hectares of land producing 85.42 thousands MTs of fleshy edible roots with per hectare yield of 8.60 MTs (BBS, 2010). Its yield can be increased in different ways such as use of improve high yielding varieties, proper cultural management, judicial application of fertilizer etc. (Sadu, 1986).

Salinity remains as one of the world oldest and most serious environmental problems in crop production (William, 1986). Excess soluble salt content is the principal growth limiting factor for the cultivated plants on the coastal saline soil. The nature and content of soluble salts, salt dynamic and water regimes during the growth season strongly influence crop growth (Karim *et al.,* 1990). Salinity causes not only the yield reductions but also it affects the germination in many glycophyte crop plants throughout the world. Growth suppression may be a non-specific effect of salts, depending more on the total concentration of soluble salts than on specific ions (Adams, 1991). In general, salinity affects almost

every aspect of the physiology and biochemistry of plants (Cuartero *et al.,* 2005). Salinity can induce water stress as it increases the osmotic pressure of the soil solution. High salinity may also result in too high an internal ion concentration (ion excess) and thus cause growth reduction. It is often difficult to assess the relative importance of ion excess and water stress as growth limiting factors (Greenway and Munns, 1980). Germination and water stress induced by salinity may influence plant growth by adverse effects on dry matter partitioning, cell extension, cell division, leaf photosynthesis and or transpiration (Maas and Hoffman, 1977). Effects on photosynthesis may be attributed both to stomatal and nonstomatal responses due to excess salinity (Cheeseman, 1988). The reduction of leaf photosynthesis at high salinity was the result of reduced stomatal conductance (Xu *et al.,* 1994). In Bangladesh, more than 30% of the total cultivable area is in the coastal belt. Out of 2.85 million hectares of the coastal and off-shore areas, about 0.83 million hectares are affected by different degrees of salinity (Karim *et al.,* 1990). Moreover, the salt affected area is increasing day by day. About 2.8 million hectares of land under saline area remain fallow for about 4-7 months (middle of November-June) in each year ((Karim *et al.,* 1982). So the presence of excess soluble salt in soil is one of the major factors that reduces the growth and development of cultivated crop plant in coastal areas of Bangladesh. The salinity problem is severe in the winter though during summer the salt concentration decreases (Karim *et al.,* 1990). The need to develop crops with higher salt tolerance has increased greatly within the last decade due to increased salinity problems throughout the world (Sivritepe *et al.,* 2003).

The yield of radish is much lower in saline soil compared to salt free soil. The production technology of any vegetable as well as radish is a complex process and in saline condition it becomes more complex. So it is important to know the effect of varying degree of salinity on radish seed germination with a view to ensure optimum plant population and high yield. Therefore, the present research work was undertaken keeping in mind the following objectives:

1. To observe the effect of salinity on germination of radish seed.

2. To assess the effect of salinity on the growth and yield contributing characters of radish varieties

Materials and method

The study was undertaken during *Rabi* season from December 2012 to March 2013 to evaluate the effect of salinity on germination, growth, yield and yield attributing characters of radish.

Effect of different salinity levels on radish seed germination

Experimental site

The research work was conducted at the Molecular Horticulture Lab. Agrotechnology Discipline, Khulna University, Khulna during December 2012 to March 2013.

Treatments

There are two factors-

Factor A: salinity levels- 4 (S_0 = Control (0.66 dS m^{-1}, S_1 = 4 dS m^{-1}, S_2 = 8 dS m^{-1} ,S_3 = 12 dS m^{-1}) and Factor B: radish varieties- 3 (V_1 = Tasakisan Mula-1, V_2 = Druti, V_3 = Red Bombay (Local variety).

Experimental design

The experiment was laid out in a factorial Completely Randomized Design (CRD) with three replications.Total number of petridishes = 3 (varieties) × 4 (salinity) × 3 (replication) = 36.

Preparation of the solutions

Different concentrations of salt (0.66 dS m^{-1}, 4 dS m^{-1}, 8 dS m^{-1} and 12 dS m^{-1}) were used in the study. Required amount of common salt (NaCl) was estimated using the following formula and added to distilled water to make the required solution of NaCl.

Percent of salt = 0.064 × EC (dS m^{-1}). To make 4 dS m^{-1} salt solution 1.9 g sodium chloride (NaCl) was taken in a 1000 ml volumetric flask and filled up to

the mark with distilled water. Then 8 dS m^{-1} and 12 dS m^{-1} salt solutions were prepared in the same way by taking 3.8 g L^{-1} and 5.7 g L^{-1} NaCl, respectively.

Germination test

The germination test was conducted using petridish method. Two pieces of blotting papers (soaked with distilled water and saline solutions) were used in each petridish as substrate. Twenty five seeds for each variety were placed in each petridish at an equal distance from one another. Each treatment was replicated three times. The solutions were used for germination of seeds and distilled water was used in control. The petridishes were observed every day and respective solutions were supplied whenever required.

Data collection

Germination parameters

The petridishes were observed every day and the numbers of germinated seeds were recorded. The germination percentage was calculated using the following formula-Germination (%) =

$$\frac{\text{Number of seeds germinated}}{\text{Total number of seeds placed in petridish}} \times 100$$

The rate/speed of germination was calculated using the following formula (Krishnaswamy and Seshu, 1990).

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

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

Speed of germination (%) =

$$\frac{\text{Number of seeds germinated at 72 h}}{\text{Number of seeds germinated at 168 h}} \times 100$$

Root and shoot length measurement

Randomly selected five seedlings were taken from each petridish to measure root and shoot length. It was measured with a measuring scale and expressed in centimeters. Root and shoot length of the seedlings were measured after 14 days of seed settings. *Dry weight of root and shoot measurement*

After 14 days of seed settings the roots and shoots of the seedlings of each petridish were wrapped with brown paper and dried in oven at 70° C for 48 hours. These were measured by four digit balance and expressed in gram.

Effect of different salinity levels on growth and yield contributing characters of radish

Location

A pot experiment was conducted at the Germplasm Centre of Agrotechnology Discipline, Khulna University, Khulna during the rabi season from December 2012 to March 2013.

Soil

The soil used in pots was collected from the garden of Germplasm Centre of Agrotechnology Discipline, Khulna University, Khulna. After collecting the soil it was sun dried and ground well. Then the soil debris was removed by sieving and the soil was put into earthen pot after mixing with manure and fertilizer.

Planting materials

Three varieties of radish (*Raphanus sativus*. L) seeds were used as the planting material in the experiment. They were Tasakisan Mula-1 (BARI Mula-1), Druti (BARI Mula-3) and Red Bombay (Local variety) and denoted as V_1, V_2, V_3, respectively.

Collection of Seed

The experiment was conducted with seeds of radish cv. Tasakisan Mula-1 and Druti which are BARI registered variety and the Red Bombay variety is originated from India. Seeds of all the varieties were obtained from the Capital Seed House, Nirala, Khulna.

Soaking

Seeds were soaked in water for 24 hours and then wrapped with a piece of thin cloth prior to planting. Then they were spreaded over polythene sheet for 2 hours to dry out surface water. This treatment was given to help quick germination of seeds.

Seed sowing

Radish seeds of the tested varieties were sown in pots on 2 December 2012. Required amounts of seeds were sown in each pot. After seed sowing, the pots were watered and the soil of the pots was kept well moisture to ensure proper germination of the seeds. Other cultural practices were done wheneven required i.e. timely weeding and water supply.

Treatments

The experiment was designed to study the effect of growth, yield and yield attributes of radish. Thus the experiment consisted of two factors.

Factor A: salt solutions-4 (S_0 = Control (0.66 dS m^{-1}, S_1 = 4 dS m^{-1}, S_2 = 8 dS m^{-1}, S_3 = 12 dS m^{-1}) and Factor B: radish varieties-3 (V_1 = Tasakisan Mula-1, V_2 = Druti and V_3 = Red Bombay (Local variety).

Data collection

The data were collected from 36 randomly selected pot of plants tagged at the different stage of growth. Data on the following parameters were collected from the sample plants during the experimentations. For data collection at different growth stages, three (3) plants were selected from each treatment. To ensure growth, one harvest was done at 90 DAS. At final harvest, the sampled plants were kept into paper bag and carried out to the laboratory. The plant parts were separated into shoots, roots and leaves and their fresh and dry weight were taken. The separated different parts were dried at 70° C for 48 hours prior to recording the dry weight. The following data were collected by three plants from each treatment. The data were collected on the following parameters: number of leaves, Weight of fresh leaves, Length of leave, Width of the leaves, Weight of dry leaves, Weight of fresh roots, Length of root, Diameter of root, Weight of dry roots and Yield.

Statistical analysis

All the data collected were analyzed using analysis of variance (ANOVA) techniques using F test. The differences between the treatment means were determined by using Duncan's New Multiple Range Test (DMRT) at 1% and 5% level of significance. Functional relationships between salt concentration and yield, number of leaf per plant and yield, root length and yield, leaf fresh weight and yield were developed using simple linear regression analysis.

Results and discussion

Effect of different salinity levels on radish seed germination

Germination parameters

Germination percentage

The germination percentage was differed significantly among the varieties (Table 2). The range of germination percentage was 82.33 to 86.33 % (Table 2). The highest germination percentage (86.33%) was observed in Tasakisan Mula-1 which was statistically similar to Druti (85.00%). The improved variety Red Bombay was inferior to Tasakisan Mula-1 and Druti whose germination percentage was 82.33% (Table 2). There was significant variation in germination percentage from different salinity levels. The highest germination percentage (95.55%) was found at control (0.66 dS m^{-1}) while 12 dS m^{-1} treatment gave the lowest (72.88%) results (Table 3). Jeannette *et al.* (2002) reported seed germination is not significantly affected up to 16.3 dS m^{-1}, but is severely inhibited when salinity increased to 22 dS m^{-1}. Demir and Arif (2003) also demonstrated that the suppression of germination at high levels might be mainly due to osmotic stress and salinity also decreased germination percentage.

Germination energy (%)

There was significant variation in germination energy among the three radish varieties (Table 2). The maximum germination energy (79.00%) was observed in Tasakisan Mula-1 which was statistically similar to Druti (75.33%) and minimum (74.00%) was in Red Bombay (Table 2). Different salinity levels affected the germination energy of seeds significantly (Table 3). The highest germination energy (89.33%) was found at control treatment and the lowest germination energy (62.22%) at 12 dS m^{-1} salinity level (Table 3).

Germination capacity (%)

The germination capacity was differed significantly among the varieties (Table 2). The range of germination capacity was 82.33 to 86.33 % (Table 2). The highest germination capacity (86.33%) was observed in Tasakisan Mula-1 which was statistically similar to Druti (85.00%). The improved variety Red Bombay was inferior to Tasakisan Mula-1 and Druti whose germination capacity was 82.33% (Table 2). There was significant variation in germination capacity from different salinity levels (Table 3). The highest germination capacity (95.55%) was found at control (0.66 dS m^{-1}) while 12 dS m^{-1} treatment gave the inferior (72.88%) results (Table 3).

Table 2. Varietal differences on germination parameters among three radish varieties.

Varieties	Germination percentage	Germination energy (%)	Germination capacity (%)	Germination speed (%)
Tasakisan Mula-1	86.33 a	79.00 a	86.33 a	91.37 a
Druti	85.00 a	75.33 a	85.00 a	88.29 b
Red Bombay	82.33 b	74.00 b	82.33 b	89.59 b
Level of significance	0.01	0.01	0.01	0.05
CV (%)	3.35	3.50	3.35	4.39

The figures having different letter(s) in a column are significantly different at 1% or 5% level and figures having same letter(s) in a column are not significantly different by DMRT.

Table 2. Effect of different levels of salinity on germination parameters of three radish varieties.

Salinity levels (EC dS m^{-1})	Germination percentage	Germination energy (%)	Germination capacity (%)	Germination speed (%)
0 (0.66)	95.55 a	89.33 a	95.55 a	93.51 a
4	87.11 b	79.55 b	87.11 b	91.41 a
8	82.66 b	73.33 c	82.66 b	88.82 b
12	72.88 c	62.22 d	72.88 c	85.26 b
Level of significance	0.01	0.01	0.01	0.01
CV (%)	3.35	3.50	3.35	4.39

The figures having different letter(s) in a column are significantly different at 1% or 5% level and figures having same letter(s) in a column are not significantly different by DMRT.

Germination speed (%)

There was significant variation in germination speed among the three radish varieties (Table 2). The maximum germination speed (91.37%) was observed in Tasakisan Mula-1 and minimum (88.29%) was in Druti (Table 2). Different salinity levels affected the germination speed of seeds significantly (Table 3). The highest germination speed (93.51%) was found at control treatment and the lowest germination speed (85.26%) at 12 dS m^{-1} salinity level (Table 3).

Growth parameters

Shoot length (cm) seedling^{-1}

Radish varieties differ significantly (Table 4) in shoot length and the range was from 6.61 cm to 6.27 cm (Table 4). The highest shoot length (6.61 cm) was found in Tasakisan Mula-1. The lowest shoot length (6.27 cm) was recorded from Red Bombay. Varietal differences in shoot length were reported by Zaman *et al.* (1995) and they also observed that plant height was decreased with increasing salinity. Shoot length varied greatly across salinity levels. As the salt concentration increased, shoot length reduced. Shoot length varied from 7.27 cm to 5.50 cm (Table 5). The highest shoot length (7.27 cm) was recorded from control treatment. The lowest shoot length (5.50 cm) was recorded at 12 dS m^{-1} EC.

Table 3. Varietal differences on length and dry weight of shoot and root among the three radish varieties.

Varieties	Shoot length (cm) seedling^{-1}	Root length (cm) seedling^{-1}	Dry weight of shoot (g) seedling^{-1}	Dry weight of root (g) seedling^{-1}
Tasakisan Mula-1	6.61 a	6.29 a	0.028 a	0.024 a
Druti	6.42 a	6.08 a	0.022 a	0.021 a
Red Bombay	6.27 b	5.96 b	0.018 b	0.018 b
Level of significance	0.01	0.01	0.01	0.01
CV (%)	2.13	4.82	23.20	11.72

The figures having different letter(s) in a column are significantly different at 1% or 5% level and figures having same letter(s) in a column are not significantly different by DMRT.

Root length (cm) seedling^{-1}

There was significant variation in root length among the three radish varieties (Table 4). The maximum (6.29 cm) was observed in Tasakisan Mula-1 which was statistically similar to Druti (6.08 cm) and minimum (5.96 cm) was in Red Bombay (Table 4). Salinity also influences the root length (Table 5). The maximum length of roots (6.99 cm) was obtained from the control level and the minimum (5.04 cm) was recorded when seeds were subjected to 12 dS m^{-1} EC. Gupta *et al.* (1993) observed increased root length at moderate salinity levels (7.5 dS m^{-1}) that do not support the result of the present study. However, Zaman *et al.,* (1995) showed a significant reduction in root length due to salinity that is similar to the result of the present experiment.

Table 4. Effect of salinity levels on length and dry weight of shoots and roots among three radish varieties.

Salinity levels (EC dS m^{-1})	Shoot length (cm) seedling^{-1}	Root length (cm) seedling^{-1}	Dry weight of shoot (g) seedling^{-1}	Dry weight of root (g) seedling^{-1}
0 (0.66)	7.27 a	6.99 a	0.036 a	0.032 a
4	6.84 b	6.55 a	0.025 a	0.025 ab
8	6.12 c	5.86 b	0.019 b	0.017 b
12	5.50 d	5.04 c	0.011 b	0.009 c
Level of significance	0.01	0.01	0.01	0.01
CV (%)	2.13	4.82	23.20	11.72

The figures having different letter(s) in a column are significantly different at 1% or 5% level and figures having same letter(s) in a column are not significantly different by DMRT.

Dry weight of shoot (g) seedling^{-1}

Radish varieties show significant differences (Table 4) in dry weight of shoots. Shoot weight varied from 0.028 g to 0.018 g (Table 4). The highest shoot dry weight (0.028 g) was found in Tasakisan Mula-1 which was statistically similar to Druti (0.022 g). The lowest shoot dry weight (0.018 g) was found in Red Bombay (Table 4). Different level of salinity had significant effect on dry weight of shoot (Table 5). The dry weight of shoot was reduced with the increase in salt concentration. The highest dry weight of shoots (0.036 g) was found in control and the lowest dry weight of shoots (0.011 g) was recorded when seeds were subjected to 12 dS m^{-1}.

Dry weight of roots (g) seedling^{-1}

Radish varieties show significant differences (Table 4) in dry weight of roots. Roots dry weight varied from 0.024 g to 0.018 g (Table 4). The highest roots dry weight was found in Tasakisan Mula-1 (0.024 g) which was statistically similar to Druti (0.021 g). The lowest roots dry weight was found in Red Bombay (0.018 g) (Table 4). Different level of salinity had significant effect on dry weight of roots (Table 5). The highest dry weight of roots (0.032 g) was found in control treatment and the lowest dry weight of roots (0.009 g) was recorded from 12 dS m^{-1} level of salinity (Table 5).

Table 5. Effect of variety on yield and yield contributing characters of radish.

Varieties	No of leaf plant^{-1}	Leaf fresh weight (g)	Leaf length (cm)	Leaf width (cm)	Leaf dry weight (g)	Root fresh weight (g)	Root dry weight (g)	Root length (cm)	Root diameter (cm)	Yield g/plant
Tasakisan Mula 1	13.05 a	257.94 a	28.99 a	7.93 ab	17.50 a	281.23 a	29.80 a	16.45 a	4.92 a	281.23 a
Druti	12.66 bc	251.77 a	28.13 b	7.83 ab	17.44 ab	264.87 b	28.11 ab	15.51 b	4.85 ab	264.87 b
Red Bombay	12.58 bc	246.30 b	27.27 c	7.70 b	16.90 b	258.80 b	27.39 b	15.35 b	4.74 ab	258.80 b
CV (%)	2.59	4.16	5.25	3.27	5.44	2.26	3.11	2.54	1.93	2.26
Level of significance	0.01	0.05	0.05	0.05	0.05	0.01	0.01	0.01	0.01	0.01

The figures having different letter(s) in a column are significantly different at 1% or 5% level and figures having same letter(s) in a column are not significantly different by DMRT.

Effect of different salinity levels on growth and yield contributing characters of radish

Number of leaves plant^{-1}

Leaves plant^{-1} are one of the most important characters of radish. A significant variation (Table 6) was recorded among the radish varieties for producing the number of leaves per plant (Table 6). The highest (13.05) number of leaves was produced by Tasakisan Mula-1 and the lowest (12.58) was found in Red Bombay. It was observed from the experiment that Tasakisan Mula-1 was the highest resistant variety for producing number of leaves and which was in agreement with Druti (Table 6). The highest number of leaves (14.33) was found in control treatment and the lowest number of leaves was (11.44) in the highest salinity level at 12 dS m^{-1}. The number of leaves significantly higher in control plant, which was gradually decreased with the increase in salinity levels (Table 7).

Table 6. Effect of different salinity levels on the growth and yield of radish.

EC (dS m^{-1})	No of leaf plant^{-1}	Leaf fresh weight (g)	Leaf length (cm)	Leaf width (cm)	Leaf dry weight (g)	Root fresh weight (g)	Root dry weight (g)	Root length (cm)	Root diameter (cm)	Yield g/plant
0 (0.66)	14.33 a	277.96 a	31.77 a	9.20 a	20.22 a	313.66 a	31.68 a	18.25 a	5.19 a	313.66 a
4	13.14 b	264.10 ab	29.03 ab	8.31 b	18.47 ab	295.57 b	30.14 ab	16.52 b	5.00 a	295.57 b
8	12.14 c	249.66 b	27.33 bc	7.34 c	16.42 b	273.40 c	28.36 b	15.36 c	4.76 b	273.40 c
12	11.44 c	216.29 c	24.40 c	6.44 d	14.00 c	190.57 d	23.55 c	12.95 d	4.40 c	190.57 d
CV (%)	2.59	4.16	5.25	3.27	5.44	2.26	3.11	2.54	1.93	2.26
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

The figures having different letter(s) in a column are significantly different at 1% or 5% level and figures having same letter(s) in a column are not significantly different by DMRT.

Weight of fresh leaves

Fresh weight of leaves gives an identification of leaf age of the plant. The leafage indicates the size of the photosynthetic system. The leaf fresh weight, among the varieties was significantly (Table 6) varied at final harvest. The highest amount of leaf fresh weight (257.94 g) was observed in Tasakisan Mula-1 where Druti produced statistically similar to Tasakisan Mula-1. The minimum leaf fresh weight (246.30 g) was recorded from Red Bombay at final harvest (Table 6). Result of the present study showed that Tasakisan Mula-1 was the highest resistant variety for producing leaf fresh weight and which was followed by Druti. A significant variation in leaf fresh weight was observed in different salinity levels (Table 7). The maximum leaf fresh weight (277.96 g) was obtained from control and the minimum leaf fresh weight (216.29 g) was found in 12 dS m^{-1} salinity level (Table

7). It was found from the experiment that leaf fresh weight decreased gradually with the increase of salinity levels.

Length of leaves

There was a significant variation in length of leaves among the three radish verities (Table 6). The highest length of leaves (28.99 cm) was found in Tasakisan Mula-1 and the lowest one (27.27 cm) was observed in Red Bombay (Table 6). It was found from the experiment that Tasakisan Mula-1 was the resistant variety for producing highest leaf length. Different salinity levels affected length of leaves significantly. The highest leaf length (31.77 cm) was found at control treatment and the lowest leaf length was (24.40 cm) at 12 dS m^{-1} salinity level. Plants in control treatment had the highest length of leaves, which was gradually decreased with the increase in salinity levels (Table 7). However, the decrease was perceptible even at the level of salinity and it was significantly different at the highest level of salinity.

Width of leaves

Tasakisan Mula-1 was recorded superior in respect of leaf width (7.93 cm) which was statistically similar to Druti. Lowest leaf width was obtained from Red Bombay (7.70 cm) (Table 6). Different salinity levels affected leaf width significantly (Table 7). The highest leaf width (9.20 cm) was recorded from the control treatment and the lowest leaf width (6.44 cm) was at 12 dS m^{-1} salinity level. Plants in control treatment had the highest leaf width, which gradually decreased with the increase in salinity (Table 7).

Leaf dry weight

Significant variation was found among the varieties in respect of dry weight of leaves (Table 6). The maximum leaf dry weight (17.50 g) was observed in Tasakisan Mula-1 which was statistically identical to Druti and the minimum (16.90 g) leaf dry was produced in Red Bombay (Table 6). It was found from the experiment that Tasakisan Mula-1 and Druti were the higher resistant varieties for producing leaf dry weight and Red Bombay was susceptible. The maximum leaf dry weight (20.22 g) was found in the control treatment and the minimum (14.00 g) was found in 12 dS m^{-1} level of salinity (Table 7). It was found from the experiment that leaf dry weight decreased gradually with the increase of salinity levels.

Root fresh weight

Significant variation was found among the varieties in respect of fresh weight of root (Table 6). Fresh weight of roots varied from 258.80 g to 281.23 g. The highest fresh weight of roots was observed in Tasakisan Mula-1 (281.23 g) and the lowest (258.80 g) was observed in Red Bombay. But intermediate yield production was found in the variety Druti (264.87 g). It was found from the experiment that Tasakisan Mula-1 was the highest resistant variety for producing maximum root fresh weight. Different salinity levels affected root fresh weight significantly. The highest root fresh weight (313.66 g) was at control treatment and the lowest root fresh weight (190.57 g) was at 12 dS m^{-1} salinity level. Plants in control treatment had the highest root fresh weight, which gradually decreased with the increase in salinity level (Table 7).

Root dry weight (g)

Significant variation was found among the varieties in respect of the root dry weight (Table 6). The maximum root dry weight (29.80 g) was observed in Tasakisan Mula-1 and the minimum (27.39 g) in Red Bombay (Table 6). It was found from the experiment that Tasakisan Mula-1 was the higher resistant variety for producing leaf dry weight and Red Bombay was susceptible. The maximum root dry weight (31.68 g) was found in the control treatment and the minimum (23.55 g) was found in 12 dS m^{-1} level of salinity (Table 7). It was found from the experiment that root dry weight decreased gradually with the increase of salinity levels.

Root length (cm)

The mean length of root of three radish varieties ranged from 16.45 cm to 15.35 cm (Table 6). The maximum length (16.45 cm) of root was found in Tasakisan Mula-1 and the minimum root length (15.35 cm) was found in Red Bombay. The length of

root was significantly affected by the salinity levels (Table 7). The maximum (18.25) root length was found in control treatment and that was the lowest 12.95 cm in 12 dS m^{-1} level of salinity (Table 7).

Root diameter (cm)

The mean values of root diameter varied markedly among the varieties under the study (Table 6). The highest diameter (4.92 cm) was found in the variety of Tasakisan Mula-1 and that was minimum in Red Bombay (4.74 cm) (Table 6). The highest root diameter (5.19 cm) was found in control treatment and the lowest (4.40 cm) in the highest salinity level at 12 dS m^{-1}. The root diameter was significantly higher in control plant, which was gradually decreased with the gradual increase in salinity levels (Table 7).

Yield (g/ plant)

Significant variation was found among the varieties in respect of the yield which indicates the weight of fresh roots (Table 6). Fresh weight of roots in three varieties varied from 258.80 g to 281.23 g. The highest fresh weight of roots was observed in Tasakisan Mula-1 (281.23 g). The lowest (258.80 g) root fresh weight was observed in Red Bombay. But intermediate yield production was found in the variety Druti (264.87 g). There was statistically significant variation was observed in different salinity levels (Table 7). The highest root fresh weight (313.66 g) was at control treatment and the lowest root fresh weight was (190.57 g) at 12 dS m^{-1} salinity level. Plants in control treatment had the highest root fresh weight, which gradually decreased with the increase in salinity levels (Table 7).

Acknowledgement

The author reveals immense pleasure to express heartfelt indebtness and deepest sense of gratitude to her honorable teachers, Dr. Md. Abdul Mannan, Professor and Prosanta Kumar Dash, Assistant Professor and AEO, lab technicians, Agrotechnology Discipline, Khulna University, for their kind and painstaking guidance, compassionate help and inspiration in all phases of the study and preparation of the manuscript.

References

Adams P. 1991. Effects of increasing the salinity of the nutrient solution with major nutrients or sodium chloride on the yield, quality and composition of tomatoes grown in rockwool. Journal of Horticultural Science **66,** 201–207.

Anonymous. 1989. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics. 172.

Anonymous. 2010. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics. 120.

BBS (Bangladesh Bureau of Statistics). 2010. Statistics Year Book of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka. 57.

Bose TK, Som MG. 1986. Vegetable crops in India (1st edition). Naya prakash publications. Kalcuta, India. 409 - 425.

Cheeseman JM. 1988. Mechanisms of salinity tolerance in plants. Plant Physiology **87,** 547–550.

Cuartero J, Bolarin MC, Asins MJ, Moreno V. 2005. Increasing salt tolerance in the tomato. Journal of Experimental Botany **57,** 1045-1058.

Demir M, Arif I. 2003. Effects of different soil salinity levels on germination and seedling growth of safflower (Carthamus tinctoriusl). Turkish Journal of Agriculture **27,** 221-227.

Eguchi Y. 1979. Radish growing in Japan Uchihara International Agricultural Training centre. International Journal of Agriculture. 18(21), 321.

Gopalan C, Balasubramanium. 1966. Nutritive value of Indian foods (6th revised ed.) KMR, publishing company limited, New Delhi, India. 267-288.

Greenway H, Munns R. 1980. Mechanisms of salt tolerance in nonhalophytes. Annual Review on Plant Physiology **31,** 149–190.

Jamil M, Lee CC, Rehman SU, Lee DB, Ashraf M. 2005. Salinity (NaCl) tolerance of *Brassica* species at germination and early seedling growth. Electron Journal of Environment and Agricultural Food Chemistry **4,** 970–976.

Jeannette S, Craig R, Lynch JP. 2002. Salinity tolerance of *phaseolus* species during germination and early seedling growth. Crop Science, 1584-1594.

Karim Z, Hussain SG, Ahmed M. 1990. Salinity problems and crop intensification in the coastal regions of Bangladesh. Seminar proceedings on BARC (Bangladesh Agricultural Research Council). Dhaka, 1.

Karim Z, Shaheed SM, Salauddin ABM, Alam MK, Hoq A. 1982. Coastal saline soils and their management in Bangladesh. BARC (Bangladesh Agricultural Research Council), Dhaka. Published, 11-15.

Katyal SLK, Chandha. 1985. Vegetables growing in India. (3rd edition) Oxford and IBH publishing company limited. New Delhi, India. 53-55.

Kolbe J, Voss R. 1952. Salt tolerance of turnip, lettuce, carrot and sweet pepper (*Brassica rapa* L., *Lactuca sativa* L., *Daucus carota* L., *Capsicum annuum* L.). Japan. Journal of Tropical Agriculture **29,** 208-212.

Larry KH. 1977. Commercial vegetables crops development of Horticulture. Washington State University, Pullmar, Washington. American Journal of Horticulture **99(2),** 164.

Maas EV, Hoffman GJ. 1977. Crop salt tolerance - Current assessment. Netherland Journal of Irrigation and Drainage **103(2),** 115–134.

Mizrahi Y, Pasternak D. 1985. Effect of salinity on quality of various agricultural crops. Plant and Soil Science. Asian Journal of Plant Science, **89**, 301–307.

Rashid MM, Ahmed MS, Tasaki S, Hossain AKMA. 1983. Studies on the performance of four radish cultivars when harvested at different dates. Bangladesh Journal of Horticulture **12(1),** 1-5.

Sadu MK. 1986. Root crops and Vegetables crops in India. Naya prokash publishing company limited, Calcutta, 385-407.

Shahidullah M, Rahman MA, Karim MA, Nath KK, Jahangir AA, Haque ME. 1991. Effect of potassium on growth and yield of radish, *Raphanus sativus* L. Journal of Asiatic Society. **7(2),** 129-136.

Sivritepe N, Sivritepe HO, Eris A. 2003. The effects of NaCl priming on salt tolerance in melon seedlings grown under saline conditions. Scientific Horticulture, **97,** 229-237.

Sonneveld C, Van de K, Bos AL. 1995. Effects of nutrient levels on growth and quality of radish (*Raphanus sativus* L.) grown on different substrates. Australian Journal of Plant Nutrition **18,** 501–513.

Sonneveld C. 1988. Salt tolerance of greenhouse crops. Netherlands Journal of Agricultural. Science, **6(3),** 3–73.

Srinivas K, Naik LB. 1990. Growth and Yield of radish (*Raphanus sativus* L.) in relation to nitrogen and potash fertilizer. Indian Journal of Horticulture. **47(1),** 114-119.

William MJR. 1986. The national and international drought and salinity effects on agricultural production. Australian Journal of Plant Physiology. **13,** 1-3.

Xu HL, Gauthier L, Gosselin A. 1994 Photosynthetic responses of greenhouse tomato plants to high solution electrical conductivity and low

soil water content. Journal of Horticultural Science, **69,** 821–832.

Zaman SK, Choudhury DAM, Bhuiyan NI. 1995. Effect of salinity on germination, growth, yield and mineral composition of rice. Bangladesh Journal of Agricultural Science **24,** 103-109.