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Germination, growth and yield response of Kohlrabi, *Brassica oleracea* var. *gongylodes* L. to NaCl induced salinity stress

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Abstract

Objective: To determine the effect of different salinity levels on growth, yield, yield attributes, and different parameters of germination and seedling growth of kohlrabi, *Brassica oleracea* var. *gongylodes*, a vegetable of the family Brassicaceae. **Methods:** This study was carried out using completely randomized design in seven replications. Experimental treatment includes five levels of salinity (3, 6, 9, 12 and 15 dSm^{-1}) along with control. **Results:** Highest germination energy (56.79%), shoot length (4.84 cm), root length (3.46 cm) and dry weight of seedling (75.88 mg) were observed in control which were statistically similar to 3 dSm^{-1} (50%, 4.81cm, 3.36 cm and 69.29 mg respectively). The highly decreased germination percentage (46.79%), root length (2.17 cm) and dry weight of seedling (52.57 mg) were observed in 15 dSm^{-1} salinity level compared to their control values which was statistically similar to 12 dSm^{-1} salinity level. In case of pot study, the highest leaf number $plant^{-1}$ (15) and leaf width (15.31 cm) were obtained from control condition. Moreover, highest diameter of knob (9.04 cm), dry weight of knob (46.86 g), fresh weight of shoot (128.3 mg) and dry weight of shoot (12.57 mg) were obtained from control condition which were statistically similar to 3 dSm^{-1} (8.19 cm, 36.01 g, 99.86 mg and 10.29 mg respectively), 6 dSm^{-1} (7.43 cm, 33.9 g, 104.6 mg and 10.71 mg respectively) and 9 dSm^{-1} (7.36 cm, 32.81 g, 124.7 mg and 11.14 mg respectively) salinity levels. **Conclusion:** Considering all the growth, yield and yield attributes observed in this study, kohlrabi was found tolerant to salinity levels up to 9 dSm^{-1} while in respect of germination and seedling growth, it was found tolerant to salinity levels up to 3 dSm^{-1}.

Keywords: Salinity stress, germination, growth, kohlrabi, *Brassica oleracea*, yield, yield attributes.

1. Introduction

Kohlrabi, *Brassica oleracea* var. gongylodes, a vegetable of the family Brassicaceae, is widely cultivated in North America, India, China, Thailand and Northern Vietnam (Choil *et al*. 2010). The edible part of kohlrabi is called knob formed by swelling of tissue at the base of the stem entirely above the ground which is primarily used as a cooked vegetable. This vegetable is also used as feed but recently its consumption has gained popularity due to high ascorbic acid (vitamin C) and potassium content combined with high dietary fiber and low amount of lipid content (Ćosić *et al*. 2013). In the past decades, the cultivation of kohlrabi increased after the discovery of presence of glucosinolates in all vegetables from the Brassicaceae family including radish, cabbage, Chinese cabbage, kohlrabi and broccoli. This compound has strong anticarcinogenic properties (Johnson 2002). They are also important sources for anticancer "nutraceutical" compounds, fibers (including pectin and cellulose), calcium, zeaxanthin, glucosinolates and phenolics (Harbaum *et al*. 2007). Higher amounts of dietary fibers are helpful in controlling body weight and can be supplied only

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from vegetables with texture like kohlrabi and radish (Terry *et al*. **2001**; Liu *et al*. **2003**).

Stress is defined as an abnormal condition potentially unfavorable to any living organism, induced by the effect of different biological and environmental factors (Keshavarzi *et al*. **2011a**). During growth and development, crop plants are frequently exposed to diverse environmental stresses which slow down or even retard their growth stages. Salinity in soil or water is one of the major stresses particularly in arid and semi-arid regions which can severely diminish crop production (Moud and Maghsoudi **2008**; Keshavarzi **2011b**). In worldwide, approximately 20% of the total cultivable land (more than 0.9 billion hectares of land) is severely affected by salinity which accounts for higher than 6% of the world's total agricultural land area. Salinization in soil or water is predominantly caused by sodium chloride (NaCl) salt and plants have developed mechanisms to maintain its accumulation (Munns and Tester **2008**).

In the plant growth cycle, seed germination is the most critical and vulnerable stage of terrestrial angiosperms which determines seedling growth and establishments (Keshavarzi **2011b**). Germination is the forecasting stage of plant growth which reveals how the plant responds to salt stress (Cuartero *et al*. **2006**). Salt stress may affect the seed germination either by producing an osmotic potential outside to the seed impeding water uptake, or imposing the toxic effects of ions (Na^+ and Cl^-) on the sprouting seed (Kaya *et al.* **2006**). Moreover, salinity stress impairs germination; causes early seedling growth and nodule formation; slows down plant growth and development resulting reduction in crop yield (Tsegazeabe and Teferii **2012**). In addition, salinity also retards growth of the shoot due to the toxic effect of ions (Na^+ and Cl^-) on the cell division and elongation (Kaymakanova **2009**). Higher amount of salt in irrigation water or in soil causes both hyper ionic toxic effects and hyper osmotic stress on plants resulting demise of plant growth (Hasegawa *et al*. **2000**).

Salinity is an alarming problem in the coastal regions worldwide, particularly in the low-lying countries. Almost 830,000 hectares of coastal land of Bangladesh are affected by salinity at different levels (Baten *et al*. **2015**). In Bangladesh, costal area covers about 20% of the country amounting of 29,000 km^2. More than 30% of the productive lands of the country are in the coastal area (Haque **2006**). In coastal area, saline soils are randomly distributed in 64 thanas of 13 districts affecting 8 AEZ of the country. The three districts namely Satkhira, Khulna and Bagerhat cover the greater portions of salinity affected area (Ahmed *et al*. **2013**). The estimation revealed that a net diminution of 0.5 million MT of rice production would take place with consequence of a 0.3 m rise of sea level in coastal areas of Bangladesh (Baten *et al*. **2015**).

The effects of salt stress on *Brassica* species comprises delayed seed germination, retardation of seedling growth, reduction of shoot and root length and diminution of shoot and root dry weight (Jamil *et al*. **2007**). In Bangladesh, winter vegetables are cultivated in about 451,758 acres of land area with a total production of 146,0961 M. Tons in the year of 2007-2008 (BBS **2009**). In 2009-2010, Bangladesh produced 35,000 tons of kohlrabi $year^{-1}$ from 7.29 thousand hectares of land with an average yield 4.80 tha^{-1} which was very low against the potential yield (BBS **2010**).

However, the salinity problem in Bangladesh increases in dry season during the winter (November-May) due to upward or lateral movement of saline ground water (Haque **2006**). Therefore, the yields of winter vegetables including kohlrabi are greatly reduced due to the presence of higher soluble salt in soil. There is no available research about the effect of different salinity levels on germination, growth and yield of kohlrabi in coastal region. Therefore, it is important to assess the effect of varying degree of salinity on kohlrabi life cycle. Thus, the present study was conducted with the following objectives: 1) To determine the effect of salinity levels on germination and seedling growth of kohlrabi. 2) To evaluate the effect of salinity levels on yield and yield attributes of kohlrabi.

2. Materials and methods

2.1. Preparation of plant materials: Seeds of hybrid varieties of kohlrabi namely Early White (DEB 1701) were used in this study. After collection, these seeds were sun dried followed by hand sorting. Then seeds were placed in petridish after treating with fungicide.

2.2. Preparation of salinity levels: Six different salinity levels (0, 3, 6, 9, 12 and 15 dSm^{-1}) and seven replication were used in this study. Total 1680 seeds were placed in 42 petridishes i.e. 40 seeds/petridish.

Total number of petridishes = 6 (salinity levels) × 7 (replication) = 42

The amount of salt (NaCl) required to make the desired salinity level was estimated using the following formula.

Percentage of salt = 640mg × EC (dSm^{-1})

2.3. Procedure for germination: Seeds of kohlrabi were germinated in Whatman filter paper (sterilized) placed in petridishes (9 cm diameter). Three pieces of filter paper (soaked with distilled water as control and respective salt solution) were placed in sterilized petridish. Then 40 seeds were placed in each petridish. NaCl was used since it is a common salt in coastal area of Bangladesh. Each treatment was replicated seven times. The petridishes were monitored every day. The germination was completed within seven days. After 7th day, data on shoot and root length, fresh weight, dry weight of shoot and root were recorded.

2.4. Germination parameters: Germinated seeds were counted daily at specific time from the second day. At that time, those seeds were considered germinated of which radical length was more than 3 mm. The germination percentage was calculated using the following formula (Keshavarzi **2011b**).

Germination percentage= 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**)

2.5. Seedling vigor index (SVI): Seedling vigor index (SVI) was determined with the help of following formula (Seghatoleslami **2010**).

Seedling vigor index = Mean of seedling length (cm) × Germination percentage/100

2.6. Root and shoot length: After 7th day of germination, shoot and root length were measured with a measuring scale and expressed in centimeters.

2.7. Fresh and dry weight of seedlings: Fresh and dry weight of seedlings were recorded after 7th day of germination.

2.8. Preparation of pots: Plastic pots were filled-up with sun-dried soil and kept under natural light. Recommended dose of fertilizers was applied at the rate of 100 $Kgha^{-1}$ N, 85 $Kgha^{-1}$ P and 170 $Kgha^{-1}$ K to each pot. Cow dung, Urea, TSP and MoP were uniformly incorporated into the soil before pot filling.

Total number of pot = 6 (salinity levels) × 7 (replication) = 42

2.9. Transplanting of seedlings: After seed sowing, the seedbed was watered to keep the soil moist ensuring proper germination of the seeds. Apparently, healthy and diseases free seedlings of 35 days old were selected for transplanting. Intercultural practices were done whenever required including fertilizer application, pesticide application etc.

2.10. Data collection: Data of the number of leaves $plant^{-1}$, plant height, length of leaves, width of the leaves, number of roots $plant^{-1}$, length of roots $plant^{-1}$, fresh weight of roots, dry weight of roots, fresh weight of shoots, dry weight of shoots, diameter of knob, length of knob, fresh weight of knob, dry weight of knob were collected at seven days interval.

2.11. Statistical analysis: Data were analyzed using MSTAT-C statistical package program and the differences among the means were ranked using Duncan's New Multiple Range Test (DMRT) at 1% and 5% level of significance. Functional relationships between different parameters were developed using Microsoft Office Excel 2007 program.

3. Results

3.1. Germination parameters: Percentage, energy and capacity of germination, and seedling vigor index: Salt stress significantly decreased ($p \leq 0.01$) the percentage, energy and capacity of germination and seedling vigor index of kohlrabi at 6, 9, 12 and 15 dSm^{-1} salinity levels compared to control (**Table 1**). The lowest value for percentage (46.79%), energy (38.93%) and capacity (46.79%) of germination (46.79%) was observed at 15 dSm^{-1} while control showed 91.07, 56.79 and 91.07% respectively (**Table 1**).

3.2. Growth parameters: Shoot and root length, fresh and dry weight of seedlings: Shoot and root length of seedlings significantly decreased at 15 dSm^{-1} salinity level ($p \leq 0.01$) compared to control (**Table 2**). Significant variation was observed in fresh weight ($p \leq 0.05$) and dry weight ($p \leq 0.01$) of seedlings compared to their corresponding control values due to different salinity levels (**Table 2**). A significant decreased in fresh weight was found at 12 dSm^{-1} salinity level (464.91 mg, $p \leq 0.05$). On the contrary, the increased fresh weight was found at 3 dSm^{-1} (684.86 mg) and 6 dSm-1 (636.71 mg) salinity level (**Table 2**). In case of dry weight, significant ($p \leq 0.01$) decreased was observed at 15 dSm^{-1} (52.57 mg), 9 dSm^{-1} (59.29 mg) and 12 dSm^{-1} (55.14 mg) salinity levels compared to their control values (**Table 2**).

3.3. Functional relationship: Response of different germination and seedling growth parameters of kohlrabi to salinity levels was compared using simple linear regression analysis. A linear but negative relationship existed in all cases viz. germination percentage, germination energy, seedling vigor index, shoot length, root length and dry weight (**Fig. 1**).

Table 1. Effect of different salinity levels on germination parameters of kohlrabi

Salinity levels (dSm^{-1})	Germination percentage	Germination energy (%)	Germination capacity (%)	Seedling vigor index
0	91.07^{a}	56.79^{a}	91.07^{a}	7.56^{a}
3	68.93^{b}	50.00^{ab}	68.93^{b}	5.63^{b}
6	56.79^{c}	46.07^{abc}	56.79^{c}	3.86^{c}
9	49.29^{c}	36.43^{c}	49.29^{c}	3.19^{cd}
12	50.71^{c}	41.07^{bc}	50.71^{c}	2.91^{de}
15	46.79^{c}	38.93^{bc}	46.79^{c}	2.14^{e}
CV (%)	**11.36**	**17.02**	**11.36**	**13.69**
Level of significance	**0.01**	**0.01**	**0.01**	**0.01**

Different letter(s) in a column are significantly different at 1% or 5% level whereas same letter(s) are not significantly different by DMRT.

Table 2. Effect of different salinity levels on seedling growth parameters of kohlrabi

Salinity levels (dSm^{-1})	Shoot length (cm)	Root length (cm)	Fresh weight (mg)	Dry weight (mg)
0	4.84^{a}	3.46^{a}	597.94^{abc}	75.88^{a}
3	4.81^{a}	3.36^{ab}	684.86^{a}	69.29^{ab}
6	3.86^{b}	2.91^{ab}	636.71^{ab}	62.29^{abc}
9	3.43^{c}	3.00^{ab}	515.57^{bc}	59.29^{bc}
12	3.01^{d}	2.73^{bc}	464.91^{c}	55.14^{bc}
15	2.39^{e}	2.17^{c}	471.14^{c}	52.57^{c}
CV (%)	**6.00**	**14.14**	**22.82**	**15.47**
Level of significance	**0.01**	**0.01**	**0.05**	**0.01**

Different letter(s) in a column are significantly different at 1% or 5% level whereas same letter(s) are not significantly different by DMRT.

Table 3. Effect of different salinity levels on leaf number of kohlrabi at different days after transplanting

Salinity levels (dSm^{-1})	Leaf number (DAT)								
	14	21	28	35	42	49	56	63	70
0	4.86	6.29	9.29^{a}	10.43^{a}	11.14	11.57^{a}	12.71^{a}	13.71^{a}	15.00^{a}
3	5.43	6.71	8.43^{ab}	9.43^{ab}	10.57	10.14^{ab}	10.00^{b}	11.00^{b}	11.71^{b}
6	4.57	5.86	7.71^{b}	8.57^{ab}	10.29	8.29^{bc}	8.57^{b}	9.43^{bc}	10.00^{bc}
9	5.43	6.43	7.86^{b}	8.14^{b}	10.00	8.29^{bc}	8.71^{b}	9.00^{bc}	9.43^{bc}
12	5.14	6.86	8.29^{ab}	8.86^{ab}	9.71	7.71^{c}	8.71^{b}	8.86^{bc}	9.00^{c}
15	5.00	7.14	8.00^{b}	8.00^{b}	9.43	9.29^{bc}	8.57^{b}	8.57^{c}	8.86^{c}
CV (%)	**21.01**	**17.48**	**11.56**	**13.61**	**11.92**	**15.59**	**14.36**	**13.98**	**15.47**
Level of significance	**NS**	**NS**	**0.05**	**0.01**	**NS**	**0.01**	**0.01**	**0.01**	**0.01**

Different letter(s) in a column are significantly different at 1% or 5% level whereas same letter(s) are not significantly different by DMRT.

Table 4. Effect of different salinity levels on plant height, leaf length and leaf width of kohlrabi at 70 DAT

Salinity levels (dSm^{-1})	Plant height (cm)	Leaf length (cm)	Leaf width (cm)
0	41.86	34.43	15.29
3	39.86	33.68	14.22
6	39.61	33.14	14.26
9	38.01	32.79	13.09
12	38.30	32.48	13.74
15	37.20	32.29	13.34
CV (%)	**10.51**	**14.63**	**10.97**
Level of significance	**NS**	**NS**	**NS**

Different letter(s) in a column are significantly different at 1% or 5% level whereas same letter(s) are not significantly different by DMRT.

Table 5. Effect of different salinity levels on different parameters of growth and yield of kohlrabi

Salinity Levels (dSm^{-1})	No. of Roots	Root Length (cm)	Diameter of Knob (cm)	Fresh wt. of Knob (g)	Dry wt. of Knob (g)	Fresh wt. of Shoot (mg)	Dry wt. of Shoot (mg)	Fresh wt. of Root (mg)	Dry wt. of Root (mg)	Length of Knob (cm)
0	30.86	38.77	9.04^{a}	337.6^{a}	46.86^{a}	128.3^{a}	12.57^{a}	19.14	4.71^{a}	7.99^{a}
3	26.86	37.54	8.19^{ab}	237.7^{ab}	36.01^{ab}	99.86^{ab}	10.29^{ab}	13.71	2.57^{b}	6.36^{ab}
6	27.14	32.50	7.43^{ab}	198.4^{b}	33.90^{ab}	104.6^{ab}	10.71^{a}	14.29	3.71^{ab}	5.84^{b}
9	25.14	29.00	7.36^{ab}	192.9^{b}	32.81^{ab}	124.7^{a}	11.14^{a}	12.29	2.57^{b}	5.91^{b}
12	25.00	27.86	6.86^{b}	153.1^{b}	23.46^{b}	94.43^{ab}	10.86^{a}	13.14	3.43^{ab}	5.26^{b}
15	21.57	28.14	6.27^{b}	122.1^{b}	23.58^{b}	68.29^{b}	7.86^{b}	13.00	3.00^{b}	5.21^{b}
CV (%)	**25.79**	**32.42**	**16.97**	**53.84**	**31.51**	**30.77**	**23.23**	**31.18**	**29.15**	**20.59**
Sig. Lev.	**NS**	**NS**	**0.01**	**0.05**	**0.01**	**0.05**	**0.05**	**NS**	**0.01**	**0.01**

Different letter(s) in a column are significantly different at 1% or 5% level whereas same letter(s) are not significantly different by DMRT.

3.4. Yield and yield attributes:

3.4.1. Number of Leaves plant^{-1}: Leaf number plant^{-1} increased with increasing days of transplanting but decreased significantly ($p \leq 0.01$) with increasing salinity levels (**Table 3**).

3.4.2. Diameter of knob: Diameter of knob was significantly decreased ($p \leq 0.01$) compared to control (**Table 5**). The highest diameter of knob (9.04 cm) was obtained from control condition, which was statistically similar to 3 dSm^{-1} (8.19 cm), 6 dSm^{-1} (7.43 cm) and 9 dSm^{-1} (7.36 cm) salinity level.

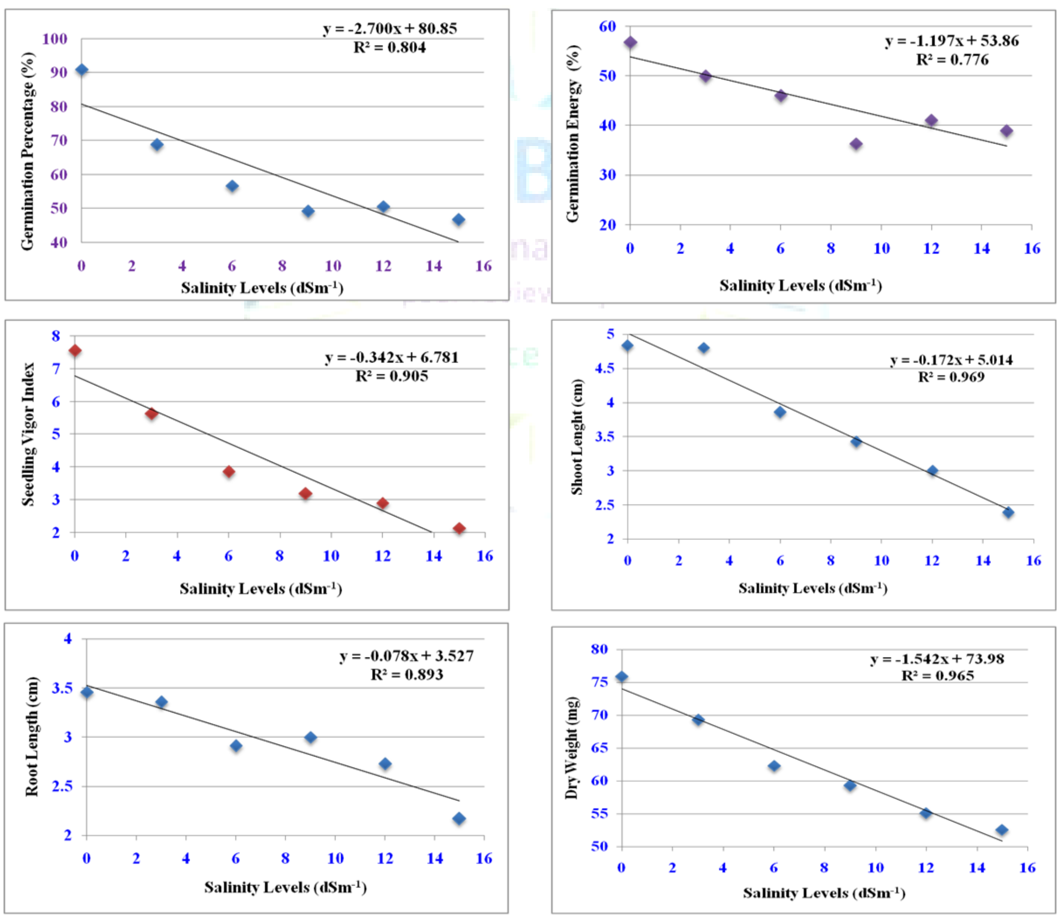

Fig. 1. Functional relationship between salinity levels and germination percentage, germination energy, seedling vigor index, shoot length, root length, dry weight

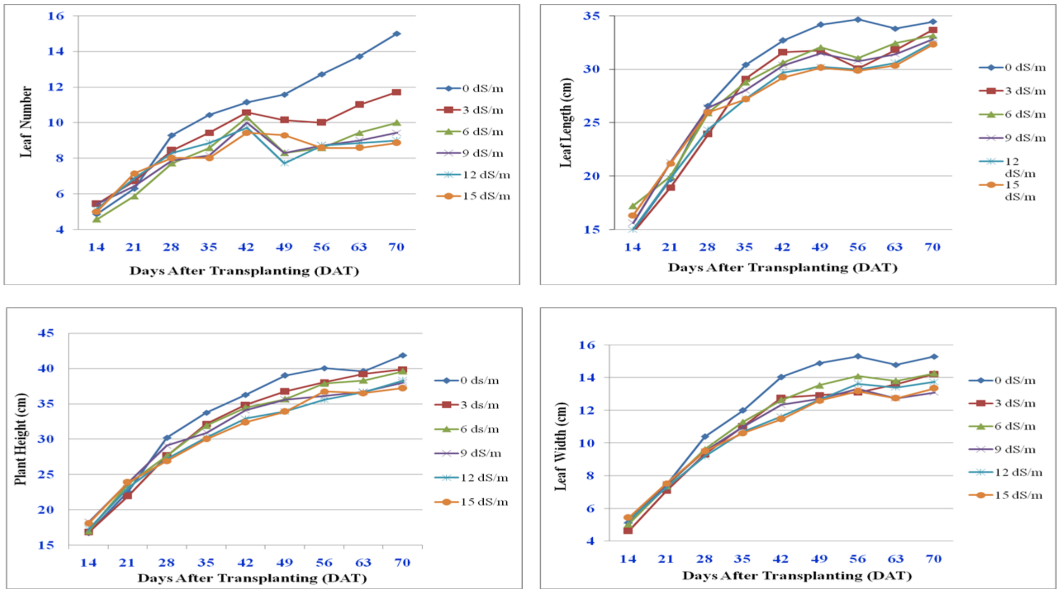

Fig 2. Effect of salinity on number, length, width of leaves and plant height of kohlrabi

Moreover, statistically, significant decreased in diameter of knob was found at 15 dSm^{-1} salinity level (6.27cm, $p\leq 0.01$) which was statistically similar to 12 dSm^{-1} (6.86 cm) (**Table 5**).

3.4.3. Length of knob: Statistically significant lowest length of knob was obtained from 15 dSm^{-1} salinity level (5.21 cm, $p\leq 0.01$) compared to control, which was statistically similar to 12 dSm^{-1} (5.26 cm), 9 dSm^{-1} (5.91 cm) and 6 dSm^{-1} (5.84 cm) salinity level (**Table 5**). The increased length of knob (7.99 cm) was obtained from control condition, which was statistically similar to 3 dSm^{-1} (6.36 cm).

3.4.4. Fresh weight of knob: Fresh weight of knob was significantly ($p\leq 0.05$) decreased compared to their corresponding controls (**Table 5**). Highest fresh weight of knob (337.6 g) was obtained from control condition, which was statistically similar to 3 dSm^{-1} (237.6 g). Statistically, significant decreased in fresh weight of knob was obtained from 15 dSm^{-1} salinity level (122.1 g, $p\leq 0.05$) which was statistically similar to 12 dSm^{-1} (153.1 g), 9 dSm^{-1} (192.9 g), 6 dSm^{-1} (198.4 g) (**Table 5**).

3.4.5. Dry weight of knob: The dry weight of knob was significantly decreased ($p\leq 0.01$) by salinity levels compared to their control values (**Table 5**). The highest dry weight of knob (46.86 g) was obtained from control condition, which was statistically similar to 3 dSm^{-1} (36.01 g), 6 dSm^{-1} (33.90 g) and 9 dSm^{-1} (32.81 g). The significant lowest dry weight of knob was obtained from 12 dSm^{-1} (23.46 g, $p\leq 0.01$) compared to their control values (**Table 5**).

3.4.6. Fresh weight of shoot: The effect of salinity levels on fresh weight of shoot was significant ($p\leq 0.05$) compared to their control values (**Table 5**). The highest fresh weight of shoot (128.3 mg) was obtained from control condition, which was statistically similar to 3 dSm^{-1} (99.86 mg), 6 dSm^{-1} (104.6 mg), 9 dSm^{-1} (124.7 mg) and 12 dSm^{-1} (94.43 mg). Moreover, statistically, significant decreased fresh weight of shoot was obtained from 15 dSm^{-1} salinity level (68.29 mg, $p\leq 0.05$) compared to their corresponding control values (**Table 5**).

3.4.7. Dry weight of shoot: The results on the effect of salt stress on dry weight of shoot are presented in **Table 5**. The data revealed that the dry weight of shoot decreased significantly ($p\leq 0.05$) with increasing salinity levels compared to their control values. The increased dry weight of shoot (12.57 mg) was obtained from control condition, which was statistically similar to 3 dSm^{-1} (10.29 mg), 6 dSm^{-1} (10.71 mg), 9 dSm^{-1} (11.14 mg) and 12 dSm^{-1} (10.86 mg). The lowest dry weight of shoot was obtained from 15 dSm^{-1} salinity level (7.86 mg, $p\leq 0.05$) (**Table 5**).

3.4.8. Fresh and Dry weight of root: The effect of salinity levels on fresh weight of root was statistically insignificant (**Table 5**).The dry weight of root was significantly affected ($p\leq 0.01$) by salinity levels compared to their control values (**Table 5**). The highest dry weight of root (4.71 mg) was obtained from control condition, which was statistically similar to 6 dSm^{-1} (3.71mg) and 12 dSm^{-1} (3.43 mg). However, statistically highly significant decreased in dry weight of root was obtained from 3 dSm^{-1} and 9 dSm^{-1} salinity level (2.57

mg, p≤ 0.01) compared to their corresponding control values which were statistically similar to 15 dSm^{-1} (3.00 mg) (**Table 5**).

4. Discussion

In kohlrabi, different germination and seedling growth parameters including germination percentage, germination energy, germination capacity and seedling vigor index decreased significantly (p≤ 0.01) with increasing salinity levels (Jamil *et al.* **2007**). Results revealed that with the increase of salt concentration, shoot length, root length, fresh weight of seedling and dry weight of seedling decreased significantly (p≤ 0.01) and the lowest value of all parameters was observed at higher salt concentration compared to control treatment. According to Hasegawa *et al.* (**2000**), dry weight of shoot and root were decreased with increasing concentration of NaCl. Tsegazeabe and Teferii (**2012**) found similar variation in different germination parameters in the study on effect of salt stress on germination and early seedling growth of Chickpea (*Cicer arietinum* L.). It is clearly stated that germination and seedling developmental stage are the most vulnerable stage among plant developmental phases to salt concentration (Keshavarzi, **2011b**).

There was no significant effect on the growth parameters of kohlrabi such as plant height, leaf length and width, number and length of roots (Kaymakanova, **2009**). But, the yield related attributes such as diameter of knob, dry weight of knob, length of knob and dry weight of root were significantly affected by different salinity levels at 1% level of significance. In *Brassica oleracea*, Zhu *et al*. (**2011**) reported that the higher salt concentration had significant adverse effect on yield parameters including dry matter content, knob length. The fresh weight of knob, fresh weight of shoot, and dry weight of shoot were significantly affected by different salinity levels at 5% level of significance. The variation in fresh weight (p≤ 0.05), dry weight (p≤ 0.01) and knob length (p≤ 0.01) varied significantly among the different salinity levels where the lowest knob weight was found in higher salt concentration (Jeannette *et al*. **2002**). Therefore, the yield of kohlrabi was significantly affected due to salt stress.

5. Conclusion

From the findings of the present study, it might be concluded that considering all germination and seedling growth parameters observed in the experiment kohlrabi was found tolerant to salinity levels up to 3 dSm^{-1}. Germination of kohlrabi was severely affected due to high salt concentration. After seedling development, kohlrabi can withstand up to 9 dSm^{-1} salinity levels and above this plant growth was started to decline. In view of all the growth, yield and yield attributes of kohlrabi was found tolerant to salinity levels up to 9 dSm^{-1}.

6. Acknowledgement

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7. Conflict of interest statement

We declare that we have no conflict of interest.

8. References

Ahmed B, Rasel HM, Hasan MR and Miah MSU (2013) Effects of soil salinity on crop production rate of the south-west zone of Bangladesh. International Conference on Mechanical, Industrial and Materials Engineering 2013 (ICMIME2013), RUET, Rajshahi, Bangladesh. pp. 799-805.

Bam RK, Kumaga FK, Ofri K and Asiedu EA (2006) Germination, vigor and dehydrogenase activity of naturally aged rice (*Oryza sativa* L.) seeds soaked in potassium and phosphorus salts. Asian J Plant Sci; 5 (6): 948-955.

Baten MA, Seal L and Lisa KS (2015) Salinity intrusion in interior coast of Bangladesh: Challenges to agriculture in the south-central coastal zone. American Journal of Climate Change; 4: 248-262.

BBS (2009) Statistics year book of Bangladesh Statistics division Ministry of planning, Government of the People's Republic of Bangladesh, Dhaka. Crop Summary, pp: 5-7.

BBS (2010) Statistics year book of Bangladesh Statistics division Ministry of planning, Government of the People's Republic of Bangladesh, Dhaka. Crop Summary, pp: 8-9.

Choil SH, Ryu DK, Park S, Ahn KG, Lim YP and An G (2010) Composition analysis between kohlrabi (*Brassica oleracea* var. *gongylodes*) and radish (*Raphanus sativus*). Korean J Hortic Sci Technol; 28 (3): 469-475.

Ćosić T, Vinterhalter B, Mitić N, Cingel A, Savić J, Ninković S and Bohanec B (2013) In vitro plant regeneration from immature zygotic embryos and repetitive somatic embryogenesis in kohlrabi (*Brassica oleracea* var. *gongylodes*). In Vitro Cell Dev Biol Plant; 49: 294–303.

Cuartero J, Bolarín MC, Asíns MJ and Moreno V (2006) Increasing salt tolerance in the tomato. J Exp Bot; 57: 1045- 1058.

Haque SA (2006) Salinity problems and crop production in coastal regions of Bangladesh. Pak J Bot; 38 (5): 1359 1365.

Harbaum B, Hubbermann EM, Wolff C, Herges R, Zhu Z and Schwarz K (2007) Identification of flavonoids and hydroxycinnamic acids in pak choi varieties (*Brassica campestris* L. ssp. *chinensis* var. *communis*) by HPLC-ESI-MSn and NMR and their quantification by HPLC-DAD. J Agric Food Chem; 55: 8251-8260.

Hasegawa PM, Bressan RA, Zhu JK and Bohnert HJ (2000) Plant cellular and molecular responses to high salinity. Annu Rev Plant Physiol Plant Mol Biol; 51: 463–499.

Jamil M, Lee KB, Jung KY, Lee DB, Han MS and Rha ES (2007) Salt stress inhibits germination and early seedling growth in cabbage (*Brassica oleracea capitata* L.). Pak J Biol Sci; 10: 910–914.

Jeannette S, Craig R and Lynch JP (2002) Salinity tolerance of phaseolus species during germination and early seedling growth. Crop Sci; 42: 1584-1594.

Johnson JT (2002) Glucosinolates in the human diet bioavailability and implications for health. Phytochem Rev; 1 (2): 183-188.

Kaya MD, Okcu G, Atak M, Çikili Y and Kolsarici O (2006) Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annuus* L.). Eur J Agron; 24: 291–295.

Kaymakanova M (2009) Effect of salinity on germination and seed physiology in bean (*Phaseolus Vulgaris* L.). Biotechnol Biotec Eq; 23 (2): 326-329.

Keshavarzi MHB (2011b) Effect of salt stress on germination and early seedling growth of savory (*Satureja hortensis*). Aust J Basic Appl Sci; 5 (12): 3274-3279.

Keshavarzi MHB, Porkareh MH, Saman PG, Koorgol R and Shakouri MJ (2011a) Effect of salt stress on germination and early seedling growth of *Osimum basilicum*. Ann Biol Res; 2 (4): 526-528.

Liu S, Willett WC, Manson JE, Hu FB, Rosner B and Colditz G (2003) Relation between changes in intakes of dietary fiber and grain products and changes in weight and development of obesity among middle-aged women. Am J Clin Nutr; 78: 920-927.

Moud M and Maghsoudi K (2008) Physiology of plant tolerance to salinity. World J Agric Sci; 4: 351-358.

Munns R and Tester M (2008) Mechanisms of salinity tolerance. Annu Rev Plant Biol; 59: 651-681.

Seghatoleslami MJ (2010) Effect of salinity on germination of *Satureja hortensis* L., *Cichorium intybus* L. and *Cyanara scolymus* L. Iran J Agric Res; 8 (5): 818-823.

Terry P, Giovannucci E, Michels KB, Bergkvist L, Hansen H, Holmberg L and Wolk A (2001) Fruit and vegetables, dietary fiber, and risk of colorectal cancer. J Natl Cancer Inst; 93: 525-533.

Tsegazeabe HH and Teferii G (2012) The effect of salinity stress on germination of chickpea (*Cicer arietinum* L.) land race of Tigray. Current Res J Biol Sci; 4 (5): 578-583.

Zhu S, Zhang X, Luo T, Liu Q, Tang Z and Jing Z (2011) Effects of NaCl stress on seed germination, early seedling growth and physiological characteristics of cauliflower (*Brassica oleracea* var. *botrytis* L.). Afr J Biotechnol; 10 (78): 17940-17947.

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