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Effects of sodium chloride salinity on growth and yield of BARI Sunflower-2 (*Helianthus annuus* L.)

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Abstract

A pot experiment was conducted to assess the effect of seven different NaCl solution treatments, namely 0, 50, 100, 150, 200, 250 and 300 mM on the growth and yield of BARI Sunflower-2 under sodium chloride stress. Growth parameters such as plant height, leaf number, leaf length, leaf width and leaf area showed a gradual decrease from50 mM to the highest treatment level. Sodium chloride stress caused a significant reduction in early stage growth parameters (15 Days after treatments (DAT), while at 45 DAT the percentages of various growth parameters compared to the control plant at the highest treatment level (300mM) except leaf area. Seed yield per plant and weight of 100 seeds were reduced, respectively by 27.69 and 28.44%at 300 mM salinity, while at moderate salinity (200 mM) seed yield per plant and weight of 100 seed were 83.28 and 84.12%, respectively, as compared to in compared to those of the control plants. The results obtained in the present study showed that the BARI Sunflower-2 cultivar is a moderately salt tolerant plant.

Key words: Sodium chloride (nacl) salinity, growth, yield, bari sunflower-2.

INTRODUCTION

Sodium chloride salinity is a major abiotic stress that reduces growth and yield of many crops and is a serious constraint on crop production worldwide (Ashraf & Wu, 1994; Munns & Tester, 2008). In Bangladesh, climate change and global warming have continuously increased the salinity of cropland due to intrusion saline water from the costal region. In this way,about one fifth area of Bangladesh is affected by salinity (Karim *et al*., 1982).

However salinity stress has a major impact on plant growth and developmental processes. Seed germination, seedling growth and vegetative growth are adversely affected by high salt concentration, ultimately leading to poor plant growth (Sairam & Tyagi, 2004). Salinity reduces the water uptake capacity of crop plants, resulting in a reduction in plant growth rate (Munns, 2002). Plant leaves can die due to excessive salt accumulation, leading tosalt toxicity, reducing leaf areaand reducing the degree of photosynthesis, ultimately resulting in yield loss (Munns, 2002a).

There is a greater shortage of oilseed production than consumption in our country. As a result, sunflower will be a promising and potential oilseed crop in Bangladesh. It can be grown in both Rabi and Kharip seasons due to its day-neutral nature. But much of southern parts of Bangladesh is now affected by salinity (Khatun *et al*., 2016). It would be beneficial if the sunflower could be cultivated in Rabi season when rice land in southern part of Bangladesh is left uncultivated. Therefore, the present experiment was conducted

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to evaluate the effects of different NaCl salinity levels on the growth, development and yield of BARI Sunflower-2.

MATERIALS AND METHODS

Plant materials: The sunflower cultivar, BARI Sunflower-2 was used as plant material. Sunflower seeds were collected from the Bangladesh Agricultural Research Institute (BARI).

Treatments: On the basis of previous experiments (Chowdhury *et al*., 2018), seven different concentrations of NaCl solution (0, 50, 100, 150, 200, 250 and 300 mM) were applied in the present experiment.

Pot preparation and management: Pot experiments were carried out in the experimental field of Botanical garden of Jahangirnagar University, Savar, Dhaka. 70 pots were used for seven treatments, with 10 pots allocated for each treatment. The pots were filled with (12 kg per pot) air dried soil. The pH and cation exchange capacity of the soil were 7.10 and 0.195 (mg/100g dry soil), respectively. Prior to sowing, 0.41g of Triple Super Phosphate (TSP), 0.5g of Murat of Potash (MOP) and 0.81g of Gypsum were added to each pot and sufficient water was added to saturate the soil. Manure and fertilizers were applied according to the Fertilizer Recommendation Guide (2005).

The pots were kept under natural sunlight until harvest. Uniform size seeds were sown directly into pots. Distilled water was applied to all the pots until the seedlings emerged. After establishment of the seedlings, distilled water in control pots and 12.5 mM NaCl solution were applied to the salt treatment. When the first leaf appeared, treatments were applied at 3-day intervals. Salt solution was first applied to the pots of plants when four leaves appeared. The brine was applied until harvest. Regular watering and weeding were carried out to ensure the same environmental conditions throughout the experimental period.

Data collection: Plant height, leaf number, leaf length, leaf width and leaf area of BARI Sunflower-2 were measured 15, 30 and 45 days after treatment (DAT). Yield and yield-determining parameters such as yield per plant, number of filled and unfilled seeds per plant, total number of seeds per plant were recorded at the final harvest.

Statistical analysis: The experimental design was performed using a ten-replicate randomized block (RBD) design (Halim *et al*., 2014). Statistical analysis was performed using SPSS program 16.00 and Microsoft Excel2013.

RESULTS AND DISCUSSION

Results obtained on various growth and yield parameters are presented in Tables 1-4 under the following headings.

Growth parameters: Plant height decreased significantly with increasing NaCl concentration (Table 1). Plant height (mean) decreased from 100.25 cm to 79.67cm from control treatment to 300 mM NaCl at 45 DAT (Table 1). Compared to the control, plant height at the highest salinity (300 mM) was reduced by 34.88, 19.38 and 20.53% at 15, 30 and 45 DAT, respectively. At each concentration of NaCl treatment, plant height was tallest in the juvenile stage (15 DAT).Decrease in height is a common trait of plants affected by salt, previously reported by Gupta (1993) and Yeo *et al*., 1991. Munns (2002) mentioned that salinity decreases water holding capacity and produces osmotic effects that cause a rapid reduction in plants' growth rate. In the present experiment, the plant height of BARI Sunflower-2, although gradually reduced in all treatments, remained at more than 85% at 250 mM sodium chloride salinity. Based on plant height, this indicates that BARI-Sunflower-2 exhibits moderate salt tolerance ability.

Leaf number: Mean leaf counts for different DAT and different treatments are presented in Table 1. The mean leaf count was reduced from 21.08 to 18.00 from the control treatment at 300 mM salinity at 45 DAT. At the highest salinity (300 mM), leaf count was reduced by 23.68, 4.09, and 14.62% at 15, 30, and 45 DAT, respectively, compared to the control) than in the mature stage (at 30 and 45 DAT) versus the NaCl salinity. Leaf count is very important for plant growth as the leaf is the most important photosynthetic organ. It has been reported that the production of green leaves and dry matter per plant decreases with increasing soil salinity (Bal & Dutt, 1984). Hossain *et al*. (2018) reported that the leaf count of BARI sunflower-2 on saline soil decreased from 16.45 to 13.03 compared to the control. Inhibition of leaf primordial formation under salt stress could be the likely reason for the low leaf numbers (Alamgir & Ali, 2006). The decrease in leaf number may be due to the accumulation of sodium chloride in the cell walls and cytoplasm of older leaves (Munns, 2002).

Table 1. Effects of different concentrations of NaCl salinity on plant height (cm) and leaf number/plant of BARI Sunflower-2 at different days after treatment (DAT)

Treatments	Plant height at different DAT			Leaf number at different DAT		
	15	30	45	15	30	45
0 mM NaCl (Control)	39.42a	59.33a	100.25a	9.50a	12.25a	21.08a
50 mM NaCl	39.12a (99.24)	56.79b (95.72)	96.92b (96.67)	9.17a (96.53)	12.08a (98.61)	20.50a (97.25)
100 mM NaCl	28.58b (72.51)	50.58b (85.26)	88.17c (87.95)	7.75b (81.57)	12.17a (99.35)	19.83b (94.07)
150 mM NaCl	26.67b (67.66)	50.42b (84.98)	88.08c (87.86)	7.42b (78.11)	11.83a (96.57)	18.92c (89.75)
200 mM NaCl	26.42b (67.03)	49.17b (82.88)	85.75c (85.53)	7.34b (77.26)	11.83a (96.57)	18.92c (89.75)
250 mM NaCl	25.83b (65.52)	49.08b (82.73)	85.67c (85.46)	7.34b (77.26)	11.75a (95.91)	18.17d (86.19)
300 mM NaCl	25.67b (65.12)	47.83b (80.62)	79.67d (79.47)	7.25b (76.32)	11.75a (95.91	18.00d (85.38)
Cultivar Mean	30.24	51.88	89.21	7.96	11.95	19.35
LSD (5%)	3.88	3.03	5.37	1.36	1.35	1.33
CV%	24.5	10.47	14.38	17.04	6.86	6.74

In a column followed by small letters do not differ significantly at 5% level of significance. Values within parentheses indicate percentage change over control where control is 100%.

Leaf length, leaf breadth and leaf area: The results showed that leaf length decreased significantly with increasing NaCl salinity (Table 2). At the highest salinity, the mean leaf lengths were 7.42, 12.04, and 15.29 cm, which were 61.62, 81.62, and 82.29% compared to the control plant at 15, 30, and 45 DAT, respectively. Compared to the control, leaf with the highest salt content (300 mM). lengths reduced significantly by 38.38, 18.38 and 17.71% for BARI Sunflower-2 at 15, 30 and 45 DAT, respectively.

Leaf width decreased significantly with increasing NaCl salinity (Table 2). At the highest salinity, the mean leaf widths were 5.71, 9.17, and 10.46 cm, which were 72.84, 75.92, and 71.31% compared to the control plant at 15, 30, and 45 DAT, respectively Control, the leaf width of the highest salinity (300 mM) decreased significantly by 27.16, 24.08 and 28.69% for BARI Sunflower-2 at 15, 30 and 45 DAT, respectively. The maximum sunflower leaf length and width was recorded in the control treatment and it was reduced with increasing NaCl salinity, consistent with the results of Yaghubi *et al*., 2013.

2. Effects of different concentrations of NaCl salinity on leaf length (cm) and leaf breadth (cm) of BARI Sunflower-2 at different days after treatment (DAT)

Treatments	Leaf length at different DAT			Leaf breadth at different DAT		
	15	30	45	15	30	45
0 mM NaCl (Control)	12.04a	14.75a	18.58a	7.84a	12.08a	14.67a
50 mM NaCl	11.08a (92.03)	12.75b (86.44)	18.42a (99.14)	7.13ab (90.95)	11.89a (98.43)	14.45a (98.50
100 mM NaCl	10.96a (91.03)	12.91b (87.53)	16.67b (89.72)	6.88ab (87.76)	11.08a (91.73)	13.21b (90.05)
150 mM NaCl	8.88b (73.75)	12.80b (86.78)	15.79bc (84.98)	6.63ab (84.57)	11.04a (91.39)	12.75b (86.91)
200 mM NaCl	8.44b (70.10)	12.25b (83.05)	15.79bc (84.98)	6.29bc (80.23)	9.25b (76.58)	12.50b (85.21)
250 mM NaCl	8.34b (69.27)	12.17b (82.51)	15.38c (82.78)	5.83c (74.37)	9.21b (76.24)	11.27c (76.82)
300 mM NaCl	7.42b (61.62)	12.04b (81.62)	15.29c (82.29)	5.71c (72.84)	9.17b (75.92)	10.46c (71.31)
Cultivar Mean	9.59	12.81	16.56	6.61	10.54	12.75
LSD (5%)	1.46	1.11	1.03	1.14	1.21	1.05
CV%	24.75	12.3	10.77	22.97	17.74	14.87

In a column followed by small letters do not differ significantly at 5% level of significance. Values within parentheses indicate percentage change over control where control is 100%.

Salinity gradually reduced the production of green leaf area (Table 3) in different treatments. At the highest salinity (300 mM), mean leaf area was 101.34, 110.04, and 150.71 square centimeters, which were 60.67, 60.17, and 69.72% compared to the control plant at 15, 30, and 45 DAT, respectively. Compared to the control, the leaf area at 300 mM NaCl concentration decreased significantly by 39.33, 39.83 and 30.28% for BARI Sunflower-2 at 15, 30 and 45 DAT, respectively. 1988; Lutts *et al*., 1996. The decrease in leaf area found in this study could be explained by the negative effect of salt on photosynthesis, resulting in a reduction in plant growth and leaf growth (Netondo *et al.*, 2004). In the present experiment, 85.21% leaf area was observed in 200 mM NaCl salinity, followed by 70.31% leaf area in 250 mM NaCl salinity at 45 DAT, indicating that this cultivar is moderately NaCl salt tolerant.

Table 3. Effect of different concentrations of NaClon leaf area (cm^2) of BARI Sunflower-2 at different days after treatment (DAT)

Treatments	Leaf Area (cm^2) at different DAT		
	15	30	45
0 mM NaCl (Control)	167.06a	182.89a	216.18a
50 mM NaCl	145.35a (87.05)	170.33a (93.14)	212.96a (98.51)
100 mM NaCl	117.71b (70.46)	133.41b (72.95)	196.85ab (91.05)
150 mM NaCl	108.27b (64.81)	127.29b (69.60)	195.52ab (90.44)
200 mM NaCl	107.91b (64.59)	123.06b (67.28)	185.54b (85.53)
250 mM NaCl	104.67b (62.65)	118.77b (64.94)	152.17c (70.39)
300 mM NaCl	101.34b (60.67)	110.04b (60.17)	150.71c (69.72)
Cultivar Mean	121.76	137.98	187.13
LSD (5%)	2.23	2.74	5.18
CV%	32.69	26.75	19.97

In a column followed by small letters do not differ significantly at 5% level of significance. Values within parentheses indicate percentage change over control where control is 100%

Total number of seeds per plant: The results presented in Table 4 showed that salt stress had delaying effects on the total number. of seeds per plant. In contrast to the control, the total number of seeds per plant was reduced by 60.86% due to 300 mM NaCl. Similarly, at 250, 200,150,100 and 50 mM NaCl concentration the number of seeds fell to 47.85, 31.84, 29.26, 27.51 and 1.55% compared to the control.

Number of filled seeds per plant: Application of the highest salinity (300 mM) reduced the number of filled seeds per plant by 72.73% compared to the control. Similarly, the number of seeds at 250, 200, 150, 100 and 50 mM NaCl concentration decreased by 56.53, 44.45, 34.73, 31.81 and 2.08%compared to the control (Table 4). Several investigators have found a reduction in the number of filled grains per ear under stressed conditions in barley (Sanchez *et al*., 2002) and wheat (Garcia, 2003), consistent with the existing results of filled seeds. The results also showed that the production of filled seeds decreased more slowly with low salinity treatments than with higher salinity treatments.

Number of unfilled seeds per plant: The results of the experiment show that the number of unfilled seeds/plant was negatively affected after different salinity levels (Table 4). The number of unfilled seeds per plant increased by 25.26% due to 300 mM salinity. Similarly, at 250, 200, 150, 100, and 50 mM NaCl, the number of unfilled seeds per plant increased by 17.89, 9.68, 5.89, 5.05, and 2.53%, respectively. An increased number of unfilled grains could be the result of assimilate deficiency during grain filling caused by early leaf senescence, as reported by Sheehy *et al*. (2001) and Murchie *et al*. (2002).

Seed yield per plant: By applying concentrations of 300, 250, 200, 150, 100 and 50 mM NaCl, seed yields per plant were15.10, 15.30, 17.39, 18.46, 19.18, 20.11 g, which increased around 27.69, 26.73, 16.72, 11.59, 8.15 and 3.69% respectively (Table 4). A decrease in yield due to salt stress was reported by Zeng & Shannon, 2000 and Cha-um & Kirdmanee, (2010), consistent with the present results. The reduction in seed yield with increased salinity was probably due to the reduction in physiological availability of water with the increase in osmotic concentration and accumulation of ions at a toxic concentration in the plant (Maas & Hoffman, 1977).

Table 4. Effects of different concentrations of NaCl on yield attributes and yield of filled and unfilled seeds of BARI Sunflower-2

Treatments	Total no. of seeds/Plant	No. of filled seeds/Plant	No. of unfilled seeds/Plant	Seed yield/Plant (g)	100 Seeds weight (g)
0 mM NaCl	815.00a	720.00a	95.00a	20.88a	4.22a
50 mM NaCl	802.40a	705.00a	97.40b	20.11a	4.03b
	(98.45)	(97.92)	(102.53)	(96.31)	(95.50)
100 mM NaCl	590.80b	491.00b	99.80c	19.18b	3.89bc
	(72.49)	(68.19)	(105.05)	(91.85)	(92.18)
150 mM NaCl	576.60c	470.00b	100.60c	18.46c	3.74c
	(70.74)	(65.27)	(105.89)	(88.41)	(88.62)
200 mM NaCl	504.20c	400.00bc	104.20c	17.39d	3.55d
	(61.86)	(55.55)	(109.68)	(83.28)	(84.12)
250 mM NaCl	425.00d	313.00c	112.00d	15.30e	3.14e
	(52.15)	(43.47)	(117.89)	(73.27)	(74.40)
300 mM NaCl	319.00e	200.00d	119.00e	15.10e	3.02e
	(39.14)	(27.77)	(125.26)	(72.31)	(71.56)
Cultivar Mean	576.14	471.28	104.00	18.06	3.66
LSD (5%)	5.27	4.34	2.82	0.15	0.10
CV%	26.93	22.28	6.73	11.74	12.01

In a column followed by small letters do not differ significantly at 5% level of significance. Values within parentheses indicate percentage change over control where control is 100%

Weight of 100 seeds: In contrast to the control, the seed weight decreased by 28.44% and 25.60% at a concentration of 300 and 250 mM NaCl, respectively. Conversely, at a concentration of 100 and 150 mM NaCl, seed weight decreased by 7.82% and 11.38%, respectively. 84.12% of the seed weight was present in 200 mM NaCl salinity, representing a high salinity among the treatments, while71.56% of the seed weight was found in the highest salinity (300 mM) (Table 4). Seed weight reduction may be due to processes such as limiting factors for cereal dry matter reduction due to salinity. Panicle composition and development and yield components such as tillering, spikelet number, sterility and grain weight may depend on panicle sodium concentration (Khatun & Flowers, 1995). Growth and Yield of BARI-Sunflower-2. It is a common phenomenon of NaCl salinity in BARI Sunflower-2, as in many other plants. However, the present experiments give an idea that the rate of various growth parameters and yield attributes is present at around 85% at a salinity of 200 mM NaCl, which is a promising character of BARI sunflower-2 for selection as a salt-tolerant cultivar. It also indicates that BARI-Sunflower-2has moderate NaCl-saline tolerance ability.

REFERENCES

Alamgir, A.N.M. and Ali, M.Y. 2006. Effects of NaCl salinity on leaf characters and physiological growth attributes of different genotypes of rice (*Oryza sativa* L.). *Bangladesh J. Bot*. **35**(2): 99-107.

Ashraf, M. and Wu, L.1994.Breeding for Salinity Tolerance in Plants. *Critical Reviews in Plant Sci*. **13** (1): 17-42.

Bal, A.R. and Dutt, S.K. 1984. Effect of soil salinity on growth of *Coix lachrymal-Jobi* L. *Indian J. Plant Physiol*. **27**: 398-400.

Bernal, C.T., Bingham, F.T. and Oertli, J. 1974. Salt tolerance of Mexican wheat 2.Relation to variable sodium chloride and length of growing seasons. *Proc. Ame. Soil. Sci. Soc*. **38**: 777-780.

Blum, A. 1988. Salinity resistance. *In*: Plant Breeding for Stress Environments. pp. 163-176. CRC press (Florida).

Cha-um, S. and Kirdmanee, C. 2010. Effect of glycine, betaine and proline on water use and photosynthetic efficiencies and growth of rice seedlings under salt stress. *Tur. J. Agri. Fores*. **34:** 517-527.

Chowdhury, F.M.T., Halim, M.A. Hossain, F. and Akhtar, N. 2018. Effects of sodium chloride on germination and seedling growth of Sunflower (*Helianthus annuus* L.). *J. Biol. Sci.* **7**(1): 35-44**.**

Fertilizer Recommendation Guide. 2005. Published by Bangladesh Agricultural Research Council, Farmgate, New Airport Road, Dhaka -1215.

Garcia, L. 2003. Evaluation of grain yield and its components in durum wheat under Mediterranean condition. *Agron. J*. **95**: 266-274.

Gupta, S. 1993. Comparative studies of germination and seedling growth of some salt tolerant selections at different salinity levels. *IRRN.* **18**:17.

Hossain, M. K., Islam, M. M., Mamun, A. A. and Al Mamun, S. M. A. 2018. Performance of sunflower genotypes in non-saline and saline soils of southern Bangladesh. *Bangladesh Agron. J.***21**(1): 1-7.

Halim, M.A., Niger, M., Ghosh, M., Akhtar, N. and Hossain, F. 2014. Interaction effects of Arsenic and Phosphorus on seedling growth, leaf pigments and leaf protein of rice cultivars under hydroponic culture. *J. Asiat. Soc. Bangladesh, Sci*. **40**(1): 141-150.

Karim, Z., Saheed, S. M., Salahuddin, A.B.M., Alam, M.K. and Hoq, A.. 1982. Coastal saline soils and their management in Bangladesh. Soil and Irrigation,publicationNo. **8**.BARC.Bangladesh.

Khatun, M., Tanvir, M.B., Hossain, M.A., Miah, M., Khandoker,S. and Rashid, M.A. 2016. Profitability of sunflower cultivation in some selected sites of Bangladesh. *Bangladesh J.Agr. Res*. **41**(4): 599-623.

Khatun, S. and Flowers, T.J. 1995. Effects of salinity on seed set in rice. *Plant Cell Environ*.**18**: 61-67.

Lutts, S., Kinet, J.M. and Bouharmont., J. 1996. Effects of various salts and of mannitol and proline accumulation in relation to osmotic adjustment in rice (*Oryza sativa* L.) cultivars differing in salinity resistance. *Ann. Bot*. **78**: 389-398.

Maas, E.V. and Hoffman,G.J.1977. Crop salt tolerance current assessment. *J. Irrig. Drainage Div*. ASCE. **103**: 115-134.

Munns, R. 2002. Comparative physiology of salt and water stress. *Plant Cell Environ*. **25**: 239-250.

Munns, R. 2002a. Salinity, growth and phytohormones. *In*: Lauchli, A. and Luttge, U. (eds) Salinity: environment-plants- molecules. Kluwer, The Netherlands. pp. 271-290.

Munns, R. and Tester, M. 2008. Mechanisms of salinity tolerance. *Annu. Rev. Plant Biol*. **59**: 651–681.

Murchie, E.H., Yang, J., Hubbart, S., Horton, P. and Peng, S. 2002. Are there associations between grain-filling rate and photosynthesis in the flag leaves of field-grown rice? *J. Exp. Bot*. **53**: 2217-2224.

Netondo, G.W., Onyango, J.C. and Beck, E. 2004. Gas exchange and chlorophyll fluorescence of sorghum under salt stress. *Crop Sci*. **44**:806-811.

Sairam, R.K. and Tyagi, A. 2004. Physiology and molecular biology of salinity stress tolerance in plants. *Current Science*, **86**(3): 407-421.

Sanchez, D., Garcia, J. and Antolin, M. 2002. Effects of soil drought and atmospheric humidity on yield, gas exchange, and stable car-bon isotope composition of barley. *Photosynthetica*. **40**: 415-421

Sheehy, J.E., Dionora, M.J.A. and Mitchell, P.L. 2001. Spikelet numbers, sink size and potential yield in rice. *Field Crops Res*. **71**: 77-85.

Yeo, A.R., Lee, K.S., Izard, P., Boursierand, P.J., Flowers, T. J. 1991. Short and long term effects of salinity of leaf growth in rice (*Oryza sativa* L.). *J. Exp. Bot*. **2**:881-889.

Yaghubi, M., Nematzadeh, G. and Modarresi, M. 2013. Changes in some morphological traits of two contrast rice (*Oryza sativa* L.) cultivars in response to salinity. *Intl. J. Farm & Alli Sci*, **2**:1037-1041.

Zeng, L. and Shannon, M.C. 2000. Effects of salinity on grain and yield components of rice at different seeding densities. *Agro. J*. **92:** 418-423.