EFFECTS OF SALINITY ON THE GROWTH AND DEVELOPMENT OF GROUNDNUT PLANT (Arachis hypogaea L.)

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ABSTRACT

The present study investigated the effects of salinity on the growth of groundnut (Arachis hypogaea L.), variety BARI Badam-8. The plants were grown in a series of plastic pots under controlled light and temperature conditions in the growth room. Salt (NaCl) solutions of different concentrations (0 mM, 50 mM, 100 mM, 150 mM, 200 mM, and 250 mM) were added to the pots, with three replicates. Results showed that shoot height, number of plants, main root length and lateral root length significantly decreased with the increase of salt concentrations. Fresh weight as well as dry weight of shoots and roots also decreased with the increase of salt concentrations while leaf proline and protein concentrations increased. Overall results indicate that high salinity condition is not suitable for growing groundnut.

Keywords: Groundnut, salinity, salt tolerance

INTRODUCTION

Salinity can limit the growth and development of plants (Shanon, 1986). It is reported that 20% of the agricultural land and 50% of the world’s crop land are salt affected and the area under salinity is increasing throughout the world (Yokoi et al., 2002; Ponnamperuma, 1984).

Groundnut is a tropical legume which can feed human and poultry. Lipid content of groundnut is 42-52 percent, and protein is 25-32 percent. There are many vitamin and minerals in groundnut including vitamin A, vitamin B, Riboflavin, Folate, Mg, P, Mn, and some of the antioxidant compounds such as vitamin E and vitamin D (Sharif, 1997 and Karra et al., 2013).

The climatic and edaphic conditions of coastal areas of Bangladesh are suitable for growing groundnut, but this is limited by high soil salinity and high pH (Reddy and Kaul, 1996). A groundnut cultivar needs to tolerate up to 8 dS/m salinity. Salinity decreases the growth indices of the seedlings as well as the seed size (Smart, 1994). However, cultivation of groundnut has been challenged in Bangladesh due to increased salinity over the years (Sikder and Elias, 1985).

The main objective of the present study was to identify whether the variety, BARI Badam 8, is salt tolerant by examining the effects of salinity on seed germination rate and growth parameters (shoot height, root length, fresh and dry biomass of shoot and root) under different known concentrations of salt (NaCl) solution.

MATERIALS AND METHODS

Seeds of groundnut (A. hypogaea L.), BARI Badam-8, was collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur. Germination rate and weight of 100 seeds were recorded. Before germination, seeds were surface-sterilized with 5% sodium hypochlorite. Then, the seeds were...
left for three days for germination in a Petri-dish with autoclaved distilled water.

Three-day old seedlings were transferred to plastic pots previously filled with soil collected from the Botanical Garden of Jagannath University, Dhaka. Plants were supplied with salt solutions (NaCl) of six concentrations (0 mM, 50 mM, 100 mM, 150 mM, 200 mM, and 250 mM). Salt solution was applied to the pots once a week and water was applied once in every two days. Each treatment had three replicates. Thus, a total of 18 pots were used to grow plants in the growth room at the Department of Botany, Jagannath University. Ten plants were grown in each pot and the plants were allowed to grow for 6 weeks in the growth room.

Soil pH was determined from suspension of soil: water (2:1, v:w) using pH meter (Hanna pH meter, pHep). Soil conductivity was determined in suspension with distilled water (5:1, v:w) using conductivity meter (Hanna conductivity meter). Soil moisture content (%) was determined from 10 g fresh soil after oven-drying at 80°C for 24 h. Organic Carbon content was analyzed by Walkley and Black method (Black, 1965). Total N content was determined by Kjeldahl method (Black, 1965). Soil P content was determined by Vanadomolybdophosphoric yellow color method (Jackson, 1958).

Shoots and roots were separated from the plants. Shoot height, number of live plants, fresh weight, dry weight and main root length, lateral root length, fresh weight and dry weight were noted. Dry weight was measured after drying in oven at 60°C for 24 h. The 1g fresh leaf was used for the extraction of proline; optical density was recorded at 520nm wavelength by spectrophotometer. Proline content being expressed per gram leaf. Fresh leaf 1 g was used for the extraction of protein.

Table 1. Germination test of groundnut seeds at different concentrations of salt solution

| Salt concentrations (mM) | Total seed | Germination rate (%)  | Mean seedling length (cm) |
|--------------------------|------------|-----------------------|--------------------------|
|                          |            | 1st day | 2nd day | 3rd day |                          |
| 0                        | 6          | 67      | 100     | 100     | 1.5                      |
| 50                       | 6          | 50      | 84      | 100     | 1.1                      |
| 100                      | 6          | 34      | 67      | 84      | 0.8                      |
| 150                      | 6          | 17      | 34      | 67      | 0.7                      |
| 200                      | 6          | 17      | 34      | 50      | 0.5                      |
| 250                      | 6          | 0       | 17      | 34      | 0.3                      |
Shoot height and live plants

Effects of salt content on the shoot height and live plant of groundnut presented in Table 2 showed that shoot height and the number of plants differed significantly (P<0.001) with different concentrations of salt. Shoot height and the number of survived plants decreased with the increase of salt concentrations. Decreased growth under salt stress has been reported on arocado plant species (Bernstein et al., 2004). At 12 days, the highest shoot height (19.51±0.96 cm) was found at 50 mM salt concentration while at 22, 32 and 42 days it was highest in control.

Main root length and lateral root length

The effect of different salinity levels on main root length and lateral root length of groundnut are presented in Table 3. It showed significant difference (P<0.001 and P=0.004, respectively). Root length decreased with increasing salinity levels and ranged between (1.16±0.60) cm in 250 mM and (4.63±0.63) cm in control treatment. In case of lateral root length, it also decreased with the increase of salinity and

Table 2. Effects of salt solutions on the shoot height and number of live plants of groundnut

| Salt conc. (mM) | 12 days | 22 days | 32 days | 42 days |
|----------------|--------|--------|--------|--------|
|                | Live plants (%) | Height (cm) | Live plants (%) | Height (cm) | Live plants (%) | Height (cm) | Live plants (%) | Height (cm) |
| 0              | 80.0±0.00a | 17.3±0.42abc | 80.0±0.00a | 23.5±0.19a | 76.3±1.58a | 23.1±0.36ab | 74.0±3.05a | 26.1±0.29a |
| 50             | 76.7±1.66a | 19.5±0.96a | 73.0±1.00ab | 22.5±0.37ab | 69.0±1.00ab | 23.9±0.31a | 59.3±0.66ab | 25.3±0.29ab |
| 100            | 78.3±1.66a | 17.0±1.00ab | 74.0±1.00ab | 20.1±0.29c | 65.3±2.66b | 20.8±0.15c | 53.3±1.66bc | 21.8±0.16ab |
| 150            | 78.3±1.66a | 15.4±0.29bc | 74.0±1.00ab | 20.1±0.29c | 65.3±2.66b | 20.8±0.15c | 53.3±1.66bc | 21.8±0.16ab |
| 200            | 70.0±0.00b | 15.9±0.37d | 66.0±1.00bc | 17.8±0.37d | 52.3±1.45c | 19.2±0.18d | 38.6±1.66c | 19.8±0.33ab |
| 250            | 66.7±1.66b | 15.4±0.26c | 55.7±4.70c | 16.4±0.32d | 43.3±3.33d | 18.0±0.28d | 16.6±18.81d | 12.6±1.26b |

F-ratio 15.6 8.79 16.6 80.16 28.29 56.89 24.64 3.68
P-value <0.001 <0.001 <0.001 <0.001 <0.001 <0.001 <0.001 0.03

Means followed by the same letter does not differ significantly.

Table 3. Effects of salt solutions on the root length of groundnut

| Salt conc. (mM) | Root length (cm) | Lateral root length (cm) |
|----------------|------------------|--------------------------|
| 0              | 5.70±0.10a       | 4.63±0.63a               |
| 50             | 4.40±0.05b       | 4.06±0.47a               |
| 100            | 3.93±0.06bc      | 3.40±0.30ab              |
| 150            | 3.23±0.14cd      | 2.83±0.16ab              |
| 200            | 2.23±0.14de      | 2.46±0.26ab              |
| 250            | 1.16±0.60e       | 1.33±0.66b               |

F-ratio 36.84 6.64
P-value <0.001 0.004

Means followed by the same letter does not differ significantly.
Shoot fresh and dry weight

The effects of different salinity levels on plant fresh and dry weight are displayed in Table 4. It showed significant difference ($P = 0.004$ and $P = 0.001$, respectively). The highest plant fresh weight was found in control (1.36 ± 0.15 g) and the lowest fresh weight was in 250 mM (0.33 ± 0.16 g). The highest plant dry weight was noted in control (0.15±0.01g), and the lowest plant fresh weight in 250 mM (0.04 ± 0.02 g). It was observed that fresh and dry weights decreased gradually from control to 250 mM salt treatment.

Root fresh and dry weight

The effects of different salinity levels on root fresh and dry weight are presented in Table 4. Root fresh and dry weight showed significant difference ($P = 0.003$ and <.001). Root fresh weight ranged from 0.019±0.009 g to 0.060±0.006g and dry weight from 0.002 ± 0.001g to 0.015 ± 0.001 g. The highest root fresh weight was obtained in control (0.060 ±0.006g) and the lowest root fresh weight in 250 mM (0.019±0.009g). Similar trend was found in case of root fresh and dry weights. High salinity may inhibit root and plant elongation due to slowing down the water uptake by the plant which might be another reason for this decrease (Werner and Finkelstein, 1995). Salinity can rapidly inhibit root growth and hence capacity of water uptake and essential mineral nutrition from soil (Neumann, 1995).

Table 4. Effects of salt solutions on fresh and dry biomass (shoot and root) of groundnut

| Salt conc. (mM) | Shoot fresh weight (g/plant) | Shoot dry weight (g/plant) | Root fresh weight (g/plant) | Root dry weight (g/plant) |
|-----------------|-----------------------------|---------------------------|----------------------------|--------------------------|
| 0               | 1.36±0.15a                  | 0.15±0.01a                | 0.060±0.006a               | 0.015±0.001a             |
| 50              | 1.06±0.13a                  | 0.12±0.009ab              | 0.052±0.001a               | 0.015±0.001a             |
| 100             | 1.01±0.13ab                 | 0.10±0.01abc              | 0.048±0.003a               | 0.011±0.0008ab           |
| 150             | 1.00±0.12ab                 | 0.09±0.01abc              | 0.036±0.003ab              | 0.007±0.0003bc           |
| 200             | 0.90±0.02ab                 | 0.08±0.002bc              | 0.034±0.002ab              | 0.005±0.0004cd           |
| 250             | 0.33±0.16b                  | 0.04±0.02c                | 0.019±0.009b               | 0.002±0.001d             |
| F-ratio         | 6.64                        | 8.83                      | 7.20                       | 30.71                    |
| P-value         | 0.004                       | 0.001                     | 0.003                      | <.001                    |

Means followed by the same letter does not differ significantly.
**Proline and Protein content**

Effects of salinity on the proline and protein contents of groundnut plants are shown in Table 5. In the leaf tissues the proline and protein contents differed significantly (P<0.001) among different concentrations of salt. Proline accumulation in root tissue increased with the increase of salt concentrations. The lowest proline content was (0.503±0.012 µg/g) recorded in control and the highest proline content was (2.15±0.008µg/g) obtained in 250 mM salt treatment. Cha-Um and Kirdmanee (2009) have reported higher proline concentration in lentil plants under salt stress condition.

The lowest protein content (0.210±0.008 mg/g) was found in control and the highest protein content (0.475±0.024 mg/g) in 250 mM salt concentrations.

Overall, results indicate that the growth parameters of groundnut (BARI Badam-8) plants were markedly affected by 250 mM salt treatments indicating that high salinity is not suitable for cultivation of groundnut.

Table 5. Proline and protein concentrations of groundnut plant under different salt concentrations

| Salt conc. (Mm) | Proline concentrations (µg/g) | Protein concentrations (mg/g) |
|-----------------|-----------------------------|-------------------------------|
| 0               | 0.5±0.012f                  | 0.21±0.008d                  |
| 50              | 0.8±0.017e                  | 0.22±0.012cd                 |
| 100             | 1.0±0.017d                  | 0.328±0.01bc                 |
| 150             | 1.75±0.015c                 | 0.303±0.01b                  |
| 200             | 2.0±0.014b                  | 0.372±0.01b                  |
| 250             | 2.15±0.008a                 | 0.475±0.02a                  |
| F-ratio         | 2226.77                     | 55.98                        |
| P-value         | <0.001                      | <0.001                       |

Means followed by the same letter does not differ significantly.

REFERENCES

Aydinşakir, K., D. Büyüktas, N. Dinc and C. Karaca. 2015. Impact of salinity stress on growing, seedling development and water consumption of peanut (Arachis hypogaea cv. NC-7). Akdeniz University Ziraat Fakultesi Dergisi, 28(2): 77-84.

Bernstein, N., A. Meiri and M. Zilbersteine. 2004. Root growth of avocado is more sensitive to the salinity than shoot growth.

Black, C.A. 1965. Methods of soil and plant analysis. Part I and II. American Society of Agronomy.

Cha-Um, S. and C. Kirdmanee. 2009. Effect of salt stress on proline accumulation, photosynthetic ability and growth characters in two maize cultivars. Pak. J. Bot. 41: 87-98.

Jackson, M. I. 1958. Soil Chemical Analysis. Prentice-Hall Inc., Englewood Cliffs, NJ. pp. 153.
Jamil, M. and E.S. Rha. 2004. The effect of salinity (NaCl) on the germination and seedling of sugar beet (*Beta vulgaris* L.) and cabbage (*Brassica oleracea* capitata L.). *Korean Journal of Plant Research*. 7: 226-232.

Karra, G., Nadenla, R., Shireesh K. R., Srilatha, K., Mamatha, P. and Umamaheswar R.V. 2013. An overview on *Arachis hypogaea* plant. *International Journal of Pharmaceutical Sciences and Research*. 4(12): 4508-4518.

Neumann, P. M. 1995. Inhibition of root growth by salinity stress: Toxicity or an adaptive biophysical response. Structure and Function of Roots. The Netherlands: Kluwer Academic Publishers. pp: 299-304.

Ponnamperuma, F.N. 1984. Role of Cultivar Tolerance in increasing rice production on saline land in: Staples, R. C. and G. H. Toenniessen, (eds). Salinity Tolerance in Plants Strategies for Crop Improvement, Wiley, New York. pp. 255-271.

Reddy, L. J. and A. K. Kaul. 1996. Status and prospects of Groundnut in Bangladesh, Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

Sharifi, R.S. 1997. Industrial Plant, *Mahdd Tamadon*. pp. 407.

Shanon, M.C. 1986. New insights in plant breeding efforts for improved salt tolerance. *Hort. Technol.*, 6: 96–99.

Sikder, F. S. and S. M. Elias. 1985. An economic assessment of lentil cultivation in some selected areas of Bangladesh. *Economic Affairs, India*. 30(3): 181-186.

Smart, J. 1994. The groundnut crop: A scientific basis for improvement. London. Chapman & Hall. pp. 734.

Tejovathi, G., M. A. Khadeer and S.Y. Anwer. 1988. Studies on certain enzymes in salt tolerant and sensitive varieties of sunflower. *Indian J. Bot.* 11: 113–117.

Werner, J. E. and R. R. Finkelstein. 1995. Arabidopsis mutants with reduced response to NaCl and osmotic stress. *Physiologia Plantarum* 93(4): 659-666.

Yokoi, S. R., A. Bressan and P. M. Hasegawa 2002. Salt stress tolerance of plants. *JIRCAS Working Report*. pp. 25-33.

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