**In Vitro Regeneration of Onion (Allium cepa L.) Genotypes under Salt Stress Condition**

Asfiquz Rahman Plabon¹, M. E. Hoque¹, Farhana Afrin Vabna¹*
and Fahima Khatun¹

¹Department of Biotechnology, Sher-e-Bangla Agricultural University, Bangladesh.

**Authors’ contributions**

This work was carried out in collaboration among all authors. Authors ARP and MEH designed the study, performed the research work and statistical analysis. Authors MEH, FK and FAV wrote the protocol, managed the analyses of the study and wrote the manuscript. All authors read and approved the final manuscript.

**Article Information**

DOI: 10.9734/ARJA/2021/v14i130116

Editor(s):
(1) Dr. Afroz Alam, Banasthali University, India.
Reviewers:
(1) Mary L Mhazo, Eswatini.
(2) Sunjeet Kumar, Chinese Academy of Science, China.
Complete Peer review History: [http://www.sdiarticle4.com/review-history/66183](http://www.sdiarticle4.com/review-history/66183)

Received 07 January 2021
Accepted 11 March 2021
Published 23 March 2021

**ABSTRACT**

Salinity is a major problem affecting crop production all over the world. Excessive soil salinity can reduce the productivity of many agricultural crops including many vegetables and spices. Onion is one of the most important spices in the Asiatic region which is now in high demand. The experiment was conducted to observe in vitro regeneration of onion (Allium cepa L.) under salt stress condition from September 2016 to July 2017. The experiment was conducted as two factorial (genotype and treatment) Completely Randomized Design (CRD) with 3 replications for each treatment. Shoot tip segments of three genotypes namely Faridpuri, Taherpuri and Pusa red (Indian) were cultured in MS (Murashige and skoog, 1962) media supplemented with 25, 50, 75 and 100 mM NaCl. The genotype Faridpuri gave maximum salt tolerance up to 100 mM salinity level with 10.60 cm shoot length and 1.94 cm root length having the highest relative shoot and root growth. Pusa red was found to be salinity sensitive genotype which showing lowest shoot length of 7.03 cm and root length of 0.96 cm at 100 mM NaCl treatment. However, Taherpuri was tolerant up to 100 mM salinity level with 8.14 cm shoot length and 1.25 cm root length. Both the highest fresh weight of root (54.77 mg) and dry weight of root (41.36 mg) was from the genotype Faridpuri with 25 mM NaCl.
productivity of brutal environmental factors limiting the levels of salinity [7]. Salinity is one of the most areas of Bangladesh are affected by different million hectares of cultivable land of the coasta estimated to be 10 million ha [6]. The amount of world agricultural land destroyed by salt accumulation each year is estimated to be 10 million ha [6]. About 1.0 million hectares of cultivable land of the coastal areas of Bangladesh are affected by different levels of salinity [7]. Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the crop plants are sensitive to high concentrations of salts in the soil. In most of the cases, the negative effects of salinity have been attributed to increase in Na⁺ and Cl⁻ ions in different plants hence these ions produce the critical conditions for plant survival by intercepting different plant mechanisms. Although both Na⁺ and Cl⁻ are the major ions which produce many physiological disorders in plants, Cl⁻ is the most dangerous [8]. Salinity at higher levels causes both hyperionic and hyperosmotic stress and can lead to plant death. The stress can cause membrane damage, nutrient imbalance, altered levels of growth regulators, enzymatic inhibition and metabolic dysfunction, including reduced photosynthesis which ultimately leads to plant death [9,10]. Salinity inhibits the growth of plants by affecting both water absorption and biochemical processes, such as nitrogen assimilation and protein biosynthesis [11]. Under saline conditions, the plants fail to maintain the required balance of organic constituents leading to suppressed growth and yield. In developing countries, the limited supply of good quality water in many arid and semi-arid regions necessitates the use of saline water where available for crop production. This, in turn, requires the screening of crop plant genotypes for their tolerance to salinity. Salt tolerance of crops is the maximum salt level a crop tolerates without losing its productivity while it is affected negatively at higher levels. Salt tolerant crops are being used as an effective tool for improving crop production in saline soil. Researchers have already developed salt tolerant genotypes of many crops (eg. rice, wheat, barley, maize, potato, cabbage, tomato, onion, melon, spinach, bean, cucumber etc.) which are successfully growing in different salt affected areas. In Bangladesh, many of these salt tolerant crop varieties are being cultivated in the coastal salt affected areas nowadays. Although different salt tolerant rice varieties are widely cultivated in those areas, spice crops like onion varieties are also introduced in those areas. Tissue culture techniques have been applied to the plant species in an attempt to screen salt

Keywords: In vitro; regeneration; onion; salinity.

1. INTRODUCTION

Onion (Allium cepa L.) is one of the most important bulb crops and popular vegetable grown for its pungent bulbs and flavorful leaves. It is a member of Alliaceae family belonging to the genus Allium [1]. There are more than 500 species within the genus Allium, of these most are bulbous plants. It is one of the most important spice as well as promising vegetable in all over the world. Bangladesh was ranked 9th in world onion production in 2020 [2]. About 18,02866 metric tons of onion is produced from 4,26157 acres of land in Bangladesh [3]. In Bangladesh, commercial onion production is concentrated in the districts of Faridpur, Mymensingh, Rangpur and Pabna.

Onions are excellent sources of vitamin C, sulphuric compounds, flavonoids and phytochemicals. They all are helpful in maintaining good health and have anticancer and antimicrobial properties. Most onion cultivars contain about 89% water, 9% carbohydrates (including 4% sugar and 2% dietary fibre), 1% protein, and negligible fat. Onions contain low amounts of essential nutrients and have an energy value of 166 kJ (40 kilocalories) in a 100 g (3.5 oz) amount [4].

Onion is mainly produced in the winter season. Cultivation in summer season is constrained due to adverse weather and implementation of proper cultural practices challenges. But demand for its use is ever increasing irrespective of season.

Salinity is a state of presence of high salt concentration on soil or water that is more than the natural occurrence. It was estimated that about 20% (45 million ha) of irrigated land, producing one-third of the world’s food, is salt-affected [5].

Again, the amount of world agricultural land destroyed by salt accumulation each year is estimated to be 10 million ha [6]. These harsh conditions are having significant negative impacts on plant growth and productivity. Despite the challenges, researchers are continually working on developing salt-tolerant genotypes to enhance crop productivity in saline environments. In this regard, tissue culture techniques have been employed as an effective tool for developing salt-tolerant onion genotypes.

Keywords: In vitro; regeneration; onion; salinity.

1. INTRODUCTION

Onion (Allium cepa L.) is one of the most important bulb crops and popular vegetable grown for its pungent bulbs and flavorful leaves. It is a member of Alliaceae family belonging to the genus Allium [1]. There are more than 500 species within the genus Allium, of these most are bulbous plants. It is one of the most important spice as well as promising vegetable in all over the world. Bangladesh was ranked 9th in world onion production in 2020 [2]. About 18,02866 metric tons of onion is produced from 4,26157 acres of land in Bangladesh [3]. In Bangladesh, commercial onion production is concentrated in the districts of Faridpur, Mymensingh, Rangpur and Pabna.

Onions are excellent sources of vitamin C, sulphuric compounds, flavonoids and phytochemicals. They all are helpful in maintaining good health and have anticancer and antimicrobial properties. Most onion cultivars contain about 89% water, 9% carbohydrates (including 4% sugar and 2% dietary fibre), 1% protein, and negligible fat. Onions contain low amounts of essential nutrients and have an energy value of 166 kJ (40 kilocalories) in a 100 g (3.5 oz) amount [4].

Onion is mainly produced in the winter season. Cultivation in summer season is constrained due to adverse weather and implementation of proper cultural practices challenges. But demand for its use is ever increasing irrespective of season.

Salinity is a state of presence of high salt concentration on soil or water that is more than the natural occurrence. It was estimated that about 20% (45 million ha) of irrigated land, producing one-third of the world’s food, is salt-affected [5].

Again, the amount of world agricultural land destroyed by salt accumulation each year is estimated to be 10 million ha [6]. About 1.0 million hectares of cultivable land of the coastal areas of Bangladesh are affected by different levels of salinity [7]. Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the
tolerant genotypes within a very short period of time. The present work was carried out to study the influence of salt level 25, 50, 75 and 100 mM NaCl on regeneration for three onion genotypes, sub-culturing at 10-20 day intervals and in vitro selection of salt tolerant genotypes. So, the objective of the study is to determine the effect of salt concentration upto 100 mM/9.13 dsm⁻¹ on onion regeneration and to find out the best genotypes among the three onion cultivars. An efficient, simple and reliable in vitro regeneration protocol is needed for identification of best salt tolerant genotype of onion in vitro condition. Although huge research work has been done worldwide on salt stress study but very few work has been done under Bangladesh condition. The genotypes which we used in this experiment were not tested for salt tolerance. The most popular genotypes viz. Faridpuri, Taherpuri, Pusa red (Indian) need to study under salt stress condition for the benefit of national interest.

2. MATERIALS AND METHODS

The present research was carried out in Biotechnology Laboratory of the Department of Biotechnology, Sher-e-Bangla Agricultural University. Three genotypes namely Faridpuri, Taherpuri and Pusa red (Indian) were collected from the Bangladesh Agricultural research Institute (BARI), Gazipur and used as investigated materials in this present study. The shoot tips of Allium cepa L. were used as experimental materials in the present investigation.

Salinity treatments for in vitro onion regeneration were \( T_1 = 25 \text{ mM NaCl in MS media (2.28 dsm}^{-1}) \), \( T_2 = 50 \text{ mM NaCl in MS media (4.57 dsm}^{-1}) \), \( T_3 = 75 \text{ mM NaCl in MS media (6.85 dsm}^{-1}) \), \( T_4 = 100 \text{ mM NaCl in MS media (9.13 dsm}^{-1}) \). Three onion genotypes viz. Faridpuri, Taherpuri, Pusa red (Indian) used as another factorial.

The shoot tip segment was cut to optimum size required for inoculation in culture vial. Explants were washed in running tap water and then washed again thoroughly by adding a few drops of Tween-20 for 5 minutes. Then they were washed with distilled water for several times followed by sterilization with 70% ethanol for 1 min. They were then surface sterilized in a 0.2% mercuric chloride for 2 min followed by rinsing them four times with double distilled water inside the Laminar Air flow chamber. Finally, 0.5–1.0 cm sized explants were cultured on Murashige and Skoog (MS, 1962) medium [12] supplemented with specific concentration of NaCl treatment (25, 50, 75 and 100 mM) for screening of salinity tolerance in combination with the 8 g/L agar and 30 g/L sucrose. Inoculation of explants was done in Laminar Air Flow Cabinet. The pH of the medium was adjusted to 5.8 before autoclaving. The culture jars containing explants were incubated in a growth room with 21 ±1°C under 3000-4000 lux of fluorescent light with 16/8 hours photoperiod for regeneration. The culture jars were checked daily to note the growth response and contamination. Initial sub-culturing was done after 15-25 days when the explants had produced some shoots. Sub-culturing was done at 10-20 day intervals. When shoot length was 4-5 cm with 3-4 well developed leaves, shoots/plantlets were removed aseptically from the culture vials, separated and cultured again on freshly prepared medium containing different combinations of salt for root induction. Parameters recorded during the experiment were days required for shoot and root initiation, number of shoot per explants, length of the shoot (cm), number of leaves per plant, number of roots per explants, length of root (cm), fresh weight (mg) and dry weight (mg) of root.

The fresh weight of root was measured in mg by a digital balance at 28th day after culture using following formula:

\[
\text{Fresh weight of root} = \frac{\text{Total weight of root measured}}{\text{Total number of root measured}}
\]

Root were collected at 28th day after culture and dried in an oven at 30°C for 48 hours. Then dry weight of the root/shoot was measured in mg by a digital balance using following formula:

\[
\text{Dry weight of root} = \frac{\text{Total weight of root}}{\text{Total number of root measured}}
\]

The experiment was conducted under laboratory conditions where all the factors were constant. For this reason, experiments were arranged in two factorial (genotype and treatment) Completely Randomized Design (CRD) with 3 replications for each treatment. Data for the characters under the study were statistically analyzed following MSTAT-C (1990) package computer program for in vitro shoot and root bioassay for salinity. The analysis of variance
Equal inoculums (250 mg) of proliferated callus depressed upon increasing of salts in medium. Multiple shoot regeneration was noticed due to NaCl treatment which was statistically similar to Pusa red genotype with 50 mM and 100 mM at the same 25 mM NaCl treatment. On the other hand, the highest time (9.67 days) was needed for Pusa red genotype with 50 mM and 100 mM NaCl treatment which was statistically similar to other treatment (Table 1).

3. RESULTS AND DISCUSSION

Three onion genotypes Faridpuri, Taherpuri and Pusa red cultured on MS medium supplemented with different concentration of NaCl in combination with IBA are presented below.

3.1 Days Required for Shoot Initiation

Days required to shoot regeneration was varied significantly with the combined effect of different genotypes and salinity level. The lowest time (6.34 days) was needed in the case of Faridpuri (Plate 1) with 25 mM NaCl treatment, followed by Taherpuri (7.51 days) and Pusa red (8.66 days) at the same 25 mM NaCl treatment. On the other hand, the highest time (9.67 days) was needed for Pusa red genotype with 50 mM and 100 mM NaCl treatment which was statistically similar to other treatment (Table 1).

3.2 Multiple Shoot Proliferation per Plantlet

Multiple shoot regeneration was noticed due to application of the treatments. The treatment of 25 mM NaCl showed maximum number of shoots (4.67, 4.69, 6.02) at 14, 21 and 28 DAI in the genotype Faridpuri followed by Taherpuri (3.43, 4.00, 4.30) and Pusa red (2.72, 3.24, 3.40) at 14, 21 and 28 days respectively.(Plate 2). The minimum numbers of shoots (1.22, 1.26, 1.34) at 14, 21 and 28 DAI respectively were produced from Pusa red in 100 mM NaCl which was significantly different from rest of the treatment (Table 1). Bekheet [13] observed that the number of proliferated shoots and their growth were depressed upon increasing of salts in medium. Equal inoculums (250 mg) of proliferated callus were sub-cultured on callus growth medium (MS+2 mg/l 2,4-D + 1 mg/l BA). supplemented with 0, 2000, 4000 and 6000 ppm of salt mixture. The best result of salt tolerance ratio scored under 2000 ppm salt mixture whereas shoot buds grown on medium contained 6000 ppm scored the lowest growth parameters.

3.3 Length of Shoot Per Plantlet (CM)

The effect of different concentrations of salt showed variations on shoot length of the plantlet (Table 1). The maximum shoot length (13.5 cm) was recorded in Faridpuri genotype at 50 mM NaCl treatment (28 days) (Plate 3). Whereas, the shoot length was 9.50 cm in Taherpuri and 8.43 cm in Pusa red at the same treatment (28 days). On the other hand, the minimum shoot length (7.03 cm) was observed in Pusa red genotype with 100 mM NaCl treatment (28 days). In this experiment, it was observed that the response of Faridpuri genotype in respect of salt tolerance was comparatively better than other genotypes (Plate 3). Joshi et al. [14] observed how NaCl levels affect the biochemical responses of onion (Allium cepa L.) seedlings. Seed of the genotypes N-2-4-1 (genotype 1), B-780 (genotype 2), Phule Samarth (genotype 3), Bhima Red (genotype 4), Bhima Raj (genotype 5), and Bhima Super (genotype 6) were exposed to NaCl levels from 42.78 mM (0.25%) to 171.11 mM (1.0%). Increasing salt level adversely affected seedling growth in all genotypes.
3.4 Number of Leaves per Plantlet

Significant difference was found in combined effect of genotypes and salt stress in number of leaves per plantlet at 14, 21 and 28 DAI (Fig. 1). The genotype Faridpuri produced the maximum number (4.67) of leaves per plantlet in the concentration of 25 mM NaCl treatment (28 days) (Plate 4). The genotype Taherpuri produced 4.33 number of leaves and Pusa red produced 4.25 number of leaves at 25 mM treatment. So, average number of leaves was also higher in the same treatment in other genotypes, which is statistically different from rest of the treatment. It was noticed that the number of leaves regenerated was decreased in relation with higher concentration of salt treatment. It means that higher concentration of salt has negative effect on shoot development. However, the minimum number of leaves (2.12) was produced from Pusa red with 25 mM NaCl treatment at 14 days. Again, improvement of abiotic stress tolerance in onion was studied by Fatih Hanci [15]. A total of 192 seeds were sowed at the second stage of the study. Only 14 of them survived at end of the experiment. The study was conducted for 5 years with three treatment levels of 0, 250 and 350 mM NaCl to compare the unselected population. All observed parameters such as plant length (cm), leaf number, leaf diameter (mm) were reduced with the increase of salinity level.

Plate 4. Effect of salinity on number of leaves per plantlet (Faridpuri)

3.5 Days Required for Root Initiation

Among the three genotypes, Taherpuri and Pusa red were significantly different from Faridpuri in respect of days to root initiation. Maximum period (16.33 days) was recorded in case of Taherpuri with 100 mM NaCl treatment which was statistically similar with Pusa red with 100 mM NaCl and minimum days was found in Faridpuri genotype. The minimum days (12.76 days) was needed for Faridpuri with 100 mM NaCl treatment (Table 2).

3.6 Number of Root

Combined effect of genotypes and salt stress varied significantly for total number of root per explant at 14, 21 and 28 days after inoculation (Table 2). It reveals that, the highest number of root (9.98) was obtained from Faridpuri genotype with 25 mM NaCl treatment (28 days). It was followed by Taherpuri and Pusa red at the same treatment. The genotype Pusa red showed minimum number (2.22) of roots with 50 mM NaCl treatment at 28 DAI. Among the three genotypes, the response of Faridpuri was well in all the treatments in respect of number of root production (Plate 5).

Plate 5. Effect of salinity on number of root (Faridpuri) produced per plantlet of onion

3.7 Length of Root (CM)

After four weeks of inoculation remarkable variation was observed among the genotypes in terms of root length (Table 2). The highest root length (2.30 cm) was observed in Faridpuri with 25 mM treatment (28 days) and the lowest root length (0.96 cm) was found in Pusa red with 100 mM treatment (28 days). With the increasing salt concentration, root length was adversely affected. Similar result was observed by Kiełkowska [16], root meristem cell cross-section area, nuclear volume as well as overall root growth was decreased under osmotic and salt stress condition after 20 days of initiation.

3.8 Fresh Weight of Root (MG)

Combined effect of genotypes and salt stress varied significantly for fresh weight in root per plantlet at 5% level of significance at laboratory condition. The highest fresh weight of root (54.77 mg) was obtained from the genotype Faridpuri with 25 mM NaCl treatment. At the same treatment it was 50.38 mg and 48.32 mg in Taherpuri and Pusa red genotype. On the Other hand, the minimum fresh weight of root (30.32
mg) was found from Pusa red with 75 mM NaCl treatment (Fig. 2).

### 3.9 Dry Weight of Root (MG)

Significant variation was observed among the genotypes on dry weight of root. The highest dry weight of root (41.36 mg) was obtained from genotype Faridpuri at 25 mM salt concentration and the lowest dry weight (23.13 mg) was obtained from genotype Pusa red at the 50 mM NaCl treatment (28 days) (Fig. 3).

![Fig. 1. Effect of genotype and salinity on number of leaves per plantlet for the three onion genotypes](image1)

![Fig. 2. Effect of genotype and salinity level on fresh weight of root of onion](image2)

![Fig. 3. Effect of genotype and salinity level on dry weight of root of onion](image3)
Table 1. Effect of genotype and salinity on days to shoot initiation and number of shoot per plantlet and length of shoot of onion

| Genotypes   | Treatments MS+NaCl (mM) | Days to shoot initiation | Number of shoot per plantlet | Length of shoot (cm) |
|-------------|-------------------------|--------------------------|------------------------------|----------------------|
|             |                         | 14DAI 1DAI 21DAI 28DAI   | 14 DAI 21 DAI 28 DAI        |                      |
| Faridpuri   | 25                      | 6.34 de 4.67 ab 4.69 bc | 6.02 bc 8.55 a 9.79 abc    | 12 bc                |
|             | 50                      | 7.33 bcde 3.66 bc 3.68 bcdef | 5.09 bc 8.87 a 10.37 abc | 13.5 a               |
|             | 75                      | 6.54 de 3.65 bc 3.66 bcdef | 5.04 bcde 6.76 bcde 8.58 bcde | 10.8 cd |
|             | 100                     | 7.32 bcde 2.70 cde 2.67 defgh | 4.01 cdef 6.47 cd 7.77 defgh | 10.6 cd |
| Taherpuri   | 25                      | 7.51 bcd 3.43 bcd 4.00 bcde | 4.30 cdef 8.14 ab 8.93 bcde | 11.29 cd |
|             | 50                      | 8.26 ab 2.42 cde 3.06 cdefgh | 4.12 bcdef 7.83 abc 8.30 cdef | 9.50 de |
|             | 75                      | 7.50 bcd 1.94 de 2.17 efgh | 3.12 efg 6.04 d 7.23 efg | 8.32 ef |
|             | 100                     | 8.61 abc 1.67 e 1.35 gh | 2.24 fg 5.75 d 6.35 gh | 8.14 ef |
| Pusa red    | 25                      | 8.66 ab 2.72 cde 3.24 bcdefg | 3.40 efg 7.92 abc 8.26 cdef | 9.03 de |
|             | 50                      | 9.67 a 1.64 e 2.32 efg | 3.32 def 7.63 abc | 7.66 defg 8.43 ef |
|             | 75                      | 8.56 ab 1.23 e 1.75 fg | 2.35 bfg 5.81 d 6.48 fg | 7.92 f |
|             | 100                     | 9.67 a 1.22 e 1.26 h | 1.34 g 5.55 d 5.72 h | 7.03 f |
| LSD (0.05)  | 1.83                    | 1.39 1.71 1.77          | 1.42 1.69 1.76          |                      |
| CV (%)      | 4.26                    | 7.98 11.14 4.75         | 11.53 12.21 10.09       |                      |

*Figures in the columns followed by different letters are significantly different by DMRT at p=0.05, LSD = Least significant difference, CV% = Percentage of coefficient of variance.*
Table 2. Effect of genotype and salinity on days to root initiation, number of root per plantlet and length of root of onion

| Genotypes | Treatments MS+NaCl (mM) | Days to root initiation | Number of root per plantlet | Length of root (cm) | 14 DAI | 21 DAI | 28 DAI | 14 DAI | 21 DAI | 28 DAI |
|-----------|-------------------------|------------------------|-----------------------------|---------------------|--------|--------|--------|--------|--------|--------|
| Faridpuri | 25                      | 12.94 e                | 5.05 ab                     | 6.40 a              | 9.96 b | 2.25 a | 2.57 abc | 2.30 ab |
|           | 50                      | 13.05 d                | 4.65 bc                     | 6.03 a              | 9.76 b | 1.92 abc| 1.93 bc | 1.95 abcd|
|           | 75                      | 14.60 bc               | 4.32 bc                     | 5.35 b              | 6.68 cd| 1.70 abcd| 1.93 cd | 1.98 abcd|
|           | 100                     | 12.76 e                | 4.00 bc                     | 4.54 cd             | 4.73 ef| 1.51 abcde| 1.80 cd | 1.94 abcd|
| Taherpuri | 25                      | 14.34 bc               | 3.10 bcd                    | 4.89 de             | 7.93 c | 1.20 bcd| 1.62 cdef| 1.93 abcd|
|           | 50                      | 14.53 bc               | 2.15 cd                     | 3.84 de             | 6.84 cd| 1.00 cdef| 1.33 efgh| 1.65 bcde|
|           | 75                      | 15.42 ab               | 2.18 cd                     | 3.72 de             | 4.97 ef| 0.95 cdef| 1.12 gh | 1.42 de |
|           | 100                     | 16.33 a                | 1.28 d                      | 2.88 f              | 2.96 g | 0.84 def | 1.10 gh | 1.25 ef |
| Pusa red  | 25                      | 14.11 bc               | 2.98 cd                     | 4.00 cd             | 7.24 c | 1.03 cdef| 1.45 defg| 1.86 bcde|
|           | 50                      | 14.24 bc               | 1.96 cd                     | 1.33 g              | 2.22 g | 0.83 def | 1.44 cdef| 1.53 cde |
|           | 75                      | 15.42 ab               | 1.43 d                      | 3.24 ef             | 4.95 f | 0.84 ef  | 0.98 h  | 1.35 de |
|           | 100                     | 16.20 a                | 1.36 d                      | 3.13 ef             | 5.20 ef| 0.62 f  | 0.90 h  | 0.96 f  |
| LSD (0.05)|                         | 1.29                   | 1.77                        | 0.82                | 1.17   | 0.70    | 0.44    | 0.67    |
| CV (%)    |                         | 5.34                   | 4.40                        | 12.16               | 10.55  | 9.42    | 5.51    | 3.19    |

*Figures in the columns followed by different letters are significantly different by DMRT at p=0.05, LSD = Least significant difference, CV% = Percentage of coefficient of variance*
4. CONCLUSION

Based on the above discussion it may be concluded that the onion genotypes were not significantly affected upto 75 mM salinity level. Among the three genotypes the Faridpuri genotype was found to have better tolerance upto 100 mM salinity level. Further research can be carried out to identify stable salt tolerant genotype in onion cultivars. This can allow year round production of onion to meet national demand. Coastal area of our country is adversely affected by salinity and due to that huge land of southern belt of Bangladesh was uncultivated and remained as fallow land. Salinity tolerant genotype of any crops like onion is badly needed for those areas. The experimental findings provided some useful implications which would be helpful for further onion research programs in context of salinity problem.

ACKNOWLEDGEMENTS

Authors are thankful to Sher-e-Bangla Agricultural University, Dhaka and NST fellowship program for providing financial assistance for research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hamlet P. Taxonomy, evolution and history. In: Rabinowitch, HD and Brewster (eds); 1990.
2. Onions JL, Allied Crops. CRC press, Boca Raton, Florida. 1990;(1):1-26. Available:https://en.wikipedia.org/wiki/International_rankings_of_Bangladesh
3. BBS (Bangladesh Bureau of Statistics). Yearbook of agricultural statistics, statistics and informatics division (SID), ministry of planning, Government of the people’s republic of Bangladesh, Dhaka, Bangladesh; 31st ed.; 2019.
4. US National Onion Association. History of onions. Greeley, CO; 2011. Retrieved 23 January 2017
5. Shrivastava P, Kumar R. Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. Saudi J Biol Sci. 2015;22:123–131. Aavailable:https://doi.org/10.1371/journal.pone.020638
6. Pimentel D, Berger B, Filiberto D, Newton M, Wolfe B, Karabinakis E, et al. Water resources: Agricultural and environmental issues. Bio Science. 2004;54:909–918.
7. Karim Z, Hussain SG, Ahmed M. Salinity problem and crop intensification in the coastal region of Bangladesh. BARC Soil Publication. 1990;33:63.
8. Tavakkoli E, Rengasamy P, McDonald GK. High concentrations of Na⁺ and Cl⁻ ions in soil solution have simultaneous detrimental effects on growth of faba bean under salinity stress. J. Exp. Bot. 2010;(61):4449–4459.
9. Hasanuzzaman M, Fujita M. Selenium and plant health: The physiological role of selenium. In: Aomori C, Hokkaido M. (eds) Selenium: Sources, functions and health effects. Nova Publishers, New York; 2012.
10. Mahajan S, Tuteja N. Cold, salinity and drought stresses: An overview. Arch Biochem. Biophys. 2005;44(4):139–158.
11. Dubey R. Protein synthesis by plants under stressful conditions. In: Handbook of plant and crop stress, Mohammed P (ed.) marcel Dekker, New York. 1994;277-299.
12. Murashige T, Skoog F. A revised medium for rapid growth and bio assays with tobacco tissue cultures. Physiologia Plantarum. 1962;15(3):473–497.
13. Bekheet SA, Taha HS, Solliman ME. Salt tolerance in tissue culture of onion (Allium cepa L.). Arab. J. Biotech. 2006; 9(3):467-476.
14. Joshi N, Sawant P. Response of onion (Allium cepa L.) seed germination and early seedling development to salt level. Int. J. of Vegetable Sci. 2012; 18(1):3-19.
15. Hanci F. Improvement of abiotic stress tolerance in onion: Selection studies under salinity conditions. The International Journal of Engineering and Science (IJES). 2018;7(9):54-58.
16. Kielkowska A. *Allium cepa* root meristem cells under osmotic (sorbitol) and salt (NaCl) stress *in vitro*. Acta Bot. Croat. 2017;76(2):146–153.