Effect of salinity on agro-morphogenic traits of tomatillo genotypes

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Introduction

The tomatillo, Physalis ixocarpa Bro. or P. philadelphica Lam. (2n=2x=24), is an important crop in Mexico, and now-a-days both cultivated and weedy annuals have been introduced and appreciated worldwide. It is an allogamous, annual plant of Solanaceae family under the angiosperm genus Physalis. Tomatillo plants bear small, spherical and bright green (Physalis philadelphica Lam.) or green-purple (Physalis ixocarpa Bro.) fruits surrounded by an inedible, paper-like husk formed from the calyx (Morton, 1987). Thus, it is also known as the “Mexican husk tomato”. Tomatillos are slightly acidic true berries with many tiny seeds. Fruits are harvested when the fruits fill the calyx. It is a highly nutritious fruit with a combination of vitamins and minerals. Edible fruit contains high dietary fiber, pectin, vitamin A, vitamin-C, vitamin-K, niacin, riboflavin, thiamin, β-carotenes (zeaxanthin and lutein), calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), phosphorous (P), potassium (K) and copper (Cu) (Yamaguchi, 1987).
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1983). Fruits are rich in antioxidants, like withanolides (ixocarpalactone A, ixocarpalactone B, philadelphicalactone B, and withaphysacarpin). Withanolides (e.g. IxoA) are potent inducers of quinone reductase, which is more powerful in preventing colon cancer than chemotherapy (Choi et al., 2006). Tomatillos are the key ingredient of Mexican cuisine, particularly salsa verde (Escobar et al., 2014; Waterfall, 1958). Fruits are often used in jams, preserves, stews, soups, salads, curries, stir-fries, baking, cooking with meats, marmalade, and desserts (Morton, 1987).

Though tomatillos are native to Mexico and Central America, and they are presently one of the most important crops in Mexico (Cantwell et al., 1992), being the fourth vegetable in production surface with an area of 47,473 ha in 2009 (Borja-Bravo et al., 2013). Nowadays it is also cultivated in India, Australia, South Africa, USA and even in Bangladesh. Tomatillo has been recently introduced in our country as a vegetable crop by the Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka in 2013. Even two varieties of tomatillo have been released named SAU tomatillo 1 and SAU tomatillo 2 in 2016 (Reza, 2016). Previous several researches exhibited that tomatillo is a high yielding crop in our country’s aspect than its origin, Mexico (Karim, 2016). Our Rabi season atmosphere has found to be highly favorable for growing tomatillo. Now, further efforts are obligatory to observe the performance of tomatillo under different biotic and abiotic stress condition.

Salinity is one of the major problem of coastal regions of our country, like Jessore, Narail, Gopalganj, Shariatpur, Chandpur, Satkhira, Khulna, Bagerhat, Pirozpur, Jhalakati, Barguna, Barisal, Patuakhali, Bhola, Lakshmipur, Noakhali, Feni, Chittagong, and Cox's Bazar. Coastal area covers about 20% of Bangladesh and over 30% of the net cultivable area. The cultivable areas in coastal districts are affected with varying degrees of soil salinity because lands are characterized by tides and salinity from the Bay of Bengal. The higher salinity levels have adverse impacts on agriculture. To overcome this problem, saline soils can be used to grow salt tolerant crop plants. Thus development of salinity stress tolerant crops is a key to global agricultural goal.

As a newly introduced crop, tomatillo needs many further research in terms of its yield and yield contributing traits and whether it shows any particular resistance or tolerance for biotic and abiotic stresses in respect of our country’s atmosphere. This current study was conducted directing to observe the growth and yield of tomatillo genotypes under different salinity condition and to determine the response of genotype × treatment interaction based on their agro-morphogenic traits in order to select the best recommendable salt tolerant tomatillo genotypes for growing in the salinity affected southern region and coastal belt of Bangladesh.

Materials and Methods

Duration of the experiment: The experiment was conducted in the net house of Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period of November, 2017 to March, 2018 (Rabi season).

Experimental site: The location of the site was 23°74’ N latitude and 90°35’ E longitude with an elevation of 8.6 meter from sea level in Agro-ecological zone of "Madhupur Tract" (AEZ-28).

Climate and soil: Experimental site was located in the subtropical climatic zone, set aparted by plenty of sunshine and moderately low temperature prevails during October to March (Rabi season) which is suitable for growing crops in Bangladesh. The soil was sandy loam in texture having pH of 5.46 to 5.62 and EC of 0.60 dS/m with 0.82% of organic carbon content.

Experimental materials: Tomatillo genotypes used in the study were collected from the Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh on
October, 2017. A two factorial experiment was conducted which included Factor A: four tomatillo genotypes (Table 1) and Factor B: two salinity (NaCl) treatments with a control (Table 2) as experimental materials. Salinity treatments were chosen by the classification of saline area given by Soil Research Development Institute, Bangladesh (Report, 2010).

Table 1. List of four tomatillo genotypes (Factor A) used in the experiment.

| Sl. No. | Genotypes | Name/Accession No. | Source of Collection |
|---------|------------|--------------------|----------------------|
| 1.      | G_1        | SAU tomatillo 1    | GEPB, SAU            |
| 2.      | G_2        | SAU tomatillo 2    | GEPB, SAU            |
| 3.      | G_3        | PI003              | GEPB, SAU            |
| 4.      | G_4        | PI004              | GEPB, SAU            |

GEPB=Department of Genetics and Plant Breeding, SAU = Sher-e-Bangla Agricultural University

Table 2. List of salinity treatments (Factor B) of NaCl used in the experiment.

| Sl. No. | Salinity Treatments | Electrical Conductivity (dS/m) | Types of Salinity |
|---------|---------------------|-------------------------------|-------------------|
| 1.      | T_1                 | Control                       | Non-saline        |
| 2.      | T_2                 | 8.0                            | Slightly saline   |
| 3.      | T_3                 | 12.0                           | Moderately saline |

Design and layout: The experiment was outlined in Completely Randomized Design (CRD) with three replications using two factors. Factor A included four tomatillo genotypes and Factor B included two salinity treatments with a control. The experiment was conducted in three replications and total 36 plastic pots were used for the study.

Seed sowing, pot preparation and transplantation: The seed sowing was carried out on November 9, 2017 in the well prepared seedbed of Research Farm of Sher-e-Bangla Agricultural University. Seeds were sown in rows spaced at 10 cm apart. Recommended cultural practices were taken up before and after seed sowing. When the seedlings became 21 days old on December 1, 2017, the seedlings were transplanted into the main plastic pots. The size of the main pot was of 20 cm of height with top diameter of 30 cm and bottom diameter of 20 cm. Pots were filled up with soil on November 28, 2017, two days before of the transplantation. Soil of the main pots was well prepared according to the Fertilizer Recommendation Guide released by BARC in 2012. Each plastic pot was filled up with 10 kg of soil containing 100 g of well decomposed cow dung (as 10 tons/ha).

Salinity treatment: Saline water application was started to the selected pots at 7 days after transplanting (DAT) to help the well establishment of young seedlings. Plants in control were not exposed to salinity and were always irrigated with fresh (non-saline) water; whereas plants of salinity treatments were treated with 8 dS/m and 12 dS/m level of salinity in irrigation water. Electrical conductivity (EC) of different salinity levels in soil was adjusted by a direct reading conductivity meter (EC-meter). Salt solution (calculated) was applied 1 litre/pot in 3 to 4 days interval to maintain the exact salinity level in the soil. When soil in the pots was seemed to reach in water logging condition, then saline water was given after the soil was reached near in dried condition (visual observation).

Intercultural operation and harvesting: All necessary intercultural operations were done as per requirement. Harvesting of fruits was done after reaching to its maturity (greenish to light greenish or yellowish in color). Harvesting was started from February 17, 2018 and completed by March 10, 2018.

Statistical analysis: All the collected data were statistically analyzed by using MSTAT-C computer package program. Means for every treatment were calculated and analysis of variance (ANOVA) was performed for each character which was analyzed by F-test (Variance Ratio). Comparison between treatment means (all pair comparison) was assessed by Least
Significant Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

**Results and Discussions**

The experimental data were recorded based on different agro-morphogenic traits of tomatillo viz., days to first flowering, plant height (cm), days required to maturity, number of fruits per plant, average fruit length (mm) per plant, average fruit diameter (mm) per plant, average fruit weight (g) per plant and yield (kg) per plant. From the analysis of variance (ANOVA) (Table 3), it was observed that genotypic effects were significant for all the characters under this study which indicate the presence of variation among the genotypes for these traits. The salinity treatments were also significantly influenced these characters. The genotype × treatment interaction showed significant variation for most of the characters.

**Table 3.** Analysis of variance of different agro-morphogenic traits of tomatillo.

| SV    | df | DFF | PH | DM | NFP | AVL | AFD | AFW | YP   |
|-------|----|-----|----|----|-----|-----|-----|-----|------|
| A     | 3  | 21.741** | 33.785* | 79.185** | 77.657** | 210.711** | 294.321** | 679.396** | 0.242** |
| B     | 2  | 128.111** | 38.715* | 526.750** | 75.028** | 332.202** | 387.963** | 174.807** | 0.164** |
| AxB   | 6  | 1.741NS | 27.549* | 40.935* | 3.880** | 9.152** | 16.553** | 2.763** | 0.012** |
| Error | 22 | 5.679 | 9.967 | 10.303 | 0.498 | 1.613 | 1.426 | 0.482 | 0.001 |

**Symbol:** **Significant at 0.01 level of probability, *Significant at 0.05 level of probability, NS Non-significant, A= Genotype, B= Salinity, SV= Source of variation, df= Degrees of freedom, MSS= Mean sum square of, DFF= days to first flowering, PH= plant height (cm), DM= days required to maturity, NFP= number of fruits per plant, AVL= average fruit length (mm) per plant, AFD= average fruit diameter (mm) per plant, AFW= average fruit weight (g) per plant, YP= yield (kg) per plant.

**Days to first flowering:** Research findings showed statistically significant variation among the tomatillo genotypes in respect of days to first flowering after transplantation (Table 3). The longest period required for first flowering was found in genotype G4 (36.11 days) which was statistically identical with G2 (35.00 days) while the shortest required period was in G3 (32.78 days) which was statistically identical with G1 (33.22 days) (Table 4).

**Table 4.** Performance of tomatillo genotypes on agro-morphogenic traits.

| Genotype | DFF | PH | DM | NFP | AVL | AFD | AFW | YP   |
|----------|-----|----|----|-----|-----|-----|-----|------|
| G1       | 33.22 b | 65.00 b | 87.44 ab | 13.22 c | 25.69 a | 29.52 a | 30.57 a | 0.404 b |
| G2       | 35.00 a | 67.55 a | 86.67 b | 11.33 d | 20.20 b | 24.28 b | 18.67 c | 0.212 c |
| G3       | 32.78 b | 65.67 b | 90.56 a | 18.22 a | 25.42 a | 30.48 a | 28.71 b | 0.523 a |
| G4       | 36.11 a | 68.50 a | 83.33 c | 15.11 b | 15.52 c | 18.04 c | 12.10 d | 0.183 d |
| CV%      | 6.95 | 4.73 | 3.69 | 4.87 | 5.85 | 4.67 | 3.08 | 6.59 |
| LSD 0.05 | 1.33 | 1.09 | 2.14 | 0.69 | 1.24 | 1.17 | 0.68 | 0.02 |

**Note:** Values with the same letter are not significantly different.

Statistically highly significant variation was found among salinity treatments; T1 (Control), T2 (8 dS/m) and T3 (12 dS/m) in terms of days to first flowering (Table 3). The longest period required for first flowering was in T1 (37.33 days) and the shortest required period was in T3 (30.84 days) (Table 5). This result showed that days required for first flowering was earlier in T3 (12 dS/m) than T1 (control). Interaction
effect between tomatillo genotypes and salinity treatments was found statistically non-significant for days to first flowering (Table 3). Interaction $G_4T_1$ (40.00 days) required the maximum period for first flowering whereas interaction $G_1T_3$ (29.67 days) required the minimum period (Table 6).

Table 5. Performance of salinity treatments on agro-morphogenic traits.

| Salinity Treatment | DFF  | PH   | DM   | NFP  | AVL  | AFD  | AFW  | YP  |
|--------------------|------|------|------|------|------|------|------|-----|
| $T_1$ (control)    | 37.33 a | 68.63 a | 93.58 a | 16.67 a | 27.05 a | 31.44 a | 26.34 a | 0.439 a |
| $T_2$ (8dS/m)      | 34.67 b | 65.08 b | 87.08 b | 15.00 b | 21.57 b | 25.21 b | 22.49 b | 0.337 b |
| $T_3$ (12dS/m)     | 30.83 c | 66.33 b | 80.33 c | 11.75 c | 16.52 c | 20.08 c | 18.71 c | 0.220 c |
| CV%                | 6.95 | 4.73 | 3.69 | 4.87 | 5.85 | 4.67 | 3.08 | 6.59 |
| LSD 0.05           | 2.02 | 1.67 | 2.72 | 0.60 | 1.08 | 1.01 | 0.59 | 0.02 |

Note: Values with the same letter are not significantly different.

Table 6. Interaction effect of tomatillo genotypes and salinity treatments on agro-morphogenic traits.

| Interaction | DFF  | PH   | DM   | NFP  | AVL  | AFD  | AFW  | YP  |
|-------------|------|------|------|------|------|------|------|-----|
| $G_1T_1$    | 36.33 | 66.00 bc | 95.33 ab | 16.33 c | 34.01 a | 38.81 a | 35.29 a | 0.576 b |
| $G_1T_2$    | 33.67 | 64.00 bc | 87.67 cde | 13.67 ef | 24.33 c | 28.23 d | 30.53 c | 0.417 d |
| $G_1T_3$    | 29.67 | 65.00 bc | 79.33 gh | 9.67 h | 18.74 e | 21.51 fg | 25.88 e | 0.250 g |
| $G_2T_1$    | 37.67 | 74.33 a | 92.67 bc | 13.33 f | 24.85 c | 30.07 cd | 22.25 g | 0.297 f |
| $G_2T_2$    | 35.67 | 64.50 bc | 87.00 de | 11.67 g | 20.26 de | 22.58 f | 18.92 h | 0.221 gh |
| $G_2T_3$    | 31.67 | 63.83 c | 80.33 fgh | 9.00 h | 15.50 f | 20.18 gh | 14.85 i | 0.134 i |
| $G_3T_1$    | 35.33 | 66.50 bc | 96.00 a | 21.33 a | 29.43 b | 34.93 b | 33.17 b | 0.708 a |
| $G_3T_2$    | 32.67 | 63.33 c | 90.00 bcd | 18.67 b | 25.88 c | 31.64 c | 28.41 d | 0.530 c |
| $G_3T_3$    | 30.33 | 67.17 bc | 85.67 def | 14.67 de | 20.96 d | 24.81 e | 24.55 f | 0.360 e |
| $G_4T_1$    | 40.00 | 67.67 bc | 90.33 bcd | 15.67 cd | 19.89 de | 21.89 fg | 14.64 i | 0.229 gh |
| $G_4T_2$    | 36.67 | 68.50 bc | 83.67 efg | 16.00 c | 15.79 f | 18.39 h | 12.11 j | 0.194 h |
| $G_4T_3$    | 31.67 | 69.33 ab | 76.00 h | 13.67 ef | 10.89 g | 13.83 i | 9.54 k | 0.130 i |
| CV%         | 6.95 | 4.73 | 3.69 | 4.87 | 5.85 | 4.67 | 3.08 | 6.59 |
| LSD 0.05    | --- | 5.35 | 5.44 | 1.19 | 2.15 | 2.02 | 1.18 | 0.04 |

Note: Values with the same letter are not significantly different.

The time required for first flowering of four tomatillo genotypes decreased gradually with the increase of salinity levels (%reduction). The maximum reduction in days to first flowering was observed in $G_4$ in both cases, at $T_2$ (8 dS/m) and $T_3$ (12 dS/m) treatments (8.33% and 20.83% respectively). The minimum reduction was observed in $G_2$ (5.31%) at slightly salinity (8 dS/m) whereas in $G_3$ (14.15%) at moderate salinity (12 dS/m) condition (Table 7).

**Plant height (cm):** In this experiment, statistically significant variation was existed among the tomatillo genotypes in case of plant height (cm) (Table 3). The tallest plant was obtained from $G_4$ (68.50 cm) which was statistically identical with $G_2$ (67.55 cm) whereas the shortest one was found from $G_1$ (65.00 cm) which was statistically identical with $G_3$ (65.67 cm) (Table 4). Tomatillo genotypes showed statistically significant variation to salinity treatments for plant height (cm).
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(Table 3). The tallest plant was found in T₁ (68.63 cm) whereas the shortest plant was from T₂ (65.08 cm) which was statistically identical with T₃ (66.33 cm) (Table 5). Interaction effect between tomatillo genotypes and salinity treatments performed significant variation in respect of plant height (cm) (Table 3). The tallest plant was found in G₁T₁ (74.33 cm) which was statistically identical with G₁T₃ (69.33 cm) while the shortest plant was found in G₁T₂ (63.33 cm) which was statistically identical with G₂T₃ (63.83 cm) (Table 6). The plant height of four tomatillo genotypes was decreased gradually with the increase of salinity treatment levels (% reduction).

Table 7. Reduction percentage in agro-morphogenic traits of tomatillo under increasing salinity.

|        | DFF    | PH   | DM    | NFP   | AVL   | AFD   | AFW   | YP   |
|--------|--------|------|-------|-------|-------|-------|-------|------|
|        | T₂     | T₃   | T₂     | T₃   | T₂     | T₃   | T₂     | T₃   | T₂     | T₃   | T₂     | T₃   | T₂     | T₃   | T₂     | T₃   |
| G₁     | 7.32   | 18.33| 3.03   | 1.52 | 8.04   | 16.78| 16.29   | 40.78| 28.46   | 44.90| 27.26   | 44.58| 13.49   | 26.66| 27.60   | 56.60|
| G₂     | 5.31   | 15.93| 13.22  | 14.13| 6.12   | 13.32| 12.45   | 32.48| 18.47   | 37.63| 24.91   | 32.89| 14.97   | 33.26| 25.59   | 54.88|
| G₃     | 7.53   | 14.15| 4.77   | -1.01| 6.25   | 10.76| 12.47   | 31.22| 12.06   | 28.78| 9.57    | 29.09| 14.35   | 25.99| 25.14   | 49.15|
| G₄     | 8.33   | 20.83| -1.23  | -2.45| 7.37   | 15.86| -2.11   | 12.76| 20.61   | 45.25| 15.99   | 36.82| 17.28   | 34.84| 15.28   | 43.23|

The maximum reduction in plant height was observed in G₂ in both cases, at T₂ (8 dS/m) and T₃ (12 dS/m) salinity (13.22% and 14.13% respectively) and the minimum reduction was observed in G₁ in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity (3.03% and 1.52% respectively). Plant height was found to decrease gradually with the increase of salinity levels. Salinity was attributed to the reduction in water content and water potential of plant tissues, which resulted in internal water deficit to plants (Hishida et al., 2013). Accumulation of Na⁺, Cl⁻ and retardation in the uptake of macronutrients especially Na⁺ and Ca²⁺ cause reduction in plant growth (Juan et al., 2005; Dasgan et al., 2002). Whereas, genotype G₂ showed increase in plant height at T₂ (8 dS/m) and T₃ (12 dS/m) salinity (-1.23% and -2.45% respectively) (Table 7). According to Naidoo et al. (1995), the stimulatory effect of moderate salinity on growth of some plants can improve their growth and it may be due to the improved shoot osmotic status as a result of increasing ions uptake. The obtained results were matched with those obtained by Achilea, 2002; Agong et al., 2004; Zaki et al., 1987.

Days to maturity: Findings showed statistically highly significant variation among different tomatillo genotypes for days required to maturity (from days after transplanting to days of first harvesting) (Table 3).

The longest maturity (first harvesting) period was required in G₁ (90.56 days) which was statistically identical with G₁ (87.44 days) whereas the shortest maturity period was required for G₄ (83.33 days) (Table 4). Tomatillo genotypes showed statistically highly significant variation to salinity treatments; T₁ (Control), T₂ (8 dS/m) and T₃ (12 dS/m) in terms of days to maturity (Table 3). The earliest fruit harvesting was performed in T₃ (80.33 days) and the most delayed harvesting was performed in T₁ (93.58 days) (Table 5). This result showed that maturity time of tomatillo plant was decreased under the increased level of salinity. Similar results were also found by Agarwal et al., 2005 and Ghadiri et al., 2005. Interaction between tomatillo genotypes and salinity treatments was found statistically significant in respect of days to maturity (Table 3). The earliest fruit harvesting period was observed in G₁T₃ (76.00 days) which was statistically identical with G₁T₃ (79.33 days) and G₂T₃ (80.33 days) whereas G₃T₁ (96.00 days) was the most delayed one.
which was statistically identical with G_1 T_1 (95.33 days) (Table 6). The time required for days to maturity of tomatillo genotypes was decreased gradually with the increase of salinity treatment (%reduction). The maximum reduction was observed in the G_1 in both cases, at T_2 (8 dS/m) and T_3 (12 dS/m) (8.04% and 16.78% respectively) and the minimum reduction was observed in G_2 (6.12%) at T_2 (8 dS/m) whereas in G_3 (10.76%) at T_3 (12 dS/m) salinity stress (Table 7).

**Number of fruits per plant:** This experiment showed statistically highly significant variation among different tomatillo genotypes in case of number of fruits per plant (Table 3). The maximum number of fruits was obtained from G_3 (18.22 fruits/plant) whereas the minimum number of fruits was found in G_2 (11.33 fruits/plant) (Table 4). Tomatillo genotypes showed statistically highly significant variation to salinity treatment levels for number of fruits per plant (Table 3). The highest number of fruits per plant was found in T_1 (16.67 fruits/plant) and the lowest number of fruits was found in T_3 (11.75 fruits/plant) (Table 5). This result showed that number of tomatillo fruits per plant was decreased under the increase of salinity level. According to Islam et al. (2011), the maximum number of fruits per plant was found in control and the number was decreased gradually with the increase of salinity stress. Similar results were also found by Siddiky et al. (2012) and Al-Yahyai et al. (2010). Interaction between tomatillo genotypes and salinity treatments was found statistically highly significant for number of fruits per plant (Table 3). The highest number of fruits was obtained from G_3 T_1 (21.33 fruits/plant) whereas the lowest number of fruits was obtained from G_2 T_1 (9.00 fruits/plant) which was statistically identical with G_1 T_3 (9.67 fruits/plant) (Table 6). Number of fruits obtained from per plant of four tomatillo genotypes was decreased gradually with the increase of salinity level (%reduction). The maximum reduction in number of fruits per plant was found in G_1 in both cases, at T_2 (8 dS/m) and T_3 (12 dS/m) (16.29% and 40.78% respectively) whereas the minimum reduction was found in G_2 (12.45%) at T_2 (8 dS/m) and in G_4 (12.76%) at T_3 (12 dS/m) salinity level (Table 7). Here, genotype G_4 (-2.11%) showed increased number of fruits per plant at slightly (8 dS/m) salinity level. Such stimulatory effect of low salinity levels on yield and its components were mentioned by Babu and Thirumurugan (2001) who noted that yield components were increased under low salinity level; further increase in salinity, decreased the yield parameters. The obtained results were also matched with those reported by Maggio et al., 2007; Al-Harbi et al., 2009; Al-Omran et al., 2010 and Al-Harbi et al., 2015.

**Average fruit length (mm):** The observed result showed statistically highly significant variation for average fruit length (mm) per plant among tomatillo genotypes (Table 3). The longest fruit was found from G_1 (25.69 mm) which was statistically identical with G_3 (25.42 mm) while the shortest one was found from G_4 (15.52 mm) (Table 4). Tomatillo genotypes also showed statistically highly significant variation to different salinity treatment; T_1 (Control), T_2 (8 dS/m) and T_3 (12 dS/m) for average fruit length (mm) per plant (Table 3). The longest fruit was found in T_1 (27.05 mm) while the shortest fruit was found in T_3 (16.52 mm) (Table 5). This result showed that average fruit length of tomatillo was decreased under the increase of salinity levels because salinity has a deleterious effect on cell expansion phase due to low water content in the fruit (Hao et al., 2000, Edris et al., 2012 and Magan et al., 2008). Supply of water into the fruit under saline conditions is restricted by lower water potential in the plant (Johnson et al., 1992). Interaction between tomatillo genotypes and salinity treatments was found statistically highly significant for average fruit length (mm) per plant (Table 3). The longest fruit was found from G_1 T_1 (34.01 mm) whereas the shortest fruit was found from G_1 T_3 (10.89 mm) (Table 6). The average fruit length (mm) of four tomatillo genotypes decreased gradually with the increase of salinity treatment (%reduction). The maximum reduction in average fruit length per plant was observed in G_1 (28.46%) at T_2 (8 dS/m) and in G_4 (45.25%) at T_3 (12 dS/m) whereas the minimum
reduction was observed in G3 in both cases, at slightly
(8 dS/m) and moderately (12 dS/m) salinity (12.06% and
28.78% respectively) (Table 7).

**Average fruit diameter (mm):** Statistically highly
significant variation was found in the study for average
fruit diameter (mm) per plant among four tomatillo
genotypes (Table 3). The maximum diameter of fruit
was found in G3 (30.48 mm) which was statistically
identical with G1 (29.52 mm) while the minimum fruit
diameter was found in G4 (18.04 mm) (Table 4).
Statistically highly significant variation was found in
tomatillo genotypes exposed to different salinity
treatments; T1 (Control), T2 (8 dS/m) and T3 (12 dS/m)
in respect of average fruit diameter (mm) per plant
(Table 3). The widest fruit was found in T1 (31.44 mm)
while the narrowest fruit was found in T3 (20.08 mm)
(Table 5). Reduction in fruit diameter due to the
increase of salinity levels was also found by Edris et al.
(2012). Interaction between tomatillo genotypes and
salinity treatment showed highly significant variation
for average fruit diameter (mm) per plant (Table 3). The
maximum diameter of fruit was obtained from
G1T1 (38.81 mm) whereas the minimum fruit diameter
was from G3T3 (13.83 mm) (Table 6). Results showed
that average fruit diameter of tomatillo was decreased
gradually under the increasing salinity levels (%reduction).
The maximum reduction in average fruit diameter (mm) per plant was observed in G1 in both
cases, T2 (8 dS/m) and T3 (12 dS/m) (27.26% and
44.58% respectively) whereas the minimum reduction
was observed in G3 in both cases, at T2 (8 dS/m) and T3
(12 dS/m) (9.57% and 29.09% respectively) (Table 7).

**Average fruit weight (g):** This experiment showed
statistically highly significant variation for average
fruit weight (g) per plant among the tomatillo
genotypes (Table 3). The maximum weight of tomatillo
fruit was found in G1 (30.57 g) and the minimum fruit
weight was found in G4 (12.10 g) (Table 4).
Statistically highly significant variation was also found
in tomatillo genotypes exposed to different salinity
treatments; T1 (Control), T2 (8 dS/m) and T3 (12 dS/m)
in respect of average fruit weight (g) per plant (Table
3). The maximum weight of fruit was found in T1
(26.34 g) while the minimum fruit weight was found in
T3 (18.71 g) (Table 5). Reduction in single fruit weight
per plant due to the increase of salinity levels was
found by Al-Yahyai et al. (2010) and Islam et al.
(2011). Supply of water into the fruit under saline
conditions is restricted by a lower water potential due
to excessive accumulation of toxic ions. Less water
flow in the fruit causes reduction in fruit size and
weight (Munns, 2002). Interaction of tomatillo
genotypes and salinity treatments was found
statistically highly significant for average fruit weight
(g) per plant (Table 3). The maximum weight of fruit
was found from G1T1 (35.29 g) whereas the minimum
fruit weight was found from G3T3 (9.54 g) (Table 6).
The average fruit weight (g) per plant of four tomatillo
genotypes was decreased gradually with the increase of
salinity levels (%reduction). The maximum reduction
in average fruit weight per plant was observed in G3 in
both cases, at T2 (8 dS/m) and T3 (12 dS/m) salinity
level (17.28% and 34.84% respectively) whereas the
minimum reduction was observed in G1 (13.49%) at T2
(8 dS/m) and in G3 (25.99%) at T3 (12 dS/m) salinity
(Table 7).

**Yield per plant (kg):** In this experiment, statistically
highly significant variation was found for yield of
(mature) fruit per plant among the tomatillo
genotypes (Table 3). The highest yield per plant of tomatillo
was obtained from G3 (0.523 kg/plant) and the lowest yield
per plant was from G4 (0.183 kg/plant) (Table 4).
Statistically highly significant variation was found in
tomatillo genotypes exposed to different salinity
treatments; T1 (Control), T2 (8 dS/m) and T3 (12 dS/m)
in respect of yield of fruit (kg) per plant (Table 3). The
highest yield of fruit was found in T1 (0.439 kg/plant)
while the lowest fruit yield was found in T3 (0.220
kg/plant) (Table 5). This result showed that yield of
fruit per plant was decreased under the increasing
salinity levels. Salinity stress can reduce the fruit
number and average fruit weight per plant and thus, in
case of high salinity levels the total fruit weight per
plant can be reduced (Siddiky et al., 2012; Islam et al., 2011). Interaction between tomatillo genotypes and salinity treatments was found statistically highly significant for yield of fruit (kg) per plant (Table 3). The highest yield of fruit was found in $G_1T_1$ (0.708 kg/plant) whereas the lowest fruit yield was found in $G_1T_3$ (0.130 kg/plant) which was statistically identical with $G_3T_3$ (0.134 kg/plant) (Table 6). The yield of fruit (kg) per plant of four tomatillo genotypes decreased gradually with the increase of salinity levels (% reduction). The maximum reduction in yield of fruit per plant was observed in $G_1$ in both cases, at $T_2$ (8 dS/m) and $T_3$ (12 dS/m) (27.60% and 56.60% respectively) whereas the minimum reduction was observed in $G_4$ at both slightly (8 dS/m) and moderately (12 dS/m) salinity (15.28% and 43.23% respectively) (Table 7).

Conclusion

A large amount of area in the southern region of Bangladesh still remains uncultivated due to the high level of soil salinity. Alarmingly salinity affected areas are increasing rapidly due to the global climate change. On the other hand, the rapid growth of population needs an increase in food production. For sustainable solution of this problem, cultivation of modern high yielding salt tolerant variety and to bring the uncultivable saline lands under cultivation is apparent. Thus, screening and selection as well as introduction and development of new salt tolerant crops and genotypes are major goal of global agriculture now-a-days. As a newly introduced crop of our country, tomatillo was taken to consideration for this experiment to observe its tolerance to salinity stress and whether it is possible to recommend this crop for cultivation in our salinity affected southern regions. The analyzing data of the present study demonstrates that genotype $G_1$ and $G_3$ showed minimum reduction in yield contributing traits viz., fruit numbers, fruits length, fruit diameter, fruit weight and yield under $T_2$ (8 dS/m) and $T_3$ (12 dS/m) salinity condition. Thus, $G_1$ and $G_3$ could be recommended for cultivation ($G_1$) and further trial ($G_3$) in the Southern region of Bangladesh. Maximum reduction in days to maturity was observed in $G_1$ followed by $G_4$ under slightly (8 dS/m) and moderately (12 dS/m) salinity, thus indicating it’s owing of short duration behavior and could be served as parent materials for further hybridization or genetic transformation program.

References

Agong SG, Yoshida Y, Yazawa S, Masuda M (2004). Tomato response to salt stress. Acta Horticulturae, 637: 93-97. https://doi.org/10.17660/ActaHortic.2004.637.10

Al-Harbi AR, Wahb-Allah MA, Al-Omran AM (2009). Effects of salinity and irrigation management on growth and yield of tomato grown under greenhouse conditions. Acta Horticulturae, 807: 201-206. https://doi.org/10.17660/ActaHortic.2009.807.25

Al-Harbi AR, Al-Omran AM, Alenazi1 MM, Wahb-Allah MA (2015). Salinity and deficit irrigation influence tomato growth, yield and water use efficiency at different developmental stages. Intl. J. Agric. Biol, 17: 241-250.

Al-Omran AM, Al-Harbi AR, Wahb-Allah MA, Nadeem M, Eleter A (2010). Impact of irrigation water quality, irrigation systems, irrigation rates and soil amendments on tomato production in sandy calcareous soil. Turkish. J. Agric. Forestry, 34: 59-73.

Al-Yahyai R, Al-Ismaily S, Al-Rawahy SA (2010). Growing tomatoes under saline field conditions and the role of fertilizers. In A monograph on management of salt-affected soils and water for sustainable agriculture. edn. Ahmed M, Al-Rawahy SA and Hussain N. 62(4): 83-88.

Babu S, Thirumurugan T (2001). Effect of NaCl primary for increased salt tolerance in sesame (Sesamum indicum). J. Ecobiol, 13(4): 309-311.

Borja-Bravo M, Garcia-Salazar JA, Skaggs RK (2013). Mexican fresh tomato exports in the North
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American market: a case study of the effects of productivity on competitiveness. Canadian J. Plant Science, 93(5): 839-850. https://doi.org/10.4141/cjps2012-108

Cantwell M, Flores-Minutti J, Trejo-Gonzalez A (1992). Developmental changes and postharvest physiology of tomatillo fruits (Physalis ixocarpa Brot.). Scientia Horticulturae, 50(1-2): 59-70. https://doi.org/10.1016/S0168-9452(02)00091-2

Choi JK, Murillo G, Su BN, Pezzuto JM, Kinghorn AD, Mehta RG (2006). Ixocarpalactone A isolated from the Mexican tomatillo shows potent antiproliferative and apoptotic activity in colon cancer cells. FEBS Journal, 273(24): 5714-5723. https://doi.org/10.1111/j.1742-4658.2006.05560.x PMid:17212786

Dasgan HY, Aktas H, Abak K, Çakmak I (2002). Determination of screening techniques to salinity tolerance in tomatoes and investigation of genotype responses. Plant Sci., 163(4): 695-703. https://doi.org/10.1016/S0168-9452(02)00091-2

Edris S, Sayed T, Sahebali B, Kamran G (2012). Vegetative growth and nutrient uptake of salinity stressed cherry tomato in different calcium and potassium level. Intl. Res. J. App. Basic Science, 3(9): 1845-1853.

Escobar FC, Jankiewicz LS, Orduna VM, Brito JM (2014). The development of the husk tomato plant (Physalis ixocarpa Brot.). II. Reproductive parts. Acta Societatis Botanicorum Poloniae, 54(4): 339-349. https://doi.org/10.5586/asbp.1985.029

Ghadiri H, Dordipur I, Bybordi M, Malakouti MJ (2005). Potential use of Caspian Sea for supplementary irrigation in North Iran. Agric. Water Management, 79: 209-224. https://doi.org/10.1016/j.agwat.2005.04.010

Gomez KA, Gomez AA (1984). Comparison between treatment means. In Statistical Procedures for Agricultural Research. edn. Gomez KA and Gomez AA, John Wiley and Sons, New York, USA. pp. 187-240.

Hao X, Papadopoulos AP, Dorais M, Ehret DL, Turcotte G, Gosselin A (2000). Improving tomato fruit quality by raising the EC of NFT nutrient solutions and calcium spraying: Effects on growth, photosynthesis, yield and quality. Acta Horticulturae, 511: 213-224. https://doi.org/10.17660/ActaHortic.2000.511.24

Hishida S, Ascencio-Valle F, Fujiyama H, Orduño-Cruz A, Endo T, Larrinaga-Mayoral JA (2013). Differential responses of Jatropha Species on growth and physiological parameters to salinity stress at seedlings plant stage. Communications Soil Sci. Plant Analysis, 44(19): 2820-2829. https://doi.org/10.1080/00103624.2013.811524

Islam MT, Ara MI, Hossain MA, Sen AK, Dutta RK (2011). Identification of tomato genotypes for salt tolerance. Intl. J. Sustainable Crop Production, 6(1): 17-21.

Johnson RW, Dixon MA, Lee DR (1992). Water relations of the tomato fruit during growth. Plant Cell Environ, 15: 947-953. https://doi.org/10.1111/j.1365-3040.1992.tb01027.x

Juan M, Rivero RM, Romero L, Ruiz JM (2005). Evaluation of some nutritional and bio chemical indicators in selecting salt-resistant tomato cultivars. Environ. Expt. Bot, 54: 193-201. https://doi.org/10.1016/j.envexpbot.2004.07.004

Karim MR (2016). Estimation of genetic variability, heritability and genetic advance in agromorphogenic traits of tomatillo (Physalis ixocarpa Brot.) genotypes. MS thesis, SAU, Dhaka, Bangladesh.

Magan JJ, Gallardo M, Thompson RB, Lorenzo P (2008). Effects of salinity on fruit yield and quality of tomato grown in soil-less culture in greenhouses in Mediterranean climatic conditions. Agric. Water Management, 95(9): 1041-1055. https://doi.org/10.1016/j.agwat.2008.03.011
Maggio A, Raimondi G, Martino A, Pascal SD (2007). Salt stress response in tomato beyond the salinity tolerance threshold. Environ. Expt. Bot., 59: 276-282. https://doi.org/10.1016/j.envexpbot.2006.02.002

Morton JF (1987). Mexican husk tomato, Physalis ixocarpa Brot., Physalis aequata Jacq. In Fruits of Warm Climates. New Crop Resource Online Program. Center for New Crops and Plant Products, Purdue University, West Lafayette, Indiana. pp. 434-437.

Munns R (2002). Comparative physiology of salt and water stress. Plant Cell Environ, 25: 239-250. https://doi.org/10.1046/j.0016-8025.2001.00808.x; PMid:11841667

Naidoo Y, Jahnke J, Willert VDJ (1995). Gas exchange responses of the C4 grass Sporobolus virginicus (Poaceae) to salinity stress. In Biology of Salt Tolerant Plants, edn. Khan AM and Ungar IA, University of Karachi, Karachi. pp. 121-130.

Reza S (2016). Genetic analysis of tomato (Solanum lycopersicum L.) and tomatillo (Physalis ixocarpa Brot.) genotypes based on their quality traits. MS thesis, SAU, Dhaka, Bangladesh.

SRDI (2010). Soil salinity report of Bangladesh. Soil Resources Development Institute, SRMAF Project Ministry of Agriculture, Mrittika Bhaban, Krishikkumar Sarak Farmgate, Dhaka. p. 5.

Siddiky MA, Sardar PK, Hossain MM, Khan MS, Uddin MK (2012). Screening of different tomato varieties in saline areas of Bangladesh. Intl. J. Agril. Res. Innov. Tech, 2(1): 13-18. https://doi.org/10.3329/ijarit.v2i1.13989

Waterfall UT (1958). A taxonomic study of the genus Physalis in North America, North of Mexico. Rhodora, 60: 107-114.

Yamaguchi M (1983). World vegetables, principles, production and nutritive values. In Molecular Nutrition. edn. Bock W, AVI Publ. Company, Westport, CT, USA, and Ellis Horwood Limited, Publishers, Chichester, England. pp. 1028-1984. https://doi.org/10.1007/978-94-011-7907-2

Zaki Y, El-Alfy T, Gohary E (1987). Study of withanolides, physalins, antitumor and antimicrobial activity of Physalis peruviana L. Egyptian J. Pharmacological Science, 28: 235-245.