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RESEARCH ARTICLE

IMPACT OF SALINITY ON SEED GERMINATION AND SEEDLING PERFORMANCE OF TOMATO *(Solanum lycopersicum* L.*)* CV KC-1

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ABSTRACT

An experiment was conducted to evaluate the effect of salt stress on seed germination and seedling performance of Solanum lycopersicum *L. (tomato) cv KC-1 under controlled environment and also to select salt tolerant seedlings for plant regeneration. This experiment was laid out in a completely randomized design with three replications. Uniform seeds of tomato cv KC-1 were surface sterilized and placed on sterilized filter paper in the petridishes. Subsequently they were wetted with 5 ml of distilled water as a control or one of the NaCl (sodium chlorite) salt solutions (0, 20, 40, 60 and 80 mM NaCl. Seed germination percentage were calculated and seedling growth attributes were recoreded after seeding. Results showed that germination percentage decreased with increasing salinity levels (0 mM, 20 mM, 40 mM, 60 mM, 80 mM). Germination percentage was less than 50% for seed treated with NaCl above the level of 40 mM. Minimum value (18.3%) was recorded in 80 mM of salinity. Shoot and root lengths, dry and fresh weights of shoots and roots, relative water content and total dissolved salt content of first leaves (cotyledons) were significantly affected (P<0.001) by salt stress after 12 days of seeding. Salinity levels had a considerable effect on all parameters tested in this study. Salt content of first leaves increased with increasing NaCl concentrations. Germination and early seedling growth of Tomato cv. KC-1 was greatly affected in salt concentrations above 40 mM NaCl levels under controlled environmental conditions.*

Keywords: Chlorophyll content, salinity, seedling growth, tomato

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1.0 INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae and pepper, potato, and brinjal are some other Solanaceae crops. It is an important vegetable crop for human consumption and it is the highest nutritive crop after potato [1]. This crop is sensitive to moderate levels of salt salinity similar to other Solanaceae vegetable crops [2]. Salt stress is one of the key constraints in conventional plant propagation. Amirjani [3] stated that dry matter content in plants declined with salinity. Soil which has an electrical conductivity of saturation soil extract of more than 4 dSm^{-1} at 25°C, is generally categorized as saline soil where 4 dSm^{-1} value is equivalent to approximately 40 mM NaCl [4]. Adequate amount of soluble salts are available in saline soils which can affect normal plant growth and development of tomato plants. Yilmiz *et al*. [5] examined the effects of different levels of salt concentrations (0-150 mM NaCl) on the seedling of pepper varieties and showed the negative effects of high NaCl on plant growth and development. This study was aimed to evaluate the effect of salt stress on seed germination and early seedling growth of tomato under controlled environment conditions.

2.0 MATERIALS AND METHODS

This experiment was carried out to determine seed germination and early seedling growth of tomato under different levels of salt stress conditions. It was carried out at the Crop Science Laboratory, Eastern University, Sri Lanka and treatments were laid out in completely randomized design with three replications. Uniform seeds of tomato cv KC-1 obtained from Horticultural Crop Research and Development Institute, Gannoruwa, Sri Lanka were used for this study. Tomato cv KC-1 is a heat tolerant and high yielding variety and it is cultivated in the dry zone

Collected seeds were dipped in 70% (v/v) alcohol for one min and then surface sterilized with 20% (v/v) CloroxTM (5.25% sodium hypochlorite) with two drops of Tween 20 for 20 min. Subsequently, they were washed three times with sterilized distilled water to remove traces of Clorox. They were then dried on autoclaved filter paper for 15 min under aseptic conditions. Ten sterilized seeds of tomato were germinated in each filter paper (Whatman No. 1) placed on petridishes (9 cm diameter). Subsecuently seeds were moistened with 5 ml distilled water as a control or one of the NaCl salt solutions (0, 20, 40, 60 and 80 mM NaCl). Subsequently they were kept at 25±0.5 ºC temperature, 70% relative humidity, 16/8 hours photoperiod. Seed germination was monitored after seeds were sown. Distilled water or NaCl solutions were gradually added to filter papers once in three days in the same volume as mentioned earlier. Observation was made until 12 days after seeding to evaluate germination percentage. Seedling growth parameters and leaf salinity level were recorded. This experiment was repeated thrice.

2.1 Seed germination percentage

Germinated seeds were counted daily after seeding. Final cumulative count was made after 7 days which was considered as final germination count to calculate germination percentage. It was calculated as follows.

$$\text{Germination\%} = \frac{\text{No. of geminated seeds}}{\text{No. sown seeds}} \times 100\%$$

2.2 Shoot and root lengths of seedling

Five seedlings from each petridishes were randomly sampled from each replicates after 12 days of germination. Lengths of shoot and root were recorded using a ruler. Their lengths were taken in centimeter (cm).

2.3 Weights of shoot and root

After fresh weight of shoots were obtained, these samples were oven dried at 60 °C to a constant weight as reached. Subsecuently, the dried shoots were weighed using an electric balance. The same procedure was repeated to determine root fresh and dry weights of seedlings.

2.4 Relative water content of first leaves

Relative water content (RWC) % of first leaves (cotyledons) was measured in both salt and non-salt water treated plants after 12 days of seeding. The intact cotyledon was used to determine RWC % to prevent leakage of solute from the cut surface of cotyledon tissue. Cotyledons were carefully excised from seedlings and fresh weight of cotyledons was recorded. Subsequently, they were placed in plastic tubes filled with distilled water. Tubes were kept in a refrigerator at 4 oC for 18 hours and turgid weight was determined after blot drying. These samples were dried in an oven at 60 oC to a constant weight and then dry weight were measured. Relative water content was estimated by using the following equation [6].

$$\text{RWC\%} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100\%$$

2.5 Total dissolved salt content of leaf extract

First leaves (cotyledons) of seedlings under salt stress conditions were used to determine salinity using a portable conductivity meter (sensIONTM + EC5, USA). Leaf tissues (1 g) were placed in a small vial filled with 10 ml distilled water and heated to 60 °C for 5 min to collect extracts of leaf samples. The leaf extract was cooled and then the salt content was measured as described by Velagaleti *et al*. [7].

2.6 Statistical analysis

Data obtained were subjected to analysis of Regression and Pearson correlation using SAS 9.1.3.

3.0 RESULTS AND DISCUSSION

In the present study, seed germination and seedling growth of tomato were tested under salt stress. Results obtained in this experiment showed that different salinity levels had a significant effect on tested parameters.

3.1 Seed germination %

Results showed that there was a significant relationship (P<0.001) between salt solution concentrations and germination percentage after 7 days of seeding and seeds had germinated in all concentrations of NaCl solutions (Figure 1). Further, it was noted that maximum percentage of seed germination was achieved within 5 days in all NaCl treatments.

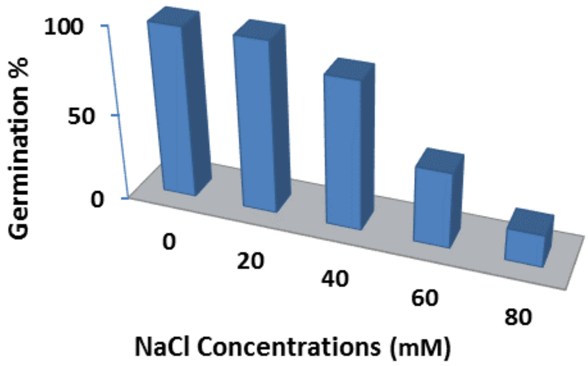

Figure 1: Relationship between salt concentrations and seed germination of tomato after 7 days of seeding.

After the age of 5 days of seeding, germination percentage was low (18.3%) at the high (80 mM) salt concentration however distilled water (control) and 20 mM NaCl solutions gave considerably higher germination percentage (98.3%) when compared to 40, 60 and 80 mM NaCl levels. None of the treated seeds on salt solutions achieved 100% germination after 7 days of seeding. Balestri and Bertini [8] reported that survival value of *Posidonia oceanica* seedlings was high at low salinity than high level.

Less than 45% of germination was recorded in 60 mM and 80 mM NaCl solutions and could be considered as salt responsive. In other treatments including the control, germination percentage was equal or above 85% and could be considered tolerable. It was also observed that cotyledons were not formed in tomoto seeds treated with 80 mM NaCl. Germination percentages gradually reduced with an increase of different salt concentrations. The finding is supported by Rahman *et al*. [9] who pointed out that salinity stress had negative association with seed germination. This may be due to the inadequate water availability for seed germination at high NaCl concentrations. Alarcon *et al*. [10] had observed a direct relationship between the degree of the saline stress applied and the decrease in water stress

3.2 Seed mortality %

Results showed that seedlings exposed to low salt concentrations were comparatively tolerant. Dead seedlings were not observed in the control treatment (0 mM) after 7 days of seeding. Mortality percentages were calculated based on germinated seeds. seedlings were regarded as dead when they turned yellow and dried out. Seedling mortality attained more than 20% in treatments above 40 mM NaCl. It was also observed that 80 mM NaCl treatment had the highest percentage (30.5%) of mortality among the germinated seeds.

3.3 Lengths of shoot and root of seedlings

Effect of different salt levels on shoot and root lengths of 12 days old seedlings is presented in Figure 2. Results showed that shoot length was remarkably associated ($P<0.001$) with concentration of NaCl solutions. It decreased with increasing salt levels and R-Square value was 0.9364. Maximum shoot length (4.36 cm) was recorded on the control treatment and was minimal (1.27 cm) on 80 mM NaCl solution. Further, it was observed that there was a slight difference in shoot length between the control (0 mM) and 20 mM NaCl levels. Datta *et al*. [11] stated that the biomass, shoot length and root length of wheat cultivars were remarkably affected by salinity.

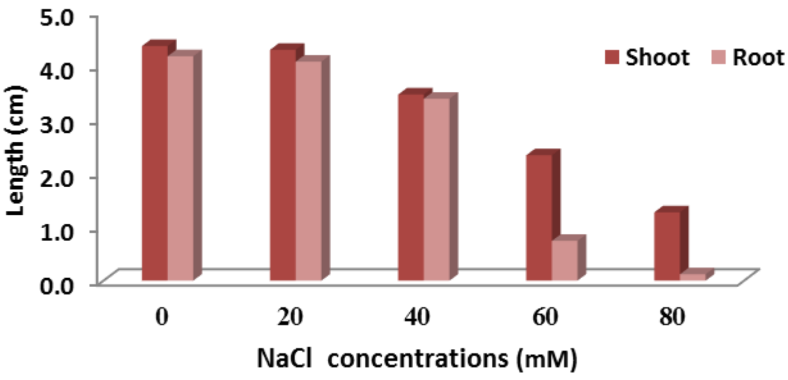

Figure 2: Effect of salt concentrations on lengths of shoot and root of seedling**.**

Results also showed that there was a significant relationship ($P<0.001$) between NaCl concentration and root length (Figure 2). The longest root length (4.17 cm) was observed in the control (0 mM NaCl level) treatment whereas the shortest length of root was exhibited in 80 mM NaCl. Root length was reduced as salinity level increased. Decrease of root length may be due to NaCl toxicity at higher level where water uptake by roots is curtailed by salt stress. This is supported by Ahmad *et al.* [12] in barley under increasing NaCl levels.

3.4 Shoot and root weights of seedlings

Results revealed that highest fresh weights of shoot and root were recorded in the control treatment (0 mM NaCl) with a mean of 34.83 mg and 3.90 mg respectively and significantly lowest values were recorded in 80 mM NaCl with an average of 1.03 mg and 0.13 mg respectively (Figure 3). Further, it was noted that there were meaningful differences in dry weight of root or shoot between control treatment and high salinity levels (40, 60, 80 mM NaCl) (Figure 4). On the other hand, there were slight differences in fresh and dry weights of shoot and root between the concentrations of 0 mM and 20 mM of NaCl. Further, findings showed that dry weights of shoot and root in the control treatment were uppermost with an average of 6.07 mg and 1.50 mg respectively while lowest values were recorded in 80 mM NaCl concentration with an average of 0.17 mg and 0.06 mg among tested treatments. Ibrahim [13] mentioned that the weights of shoot and root are highly correlated with salt tolerance at early growth stages of cotton.

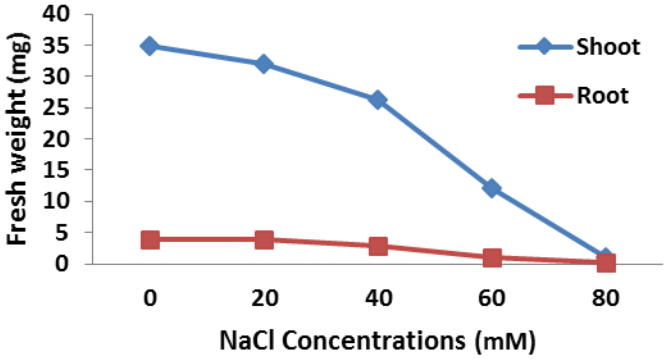

Figure 3: Effect of salt concentrations on fresh weight of shoot and root of seedlings.

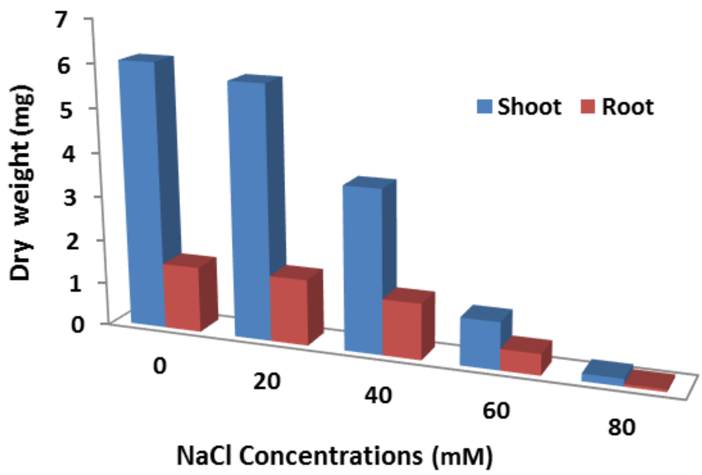

Figure 4: Effect of salt concentrations on dry weight of shoot and root of seedlings.

The remarkable reduction in shoot and root weights of seedlings was more noticeable in 60 and 80 mM NaCl solutions. It showed that these weights did not decrease severely upto 40 mM NaCl concentration, dry weight drop in 40 mM salt level was less than 40% when compared to the control treatment. Shoot and root weights decreased increasing NaCl concentrations. This reduction correlated with shoot or root lengths of seedlings. These findings are in agreement with reports by Ahmad *et al*. [12] that shoot growth of barley was drastically reduced under different salt levels. In this study, seedling growth of tomato KC-1 was affected by the salt stress which caused a decline in shoot and root growth. This may be due to increase in concentration of ions. Massai *et al*. [14] reported that salinity causes closing of stomata and reduction of water entrance into the plant and therefore results in plant weight reduction. As a result of crop growth reduction, salinity generally leads to low yield [15]. Root and shoot ratio facilitate to determine the health of plants [16].

3.5 Relative water content of first leaves

Results indicated that relative water content (RWC) of the first leaves (cotyledons) was negatively persuaded in reaction to different NaCl levels (Figure 5). An effect on RWC of first leaves was observed in different salt concentrations compared to the control at 12 days of salt treatment. RWC was more than 50% in 0 mM, 20 mM and 40 mM salt concentrations and increased with decreasing NaCl concentrations. RWC of cotyledons was low in 60 mM NaCl whereas RWC was not recorded in 80 mM NaCl solution because cotyledons were not formed. The reason for high RWC in tolerant cultivars is capability to absorb more water from the soil [17].

3.6 Total dissolved salt content of leaf extract

Total salt absorbed by the seedlings under different salinity levels were measured on digests of leaf tissues. Results showed that there was a remarkable relationship ($P<0.001$) between salt content absorbed by the seedlings and NaCl concentration (Figure 6).

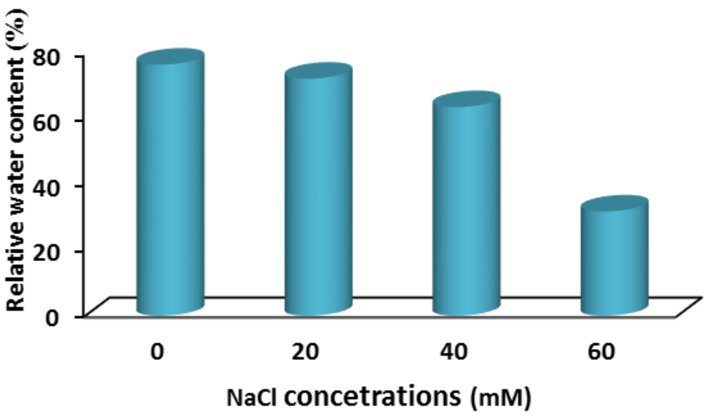

Figure 5: Effect of salt concetrations on Relative water content of leaf extract of tomato seedling at 12 days after seeding.

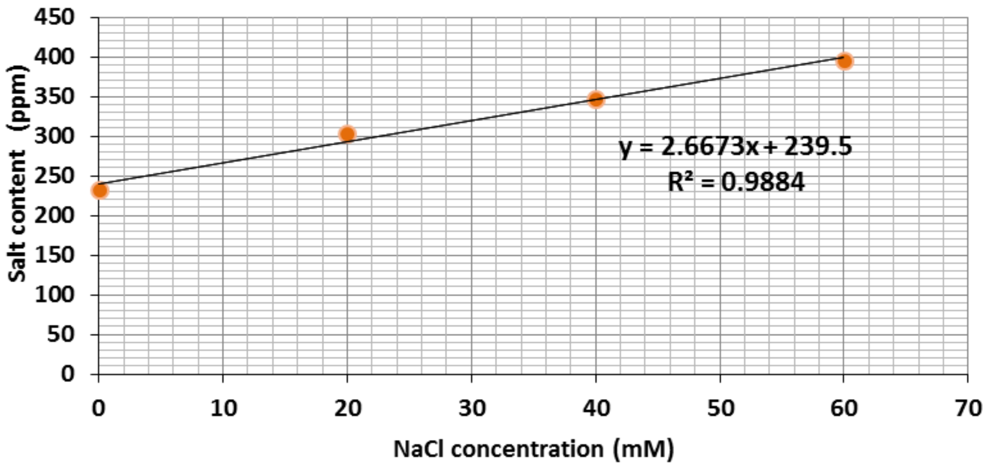

Figure 6: Relationship between NaCl concentration and total dissolved salt content of leaf extract of tomato seedling at 12 days after seeding.

Among the tested treatments, highest salt content (396.03 ppm) was recorded in 60 mM NaCl treatment. Indication that more Na^+ ions were taken up by seedlings in high NaCl concentrations which may have an effect on the physiological and biochemical changes in plants due to an osmotic effect. Salt content of leaf tissues was not determined in 80 mM NaCl treatment. It considerably decreased with reduced NaCl concentrations. The control treatment (0 mM NaCl) had considerably lower value (232.57 ppm) than other tested treatments. Albouchi *et al*. [18] stated that lowering the osmotic potential by osmolyte accumulation in response to stress increases the ability of the cell to retain its turgor pressure at low water potential.

4.0 CONCLUSION

Tomato was sensitive to salinity during seed germination and seedling growth with remarkable reduction in these parameters for salt concentrations above 40 mM NaCl. Seedling growth decreased in 60 mM and 80 mM NaCl levels. Salt content of first leaves of young seedling increased with an increase NaCl concentration. Although seedlings exhibited a considerable reduction in their growth at high salinity levels, seedlings of tomato cv KC-1 tolerated salinities upto 40 mM NaCl levels under controlled conditions.

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