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Effect of Salinity on Seed Germination and Early Seedling Growth of Tomato

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Abstract: *Salinity is major constraint to tomato production in many regions of the world. Tomato yield reduction is caused by salinity due to its adverse effect on many important physiological processes. The present study was therefore designed to select appropriate salinity level for the growth of tomato plant. Germination of tomato plants were studied under five salinity levels 0, 10, 15, 20, and 30 dSm^{-1} in the laboratory and the growth performance and biochemical characteristic were studied under pot experiment. Results revealed that germination and seedling growth of tomato were suppressed with increasing salt concentration under laboratory conditions with highest germination (100%) at 0 dSm^{-1} and lowest germination (55%) were recorded at 30 dSm^{-1} salinity levels provided that at 10 dSm^{-1} the seed germination was 93.33%. By subjecting them to salinity five levels of. At 10 dSm^{-1} salinity level produced higher plant height, shoot and root dry matter compared to other salinity level. The highest increment (1.483 $\mu molg^{-1}fw$) was in 10 dSm^{-1} salinity level, while the lowest (0.913 $\mu molg^{-1}fw$) was in 30 dSm^{-1} salinity level. The highest protein content (12.62%) was recorded in 10 dSm^{-1} salinity level, while the lowest protein content (8.24%) was observed in 30 dSm^{-1} salinity level. The concentration of Na^+ in both tomato plants shoots and roots significantly increased with increasing the salinity level. The highest concentration of this ion was recorded at the higher salinity level (30 dSm^{-1}) and the lowest was in the control treatment. K^+, Ca^{2+} and Mg^{2+} contents significantly decreased with increasing salinity. Highest concentration of these ions was recorded in the control treatment and the lowest was at the higher salinity level (10 dSm^{-1}). Finally, based on the overall results on growth performance, it is concluded that tomato plants at 10 dSm^{-1} salinity level were found to be tolerant salinity while tomato plants at 30 dSm^{-1} salinity level were observed to be susceptible to salinity.*

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I. Introduction

Tomato (*Lycopersicon esculentum*) is one of the most important vegetable crops grown all over the world and is a good model crop for conducting fruit ripening studies. Tomato is a widely distributed annual vegetable crop which is consumed fresh, cooked or after processing by canning, making into juice, pulp, paste, or as a variety of sauces; being a rich source of phytochemicals such as lycopene, β-carotene, flavonoids, vitamin C and essential nutrients (Beutner *et al*., 2001). Abiotic stresses are major constraints for global crop production. Among various abiotic stresses, salinity has become a severe threat to ensure food security by affecting about one-third of the irrigated land on earth (Mengel *et al*., 2001). Salt stress limits plant growth and productivity, mainly by inducing osmotic effects, ion-specific effects and oxidative stress (Okhovatian-Ardakani *et al*., 2010). Salinity reduces tomato seed germination and lengthens the time required for germination to such an extent that the establishment of a competitive crop by direct seeding would be difficult in soils where the electrical conductivity of a saturated extract was equal to or above 8 dSm^{-1} (Cuartero and Fernandez-Munoz, 1999). Plenty of literature is available on salt tolerant germplasms of crops under a colossal range of soil, climatic and salinity conditions. The salt-specific or ion-excess stress, defined as excessive amounts of salt (sodium and chloride) that enters in to the plant transpiration stream which can be toxic and cause injury to the cell (Hasegawa *et al*., 2000). Salinity affects the growth of plants by affecting the availability, transport, and partitioning of nutrients such as K^+, Ca^{2+}, Mg^{2+} and NO_3 due to competition of Na^+ and Cl^- with them (Braun, 1986; Flowers, 2008; Netondo, 2004). High salt concentration in the soil not only affects the plant growth but also interfere with activity of soil's microbial population. Plants are able to survive in saline conditions by excluding a large proportion of salt while taking up of water continuously (Casas, 1991; Hassidim, 1990; Munns, 2005; Moller, 2009). Seed priming (controlled hydration followed by redrying) has been used to reduce germination time, harmonize germination, improve germination rate and improve the crop establishment in many crops under stress conditions. These priming treatments which enhance seed germination include

hydropriming (Afzal *et al*., 2002) osmo-priming (Rouhi *et al*., 2011), solid matrix priming (Ghassemi-Golezani *et al*., 2010) hormonal priming halopriming (Afzal *et al*., 2009; Nawaz *et al*., 2011) sand priming (Hu *et al*., 2006). The beneficial effect of priming has been associated with various biochemical, cellular and molecular events including synthesis of DNA and proteins (Bray *et al*., 1989). Priming is also thought to increase activity of many enzymes and thus counteracts the effects of seed ageing (Lee and Kim, 2000). Priming treatment significantly enhanced the activities of catalase (CAT), peroxidase (POD), superoxide dismutase (SOD) and soluble sugar content and reduced the malondialdehyde (MDA) accumulation under the salt stress condition in the seedlings (Hu *et al*., 2006). The faster growth of tomato plants from primed seeds seems to be the result of higher capacity for osmotic adjustment because plants from primed seeds have more Na^+ and Cl^- in roots and more sugars and organic acids in leaves than plants from non-primed seeds (Cayuela *et al*., 1996). Many crop plants including tomato are susceptible to cell damage from high salinity and can survive only with decreased yields. Therefore, the present study investigated the effect of different salinity condition on the seed germination and early growth of tomato with biochemical and mineral constituents of tomato grown in the Dinajpur region of Bangladesh.

II. Materials And Methods

Laboratory experiment

Preparation of salinity treatments

Five salinity levels viz. 0 (control), 10, 15, 20 and 30 dSm^{-1} were used in this experiment. Different salinity levels were prepared by dissolving commercial salt (NaCl, Batch# 088K0089, SIGMA-ALDRICH Co., USA) at the rate of 640 mg per liter distilled water for 1 dSm^{-1} salinity level. Distilled water was used as the control i.e. 0 salinity. After preparation the salinity levels were checked by electrical conductivity meter (model: Z 865/SCHOTT Instruments, Germany) and necessary adjustment was made.

Germination test

Seeds were surface sterilized with 1% sodium hypochlorite solution, rinsed with sterile water, and **g**erminated in 11.4 cm petri-dishes lined with filter paper. Twenty-five seeds were placed on the filter paper in each petri-dish, and 10 mL of treatment solution of different salinity was used in each petri-dish to immerse the seeds partially. Six petri-dishes were placed in plastic trays and kept enclosed in a polythene bag, and the seeds were allowed to germinate at room temperature (27 ±2^oC). Distilled water was added to each petri-dish everyday as necessity. Seeds were considered germinated when both the shoot and root were extended more than 2 mm (ISTA, 1999), and the number of seeds germinated were recorded daily up to 9th day. Shoot and root lengths were measured by centimetre scale. The shoot and root samples were oven-dried to a constant weight at 65 ^oC and dry weights were recorded for each treatment.

Germination index, final germination percent and germination energy

At 9th day after final count, germination percentage was calculated as follows.

$$\text{Germination (\%)} = \frac{\text{No of seeds germinated}}{\text{Number of seeds placed}} \times 100$$

Seed were classified as tolerant (T, with 0-20% reduction), moderately tolerant (MT, with 21-40% reduction), moderately susceptible (MS, with 41-60% reduction) and susceptible (S, with >60% reduction) based on total dry matter (shoot and root) reduction due to salt impositions (Fageria, 1985).

Pot experiment

Preparation of growth media

Soil for this pot experiment was collected from HSTU field. The soil was pulverized, and inert materials, visible insect pests and plant debris were removed. The soil was then crushed, mixed thoroughly, and dried in the sun. Three kg of soil was placed in each pot. The stretches from latitude 3° 59' N to 2°44' N and longitude 100°29' E to 101°48' E.

Tomato seedling establishment and application of salinity treatments

The pots were filled with 3 kg soil well mixed with urea, triple superphosphate (TSP), muriate of potash (MP), and gypsum as sources of N, P, K and S at the rate of 60 kg N, 80 kg P_2O_5, 150 kg K_2O and 20 kg S ha^{-1}, respectively. The tomato seeds were soaked in water for 24 hours followed by incubation for 12 hours to allow sprouting**.** Three-week-old tomato seedlings were transplanted into the pots with three seedlings per pot. Two weeks after transplanting the salt treatments were applied. To avoid osmotic shock, salt solutions were added in three equal portions on alternate days until the expected conductivity (0, 10, 15, 20 and 30 dSm^{-1}) was reached. Urea was top dressed twice at 30 and 60 days after transplanting at 60 kg N/ha. Standard agronomic practices were adopted and crop protection measures were carried out as necessary. Leachates of salt solutions

were collected daily from each pot, monitored for electric conductivity (EC) measurements and necessary adjustments were made. Conductivity of soil was determined using conductivity meter (Model: ECTestr, Spectrum Technologies, Inc.).

Growth and parameters

Plant height (cm) was measured from the ground level to the tip of the longest leaf just before harvesting. Shoot and root samples were carefully separated and rinsed in distilled water. The root and shoot samples were oven-dried to a constant weight at 70^{o}C for 72 hours. The mean root dry weight hill^{-1} was calculated for each treatment.

Biochemical constituents

Proline content

Proline was estimated according to the method of Bates *et al*. (1973). 45 days old fresh tomato leaf tissue (0.5 g) was homogenized in 10 mL of 3% sulfo-salicylic acid, and filtered through Whatman No. 2 filter paper. Two mL of the filtrate was brought to reaction with 2 mL acid ninhydrin solution (1.25 g ninhydrin in 30 mL glacial acetic acid), 20 mL 6M orthophosphoric acid, and 2 mL of glacial acetic acid for 1 hour at 100°C. The reaction was then terminated in an ice bath, and extracted with 4 mL toluene, mixed vigorously by passing a continuous stream of air for 1-2 min. The chromophore containing toluene was aspirated from the aqueous phase, warmed at room temperature and the absorbance was read using scanning spectrophotometer (Model UV-3101PC, UV-VIS NIR) at 520 nm. The proline concentration was determined from a standard curve and calculated on a fresh weight basis as follows:

$$\mu mol\ proline\ g^{-1}\ fresh\ weight = (\mu g\ proline\ mL^{-1} \times mL\ of\ toluene/115.5)/\ (g\ of\ sample)$$

Chlorophyll content

Leaf samples were collected at 45 days after transplanting from each treatment. 3 cm^2 fresh leaves were transferred into small vials containing 20 mL of 80% acetone, covered with aluminum foil, and kept in the dark for 7-10 days to ensure release of all the chlorophyll from the tissues. A 3.5 ml of supernatant was then sampled to measure the absorbance using a spectrophotometer (Systronics UV- VIS 118) at 664 and 647 nm wave lengths. The chlorophyll content was calculated using the following formulae (Coombs *et al*., 1987):

$$Chlorophyll\text{-}a\ (mg/cm^2) = 3.5/3(13.19A_{664} — 2.57A_{647})$$

$$Chlorophyll\text{-}b\ (mg/cm^2) = 3.5/3\ (22.10A_{647} — 5.26A_{664})$$

Minerals content

After harvest the root and shoot samples were ground using a Wiley Hammer Mill, passed through 40 mesh screens, mixed well and stored in plastic vials until analysis. The samples were analyzed separately to determine the Na, K, Ca, Mg, S, Fe, and Zn contents using their approved methods.

Estimation of Protein content

Protein content was determined using micro-Kjeldahl method describe in AOAC (2005).

Statistical analysis

Statistical analysis of the data generated out were analyzed using the MSTATC software and Microsoft Office Excel (2017). The data were subjected to analyze the coefficient of variance and means were compared by the DMRT method.

III. Results And Discussion

Laboratory experiment

Final Germination Percentage

The effects of salinity on final germination percentage (FGP) were significant (Table 1). Germination percentages were inversely related to salt concentration level. The percentage of germination significantly decreased in tomato plants due to increasing salinity. The highest germination (93.33%), was obtained at the salinity level 10 dSm^{-1} and the lowest germination (55%) was recorded at 30 dSm^{-1} of salinity level, Overall, the results revealed that seed germination of the tested tomato plants decreased with increasing salt concentration. However, the reduction in germination might be due to disturbance of ionic homeostasis since salinity alters membrane selectivity (Na^+ over K^+). This physiological process may bring at least two challenges to the young plant (embryossnic development); (i) Na^+ toxicity and (ii) severe K^+ deficiency. Being an inorganic osmolyte, K^+ also requires for preventing osmotic challenge (so-called plasmolysis) of embryonic cell. So, germination decreased due to physiological affect as well as nutritional imbalance. The results are in agreement with the

findings of Akbar and Ponnamperuma (1982); Mondal *et al* (1988); Jamil and Rha (2007); and Momayezi *et al*. (2009a).

Table 1. Effect of salinity on final germination percentage, shoot length, root length, shoot weight and root weight of tomato varieties at 15 days

Treatment	Germination (%)	Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)
T1	100.0 a	9.600 a	6.200 a	3.560 a	0.3467 a
T2	93.33 a	8.667 b	5.767 b	2.623 b	0.3200 a
T3	83.33 b	7.733 c	5.267 c	2.160 c	0.2967 ab
T4	66.67 c	6.700 d	4.800 d	1.840 d	0.2500 bc
T5	55.00 d	5.300 e	4.367 e	1.440 e	0.2133 c
LSD	8.136	0.3203	0.2441	0.1908	0.05753
CV (%)	5.61	2.33	2.54	4.55	5.65

T1= Control (Water), T2= 10 dSm^{-1}, T3= 15 dSm^{-1}, T4= 20 dSm^{-1}, T5= 30 dSm^{-1}

Shoot and root lengths

The main effect of salinity levels on shoot length of tomato plants was found to be significant, and shoot length showed significant reduction with increased salt levels (Table 1). The highest shoot length (8.667 cm) was obtained in salinity level 10 dSm^{-1} and the lowest shoot length (5.30 cm) was recorded in 30 dSm^{-1} of salinity level. The highest root length (5.76 cm) was obtained in salinity level 10 dSm^{-1} and the lowest root length (4.36 cm) was recorded in 30 dSm^{-1} of salinity level. In the present study, the shoot and root lengths were significantly reduced by salinity. Actually, salt stress significantly reduced young shoot and young root lengths in tomato plants. The results indicated that salt stress affected not only germination but also the growth of young seedlings. The results could be explained in the following ways: (i) the young plant may suffers from water, which is known as water deficit effect of salinity (Munns, 2005), (ii) the young plant may be unable to maintain cell turgor, which is required for expanding tissues and finally, affect shoot and root growth as a whole, (iii) excess Na^+ and Cl^- may also affect shoot and root growth, which is known ion-specific effect or ion toxicity of salinity (Rahman *et al*., 2001, Djanaguiraman *et al*., 2003, Jamil and Rha, 2007). The results also corroborated with those of Momayezi *et al*. (2009a), who also observed shoot and root length reductions in tomato genotypes due to increasing salt levels

Shoot and root dry weights

Shoot dry weights were inversely related to salt concentration (Table 1). Shoot dry weight was relatively less sensitive to salt than root dry weight. Tomato plants in shoot dry weight were response to salt concentration. The highest shoot dry weight (2.62 g) was obtained from salinity level 10 dSm^{-1} and the lowest shoot dry weight (1.44 g) was recorded in 30 $dSm^{-1}$of salinity level. However, shoot dry weight of salinity level (30 dSm^{-1}) was more reduction in comparison to other salt level. Root dry weights also decreased with increasing salinity levels (Table 1). The highest root dry weight (0.32 g) was obtained from salinity level 10 dSm^{-1} and the lowest root dry weight (0.21 g) was recorded in 30 dSm^{-1} of salinity level which produced the second highest root dry weights at this salinity level. The salinity stress was observed to affect dry matter production of the tomato seedlings, which also indicated disturbance of photosynthetic ability. Similar results were observed by Jamil and Rha (2007) and Momayezi *et al.* (2009a)

Pot experiment

Plant height

The plant height of different tomato varieties was significantly influenced by salinity. The average plant height of different salinity at 10, 15, 20 and 30 dSm^{-1} salinity were recorded to be 26.69, 21.07, 51.65, 49.12 and 39.12 cm, respectively (Table 2). Plant height was recorded at different days after transplanting DAT from 26.69 to 15.02 cm. Plant height after 45 days from 51.65 to 39.12 cm. The result indicated that there was a genotypic variation on plant growth during salinity stress. Reduced photosynthesis might be one of the reasons for reduced plant growth as well as plant height under salinity stress. Several investigators also reported that photosynthesis seriously decreased with the onset of salinity (Khan *et al*., 1997; Choi *et al*., 2003; Alam *et al*., 2004; Motamed *et al*., 2008; Mahmood *et al*., 2009) which corroborated our findings.

Table 2. Effect of salinity on plant height at 30 and 45 days after transplanting of tomato plants

Treatment	Plant height (cm) at 30 days	Plant height (cm) 45 days
T1	26.69 a	51.65 a
T2	22.66 b	49.12 b
T3	21.07 c	46.04 c
T4	17.68 d	42.04 d
T5	15.02 e	39.12 e

LSD	1.110	1.121
CV (%)	2.96	1.35
T1= Control (Water), T2= 10 dSm^{-1}, T3= 15 dSm^{-1}, T4= 20 dSm^{-1}, T5= 30 dSm^{-1}		

Biochemical constituants

Proline content

The accumulation of proline was significantly influenced by the salinity. Results revealed that proline content was increased with increasing the salinity level in tomato plants (Table 3). The highest increment (1.483 $\mu molg^{-1}$ fw) was recorded at 10 dSm^{-1} salinity level, while the lowest (0.913 $\mu molg^{-1}$ fw) at 30 dSm^{-1} salinity level. The accumulation of compatible solutes such as proline is an important mechanism in higher plants under salt-stress. Proline accumulation in salt stressed plants is a primary defense response to maintain osmotic pressure in a cell. Many researchers have reported the significant role of proline in osmotic adjustment, and protection of cell structure in many crops (Desingh and Kanagaraj, 2007). Chutipaijit *et al*. (2009) reported that free proline content of tomato plants was significantly increased with increasing salinity levels. The proline accumulation of tomato genotypes was significantly influenced by the application of different concentration of salt (Momayezi *et al*., 2009b). Wanichananan *et al*. (2003) found that the proline content of tomato seedlings was affected by the presence of NaCl in the growth medium and the proline content positively correlated with the NaCl. The proline content in tomato genotype of KDML105 seedlings was enriched and higher than those of HJ seedlings under salt stressed environment (Cha-um *et al*., 2009). Similar result was observed by Moradi and Ismail (2007) where proline concentration increased significantly in tomato plants lines with increasing salinity levels.

Chlorophyll content

Chlorophyll-a in the tomato was significantly affected by salinity (Table 3). The highest chlorophyll-a (10.61 mg/g) was obtained at 10 dSm^{-1} salinity level, while the lowest value (7.663 mg/g) was recorded at 30 dSm^{-1} salinity level. However, at 30 dSm^{-1} salinity level, tomato plants were more influenced by salt stress, but more chlorophyll-a was recorded in 10 dSm^{-1} salinity level. The effect of salinity on chlorophyll-b was significant (Table 3). The highest chlorophyll-b content (4.18 mg/g) was recorded at 10 dSm^{-1} salinity level, while the lowest chlorophyll-b content (1.62 mg/g) was obtained at 30 dSm^{-1} salinity level.

Protein Content

The effect of different levels of salinity on protein was significant (Table 3). The highest protein content (12.62 %) was recorded at 10 dSm^{-1} salinity level while the lowest protein content (8.2 %) was observed at 30 dSm^{-1} salinity level.

Table 3. Effect of salinity on proline, Chlorophyll and Protein content of tomato plants at 45 days

Treatment	Proline ($\mu mol\ g^{-1}$ fw)	Chlorophyll – a (mg/g)	Chlorophyll – b (mg/g)	Protein (%)
T1	1.63 a	12.52 a	4.38 a	13.89 a
T2	1.48 b	10.61 b	4.18 a	12.62 b
T3	1.28 c	9.467 c	3.70 b	10.97 c
T4	1.16 d	8.930 c	2.84 c	10.04 d
T5	0.9133 e	7.663 d	1.62 d	8.24 e
LSD	0.0813	0.711	0.467	0.551
CV (%)	3.67	3.98	7.68	2.72
T1= Control (Water), T2= 10 dSm^{-1}, T3= 15 dSm^{-1}, T4= 20 dSm^{-1}, T5= 30 dSm^{-1}				

Mineral elements in shoot and root

Sodium content

Varietal differences for Na concentrations in shoots and roots were pronounced ranging from 99.44 to 123.3 mg per 100 g under control conditions. Sodium concentrations in tomato plants were observed to increase progressively with increasing salinity (Table 4), the highest Na content was found in 10 dSm^{-1} salinity level with relative values of 110.7 mg/100g compared to the control, while the lowest was in 30 dSm^{-1} salinity level with relative values of 99.44 mg/100g compared to the control. These results may be explained in the following ways: At high Na, HKT may be relevant for Na rather than K uptake (Maathuis and Amtmann, 1999); massive influx of Na^+ into the cells via non-selective cation channels (NSCCs) which occurs in the presence of excess Na in typical saline environments (Rahman *et al*., 2008). Similar findings are also reported that sodium ions in tomato shoot and root generally increased in salt-stressed conditions, but the rate of increase was dependent on salt concentration (Djanaguiraman *et al*., 2006; Ahmad *et al*., 2007; Momayezi *et al*., 2009b; Mahmood *et al*., 2009; Ikram-ul-Haq *et al*., 2010; Amirjani, 2010).

Potassium content

Potassium (K) concentration in shoot and root of tomato plants ranged from 530.0.0 to 441.0 mg/100g in control plants. Potassium concentrations of the three selected rice varieties were found to decrease significantly with increasing salinity (Table 4), The highest amount of K (530.0 mg/100g) was found in10 dSm^{-1} salinity level, with relative to the control, while the, (441.0 mg/100g) lowest was recorded in 30 dSm^{-1} salinity level, relative to the control. K^+ concentrations were reduced with increasing salinity levels. The possible causes are (i) high external Na negatively affects K acquisition due to similar physiochemical properties of Na and K; (ii) KUP (potassium uptake permease)/HAK (High Affinity K) transporters are extremely selective for K and they are blocked by Na under salt stress (Santa-Maria *et al*., 1997). The present results are in accordance with the research reports of Mahmood *et al*. (2009); Ikram-ul-Haq *et al*. (2010); Amirjani, (2010) and Summart *et al*. (2010).

Calcium content

Calcium concentration in shoots and roots of tomato plants were observed in the range of 1.26 to 0.72% in control plants. Calcium content was affected by salinity with clear differences among tomato plants (Table 4), The highest amount of (1.26%), calcium content was found in 10 dSm^{-1} salinity level, the lowest amount of calcium content (0.72%). was found in 30 dSm^{-1} salinity level. Calcium is essential for the maintenance of cell membrane integrity. Calcium plays an important role in the synthesis of new walls in cell, particularly the middle lamellae that separate newly divided cells**.** The rice membrane damage and enhanced Permeability due to affected by the displacement of Ca^{2+} by increasing Na^+ from the binding sites of phospholipids of membranes. In our study, calcium ion decreased with increased the salinity levels. It seemed that seedlings of tomato plant were unable to uptake the required quantities of Ca^{2+} from the medium and finally growth and development of seedlings were severely affected (Ahmad *et al*., 2007). Momayezi *et al*. (2009b) reported that calcium ion content in shoot and root of tomato plant significantly decreased with increasing salinity level. The results are in accordance with the findings was found by Amirjani (2010) and Summart *et al*. (2010).

Magnesium content

Magnesium content in shoots and roots was significantly affected by salinity levels (Table 4). The highest Mg content 1.945%) was recorded in 10 dSm^{-1} salinity level relative to the control, while the lowest (1.103%) was in 30 dSm^{-1} salinity level relative to the control. Momayezi *et al*. (2009b) noted that the amounts of Mg^{2+} in shoot and root tissues of tomato plant remained almost constant with salinity levels up to 10 dSm^{-1} and decreased significantly thereafter. Similar result was observed by Amirjani (2010) where the Mg ion in soybean crop significantly decreased by increasing salt concentration.

Table 4. Effect of salinity on mineral element constituents of tomato plants

Treatment	Sodium (mg/100 g)	Potassium (mg/100 g)	Calcium (%)	Magnesium (%)	Sulfur (mg/100 g)	Phosphorus (mg/100g)	Zinc (%)
T1	123.3 a	573.5 a	1.463 a	1.945 a	267.9 a	120.3 a	4.11 a
T2	110.7 b	530.0 b	1.260 b	1.577 b	249.9 b	111.4 b	3.82 a
T3	106.3 c	505.4 c	0.9067 c	1.310 c	231.0 c	108.4 c	2.86 b
T4	102.4 d	465.8 d	0.8200 d	1.177 c	212.6 d	105.9 d	2.33 c
T5	99.44 d	441.0 e	0.7200 e	1.103 c	206.2 d	103.5 d	1.647d
LSD	3.110	12.31	0.08136	0.1993	6.854	2.433	0.368
CV (%)	1.58	1.34	4.63	3.70	1.61	1.22	6.89

T1= Control (Water), T2= 10 dSm^{-1}, T3= 15 dSm^{-1}, T4= 20 dSm^{-1}, T5= 30 dSm^{-1}

Sulfur content

Sulfur concentrations in shoots and roots tomato plants were observed in the range of 267.9 to 206.2 mg/100g in control plants. Sulfur content was affected by salinity with clear differences among tomato plants (Table 4). The highest sulfur (267.9 mg/100g) content was recorded in 10 dSm^{-1} salinity level relative to the control, while the lowest (206.2 mg/100g) recoded was in 30 dSm^{-1}, relative to the control.

Phosphorus content

Phosphorus concentration in shoots and roots tomato plants were found in the range of 120.3 to 103.5 mg/100g in control plants. Phosphorus content was affected by salinity with clear differences among tomato plants (Table 4). The highest phosphorus content was recorded in 10 dSm^{-1} salinity level (120.3 mg/100g) relative to the control, while the lowest amount was recorded in 30 dSm^{-1}, (103.5 mg/100g) relative to the control.

Zinc content

Zinc (Zn) concentration in shoots and roots tomato plants were recorded in the range of 3.82 to 1.64 % in control plants. Zinc content was affected by salinity with clear differences among varieties (Table 4). The highest amount of Zn content was recorded in 10 dSm^{-1} salinity level relative to the control, while the lowest (3.820 %) amount was recorded in 30 dSm^{-1} salinity level, (1.647 %) relative to the control.

IV. Conclusion

The present study revealed that germination and seedling growth of tomato were suppressed with increasing salt concentration under laboratory conditions. With respect to final germination percentage, one variety of Pusa rub tomato were found to the best treatment. Based on seedling tolerance, Pusa rub tomato can adapt to 10 dSm^{-1} salt concentration and more susceptible at 30 dSm^{-1} with respect to growth, physiochemical constituents, mineral composition and yield performance.

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