Study of the Effects Irrigation Water Salinity and pH on Production and Relative Absorption of some Elements Nutrient by the Tomato Plant

Hossein Afshari, Shahram Ashraf, Abdol Ghaflar Ebadi, Sara Jalali, Hossein Abbaspour, Morteza Sam Daliri and Seyed Rasool Toudar

Department of Horticulture, Damghan Branch, Islamic Azad University, Damghan, Iran

Department of Biological Sciences, Jouybar branch, Islamic Azad University, Jouybar, Iran

Department of Science and Technology, North Tehran Branch, Islamic Azad University, Tehran, Iran

Department of Agricultural Sciences, Chalus Branch, Islamic Azad University, Chalus, Iran

Abstract: Problem statement: This study was conducted to examine the effects of irrigation water pH and Salinity on the growth and absorption of P, Na, Ca, K by tomato. Approach: The study includes two Salinity and pH factors and is consisted from 12 treatment and three repetitions. Tomato seeding grown in foam trays were transplanted in the joune 2010 to bags filled with perte in an Greenhouse at Damghan Islamic Azad University of Iran. Plant were divided into groups then irrigated with the targeted sane and pH levels. Plants were hand-irrigated with fresh water and fertized with required nutritional solutions were prepared based on bed nutrients mitation. Greenhouse temperature was maintained in suitable level using air conditioner and its humidity was controlled by hygrometer and adjusted in the range of 60-80%. Water Salinity factors were consisted from four levels (0, 3, 6 and 9 dsm\(^{-1}\)) and pH factor was consisted from three levels (6.5, 7.5 and 8.5). Salinity and pH treatments were adjusted with Nacl and H\(_2\)SO\(_4\)/N\(_2\)CO\(_3\) salts respectively. Study of the effects of Salinity and pH level on tomato were recorded and controlled depending on number of growing fruit, fertized flowers, plant dry weight, plant height, percentage of P, Ca, K in leaves. Then results were studied by Anova Variance Analysis using SAS software and obtaining significant results, Dunken test was used for comparison of average levels in probabity level of 5%. Results: Data showed that all growth parameters such as plant height, leaf area, plant dry weight, percentage of P,Ca,K in leave responded negatively as the Salinity and pH level increased. Only Na\(^+\) content in the leaves responded positively to increment in Salinity and pH level. Conclusion: Based on results, Salinity reduced plant height as well as dry weight and increasing of Salinity and pH increased supply of Na\(^+\) in tomato leaf.

Key words: Irrigation water, required nutritional solutions, ANOVAs variance, growth parameters, salts respectively, nutrients mutation, responded negatively, plant dry weight

INTRODUCTION

Salinity is an environmental stresses that mits growth and development in plants. The response of plants to excess NaCl is complex and involves changes in their morphology, physiology and metabolism (Hilal et al., 1998). Translocation of salt into roots and to shoots is a outcome of the transpirational flux required to maintain the water status of the plant and unregulated transpiration may cause toxic levels of ion accumulation in the shoot (Yeo et al., 1997; Takase et al., 2011). The supply of mineral ions to the leaf growing region may decne. The responses of plants to high Salinity may be expected to vary with different growth stages. This has been shown in pepper; Chartzoulakis and Loupassaki (1997) in eggplant; Dumbroff and Copper (1974) in tomato and Oad et al. (2001) in Corn. Young seedings and plants at the flowering stage seem to be more sensitive than mature stages (Lutts et al., 1995). Salt tolerance of plants can be grouped in three categories: (Achilea et al., 2002) exclusion of salt followed by transport and compartmentation of salt, (Adams, 1988) morphological features and biomass distribution of
MATERIALS AND METHODS

Tomato seedlings grown in foam trays were transplanted in the jounle 2010 to bags filled with perte in an Greenhouse at Damghan Islamic Azad University of Iran.

Greenhouse temperature was maintained in a suitable level using air conditioner and moisture was adjusted in the range of 60-80% with hygrometer. Plants were hand-irrigated with fresh water and fertilized with required nutritional solutions prepared based on bed nutrients mitation and considering the need concentration of nutrients for tomato in Greenhouse (critical level). The study includes two Salinity and pH factors consisted from 12 treatments and three repetitions. Four levels of Salinity namely T1 = 0, T2 = 3, T3=6,T4=9 ds m$^{-1}$ were established by dissolving NaCl salt in fresh water until reaching the concentrations. PH factor was consisted from three level (t1 = 6.5, t2 = 7.5 and t3 = 8.5). pH cultures were adjusted with H$_2$SO$_4$/N$_2$CO$_3$ salts respectively. Plant were divided into groups then irrigated with the targeted sane and pH levels. Irrigation was carried out daily and each irrigation cycle enough drain was allowed to adequate leaching and until reaching the targeted level of Salinity in the drain. Test plan was executed in the form of factorial and in the framework of totally random basic plan. The plants were supped with the standard nutrient solution during the growing season.

To determine the influence of pH and Salinity on the uptake of P, Na$^+$, Ca$^{2+}$, K$^+$ and vegetative and productivity characters, young fully expanded leaves and fruits were sampled from each experimental unit in end of research. The above samples were dried at 65°C to constant weight and used to determine the P, Na$^+$, Ca$^{2+}$, K$^+$ concentration. Recorded data included on number of growing fruit, fertilized flowers, dry matter (%), plant height(cm), percentage of leave phosphor(%) and leave area scale(cm$^2$) from the fourth leaf from the top and was determined using leaf area meter machine. Then results were studied by ANOVA Variance Analysis using SAS software and obtaining significant results, Dunken test was used for comparison of average levels in probability level of 5%.

RESULTS

Porte properties: Results from analysis of physicochemical specifications of the perte as plant bed is given in Table 1.

Nutritional solutions: Table 2 shows Composition of the used nutritional solutions for tomato during the growing season.

Vegetative and productivity characters of tomato: Table 3 indicates effects of different Salinity and pH levels on vegetative and productivity characters of tomato. Results showed that with increasing the level of Salinity and pH significantly reduced vegetative and productivity characters of tomato. Vegetative growth in terms of number of growing fruit, fertilized flowers, plant dry matter, plant height responded negatively to increasing the level of pH and Salinity under the studied range. The most plant height in different treatment was obtained in control treatment (t1=6.5,T1=0 ds m$^{-1}$). Shortest height was seen in the irrigated treatment using of 9 ds m$^{-1}$ Salinity and pH of 8.5 (t3= 8.5 and T4=9). Most number of fertile flowers in different treatments was obtained in control culture. Results indicated that fertile flowers responded negatively to the increment in Salinity and pH level as shown in Table 3. Most fertile flowers are obtained in zero Salinity (T1) and pH of 6.5 (t1) and the least flowers are seen in Salinity of 9ds m$^{-1}$ (T4) and pH=8.5(t3). Highest plant dry weight in different treatments was obtained in treatment T1 and t1. With increasing Salinity and pH in irrigation water, plant dry weight is decreased. Highest index of leave area in different treatments was obtained in treatment T1,t1 and the lowest was related to T4,t3.

Results showed that most ripen fruits in different treatment was obtained in T1,t1. Most number of ripen fruits were obtained in zero Salinity and pH of 6.5 while the least obtained in treatments of T4, t3.

Concentration of leaf P, K$^+$, Na$^+$, Ca$^{2+}$: Table 3 indicate P,K$^+$.Na$^+$,Ca$^{2+}$ percentage in tomato leaf. Results showed that the effects of Salinity and pH is significant on uptake of ions by tomato (Fig. 1-18). The increase of EC and ph from 0-9 ds m$^{-1}$ and 6.5-8.5 respectively, had significant influence on the Uptake of leaf P, K$^+$, Na$^+$, Ca$^{2+}$ by tomato. The increase of Salinity and pH decreased supply of P,K$^+$.Ca$^{2+}$ and increased supply of Na$^+$ in tomato leaf. Highest leaf P, K$^+$ and Ca$^{2+}$ percentage in different treatment was obtained in treatment T1,t1.
Table 1: Physical properties of used perlite

| Attribute          | Attribute          |
|--------------------|--------------------|
| Color              | PH Composition     |
| White and Grey     | 7.00               |
| Densities          | (70-75% silicon dioxide: SiO$_2$, (12-15% aluminum oxide: Al$_2$O$_3$, (3-4% sodium oxide: Na$_2$O),(3-5% potassium oxide: K$_2$O), (0.5-2% iron oxide: Fe$_2$O$_3$,0.2-0.7% magnesium oxide: MgO), (0.5-1.5% calcium oxide: CaO), (3-5% loss on ignition (chemical/combined water)) |
| From 1100 kg m$^{-3}$ (1.1 g cm$^{-3}$) to 30-150 kg m$^{-3}$ (expanded perlite) | Porous texture |
|                    | Surface pores or cavities develop on perlite particles during dilation These pores trap moisture on which plant roots thrive. |
| Liquid retention   | Liquid retention   |
| Perlite’s porous texture retains moisture and fertilizers. Perlite absorb water 1.4 times its weight. |
| Size               | Air circulation    |
| 2-5 mm             | 2.26 ds m$^{-1}$   |
|                    | because of their irregular shape, perlite particles provide aeration in growing mixes |

| Table 2: Effects of different salinity and pH levels on plant vegetative and productivity characters |
|--------------------------------------------------------------------------------------------------|
| Characters                              | Plant dry weight (g) | Leaf area index | Fertilized flower | Flower number | plant height (cm) |
| Salinity                                |                       |                |                  |              |                  |
| T1                                      | 71.16                  | 2.85           | 7.44             | 17.00         | 47.33             |
| T2                                      | 50.37                  | 2.50           | 4.55             | 11.33         | 33.44             |
| T3                                      | 16.74                  | 1.49           | 0.77             | 03.00         | 26.00             |
| T4                                      | 06.96                  | 0.33           | 0.00             | 00.00         | 09.50             |
| pH                                      | 40.04                  | 1.89           | 4.08             | 8.83          | 31.83             |
| t1                                      | 36.20                  | 1.81           | 3.25             | 8.00          | 28.83             |
| t2                                      | 32.69                  | 1.86           | 2.25             | 6.66          | 26.54             |

| Fig. 1: Variation in plant dry weight in different treatments |
|---------------------------------------------------------------|
| Fig. 2: Variation in plant dry weight in different treatments (ph) |
| Fig. 3: Variation in leaf area index in different treatments (salinity) |

Table 3: Effects of different salinity and pH levels on P, K$^+$, Na$^+$, Ca$^{2+}$ concentration in tomato leaf

| Treatment | Leaf ions (percent) |
|-----------|---------------------|
| Salinity  | P       | K$^+$  | Na$^+$  | Ca$^{2+}$ |
| T1        | 0.56    | 4.10   | 0.52    | 1.70       |
| T2        | 0.27    | 3.10   | 0.61    | 1.50       |
| T3        | 0.14    | 2.51   | 0.72    | 1.31       |
| T4        | 0.07    | 1.72   | 1.10    | 1.01       |
| pH        | t1      | 0.30   | 3.90    | 0.51       | 3.41       |
|           | t2      | 0.27   | 3.11    | 0.72       | 2.80       |
|           | t3      | 0.21   | 2.71    | 0.96       | 2.13       |

| Fig. 4: Variation in leaf area index in different treatments (pH) |
|---------------------------------------------------------------|
| Fig. 5: Variation in fertilized flower in different treatments (salinity) |
Fig. 6: Variation in fertilized flower in different treatments (pH)

Fig. 7: Variation in flower number in different treatments (salinity)

Fig. 8: Variation in flower number in different treatments (pH)

Fig. 9: Variation in plant height in different treatments (salinity)

Fig. 10: Variation in plant height in different treatments (pH)

Fig. 11: Variation in $K^+$ concentration in different treatments (salinity)

Fig. 12: Variation in $K^+$ concentration in different treatments (pH)

Fig. 13: Variation in $Na^+$ concentration in different treatments (salinity)
Fig. 14: Variation in Na\(^+\) concentration in different treatments (pH)

Fig. 15: Variation in Ca\(^{2+}\) concentration in different treatments (salinity)

Fig. 16: Variation in Ca\(^{2+}\) concentration in different treatments

Fig. 17: Variation in P concentration in different treatments (salinity)

Fig. 18: Variation in P concentration in different treatments (pH)

**DISCUSSION**

As mentioned above, salinity is commonly reducing growth and production of many vegetable crops such as tomatoes (Hayward and Long, 1943; Sanchez and Azuara, 1979; Li, 2000; Tantawy, 2007; Ebrahimizadeh *et al*., 2009). In this study and in agreement with previous studies, Salinity reduced plant height (Achilea *et al*., 2002; Agong *et al*., 2004; Hajer *et al*., 2006) and leaf area (Li and Stanghelni, 2001; Mulholland *et al*., 2002; Maggio *et al*., 2004; Agong *et al*., 2004), fresh weight (Hassan *et al*., 1999; Sonneveld, 2000; Amico *et al*., 2003; Hajer *et al*., 2006) as well as dry weight (Li, 2000). Salinity affects plant growth by weakening the plant’s ability to absorb water from the bed it is in. The large amount of salt found in plant bed affected by Salinity makes it hard for the plant to absorb all the nutrients necessary to be healthy.

As a result, most of the plants become weaker: And in some cases, end up dying. Plants that are found in bed with high Salinity usually absorb high concentrations of ions such as Na and Cl.

The presented results indicated that increasing of Salinity and pH restrict the uptake of K\(^+\), Ca\(^{2+}\) and P ions. High Salinity reduced uptake of Ca\(^{2+}\), k\(^+\), P mainly in the leaves. Accumulation of salts, can cause plant growth problems and result in poor growth or death of plants. Also pH affects the plant growth because it affects the availability of nutrients to the plants. The ratio in uptake of anions (negatively charged nutrients) and cations (positively charged nutrients) by plants may cause substantial shifts in pH.

Most varieties of vegetables grow at their best in a nutrient solution having a pH between 6.0 and 7.5 and a nutrient temperature between 20 and 22°C. The results showed increasing of Salinity and pH increased supply of Na\(^+\) in tomato leaf.
This can be caused by high levels of bed Na will displace Ca,K and lead to Ca and K leaching. As soil salinity increased, the K/Na and Ca/Na ratios in the soil and plant decreased.

CONCLUSION

According to this study, Salinity can reduce the plant height as well as dry weight and increasing of Salinity and pH increased supply of Na+ in tomato leaf and vegetables (optimal conditions are a nutrition with pH between 6.0 and 7.5 and a nutrient temperature between 20 and 22 °C). Increase of Salinity and pH can cause increased supply of Na+ in tomato leaf and vegetables.

REFERENCES

Achilea, O., 2002. Alleviation of salinity induced stress in cash crops by Multi K (PotassiumNitrate), five cases typifying the underlying pattern. Acta Horticul., 573: 43-48.

Adams, P., 1988. Some responses of tomatoes grown in NFT to sodium chloride. Proceedings of the 7th International Congress Soilless Culture, pp: 59-71. linkinghub.elsevier.com/retrieve/pii/S0378377408000899

Adams, P., 1991. Effect of increasing the salinity of the nutrient solution with major nutrients or sodium chloride on the yield quality and composition of tomato grown in rock wool. J. Hort. Sci., 66: 201-207.

Agong, S.G., Y. Yoshida, S. Yazawa and M. Masuda, 2004. Tomato response to salt stress. Acta Horticul., 573: 43-48.

Amico, M.L., R. Izzo, F. Tognoni, A. Pardossi and F. Navari, 2003. Application diluted Seawater to soilless culture of tomato (Lycopersicon esculentum Mill.): Effect on plant growth, yield and fruit quality and antioxidant capacity. J. Food Agric. Environ., 1: 112-116.

Chartzoulakis, K. and M. Loupassaki, 1997. Effects of NaCl Salinity on germination, growth, gas exchange and yield of greenhouse eggplant. Agric. Water Manage., 32: 215-225.

Dumbroff, E.B. and A. Cooper, 1974. Effects of salt stress applied in balanced nutrient solutions at several stages during growth of tomato. Bot. Gaz., 135: 219-224. www.jstor.org/stable/2474243

Ebrahimizadeh, M.A., M.J. Amiri, S.S. Esfamian, J. Abedi-Koupaï and M. Khozaei, 2009. The effects of different water qualities and irrigation methods on soil chemical properties. Res. J. Environ. Sci., 3: 497-503.

Hajer, A.S., A.A. Mabari, H.S. Al-Zahrani and O.A. Almaghrabi, 2006. Responses of three tomato cultivars to seawater salinity 1-Effect of salinity on the seedling growth. Afr. J. Biotechnol., 5: 855-861.

Hassan, E.H.A., 1999. Physiological Studies on the Adaptation of some Tomato Varieties Under Saline Condition. M.Sc. Thesis, Fac. Agriculture Ain Shams University.

Hayward, H.E. and E.M. Long, 1943. Some effects of sodium salts on the growth of tomato. Plant Physiol., 18: 556-569.

Hilal, M., A.M. Zenoff, G. Ponessa, H. Moreno and E.D. Massa, 1998. Sane stress alters the temporal patterns of xylem differentiation and alternative oxidative expression in developing soybean roots. Plant Physiol., 117: 695-701.

Li, Y., 2000. Analysis of Greenhouse Tomato Production in Relation to Salinity and Shoot Environment. Ph.D. Thesis, Wageningen AgriculturalUniversity, pp: 95.

Luts, S., J.M. Kinet and J. Bouharmont, 1995. Changes in plant response to NaCl during development of rice (Oryza sativa L.) varieties differing in salinity resistance. J. Exp. Bot., 46: 1843-1852. DOI: 10.1093/jxb/46.12.1843

Maggio, A., S. Pascale, G. Angeno, C. Ruggiero and G. Barbieri, 2004. Physiological response of tomato to sane irrigation in long-term sanized soils. Eur. J. Agron., 21: 149-159.

Mulholland, B.J., M. Fussell, R.N. Edmondson, J. Basham and J.M. et al., 2002. The effect of spt-root Salinity stress on tomato leaf expansion, fruit yield and quality. J. Hort. Sci. Biotechnol., 77: 509-519.

Oad, N.L., F.C. Oad, H.r. Mangio, Z.A. Abro and A. Soomro, 2001. Irrigation management strategies in corn production under various water qualities. J. Biol. Sci., 1: 251-252.

Sanchez, C.M.P. and P. Azuara, 1979. Effect of balanced solutions with different osmotic Pressure on tomato plant. J. Plant Nutr., 1: 297-307.

Sonneveld, C., 2000. Effect of Sanity on Substrate Grown Vegetables and Ornamentals in Greenhouse Horticulture, Ph.D. Dissertation, Wageningen Agriculture University, pp: 151.

Sonneveld, C. and C. de Kreij, 1999. Response of cucumber (Cucumis sativus L.) to an unequal distribution of salt in the root environment. Plant Soil, 209: 47-56.
Takase, M., J.D. Owusu-Sekyere and L.K. Sam-Amoah, 2010. Effects of water of different quality on tomato growth and development. Asian J. Plant Sci., 9: 380-384.

Takase, M., L.K. Sam-Amoah and J.D. Owusu-Sekyere, 2011. The effects of four sources of irrigation water on soil chemical and physical properties. Asian J. Plant Sci., 10: 92-96.

Tantawy, A.S., 2007. Effect of some Mineral and Organic Compounds on Sanity Tolerance in Tomato. Ph.D. Thesis. Fac. Agriculture Al-Azhar University.

Winicov, I., 1998. New molecular approaches to improving salt tolerance in crop plants. Ann. Bot., 82: 703-710.

Yeo, A.R., D. Kramer, A. Lauch and J. Gullasch, 1977. Ion distribution in salt stressed mature zea mays roots in relation to ultrastructure and retention of sodium. J. Exp. Bot., 24: 17-29.