Foliar Spraying of NPK to Relieve Salinity Stress on Tomato Plants

Hassan A. Hamouda and S.H.A. Shaaban

Department of Fertilization Technology, National Research Centre, 33 El- Buhouth St., Dokki, Giza, Egypt.

Received: 27 December 2020   Accepted: 10 February 2021   Published: 20 February 2021

ABSTRACT

A pot experiment was carried out to study the effect of NPK foliar spraying on salt tolerant of tomato plants. Seedlings were grown in plastic pots 30 cm, filled with loamy sand soil. Seedlings were irrigated every week with saline two type’s salts (NaCl and CaCl) at two levels 2g and 4g L⁻¹. Seedlings were sprayed with foliar spraying containing NPK. Two months later from transplanting of seedlings leaf samples were taken for determination nutrient contents. The result showed that NPK foliar spraying had a positive effect on soil, growth development, yield and the nutrient concentrations in leaf plant of tomato under the impact of adverse salinity. Although the salts levels of soil have an effect on the absorption of nutrients by tomato plant. But, foliar spraying has a positive effect on the concentration of N, K, Ca, Fe, Mn and Cu in plant leaves.

Keywords: Tomato, NPK foliar spraying, salinity levels, NaCl and CaCl, growth parameters, nutrient concentrations

1. Introduction

Crops are exposed to a number of abiotic and biotic stresses. Salinity is a global problem, emerging in the arid and semi-arid regions of the world. Salinity also, is one of the most deadly abiotic stresses of plants and is considered as the major land degradation problem worldwide (Pichu, 2006). It caused a number of secondary stresses, including water stress, ionic stress, and nutritional imbalance.

Soil salinity poses a global threat to plant growth and development causing significant economic losses to tomatoes and other crop plants (Kalaji et al., 2016 and Albaladejo et al., 2017). High soil salinity along with heat stress is among the most important constraints to crop production between different vital stresses (Zhang et al., 2014).

Salinity losses are difficult to estimate, at present, more than 800 million hectares of land worldwide are affected by salt and account for more than 6% of the total land area in the world (Lutts et al., 1996, Munns. and Tester, 2008 and Ruan et al., 2010).

Salinization is the increase of salt concentration in the soil. It occurs in most cases from salts dissolved in added water, which can arise due to the flooding of the soil with sea water, or the leakage of sea water or salinity groundwater through the soil, due to high levels of sea water or climate change that causes to increase drought rates and sea water. There is growing interest in plants tolerating salts, especially economic importance plants such as tomatoes, to grow more salinity soil.

Salt stress triggers and provokes several signaling pathways to maintain ionic homeostasis and osmotic adjustment. Also, salt stress reduces plant growth and influences a series of physiological processes and finally decreases photosynthesis resulting in yield reduction (Flowers et al., 2014, Song & Wang, 2014 and Zhang et al., 2009, 2014).

In addition to, salinity causes a significant deficit in water uptake from soil that ultimately disturbs the osmotic balance in the affected plants (Munns and Tester, 2008).

Although different crops differ in their ability to grow under salinity conditions, but their different responses is not understood (Loukaich, 2011).
Consequently, the water deficiency leads to secondary effects of salinity causing oxidative stress and ionic imbalance (Chen, & Murata, 2002 and Munns & Gilliham, 2015). The ability of plants to detect these ionic changes and their proper response to these changes is a prerequisite for prolonging survival in a saline condition (Deinlein et al., 2014).

Salinity induce deficiency of nutrients, especially potassium in tomato plants where under saline conditions, sodium cations compete with potassium cations for roots absorption sites also, chloride competes for nitrate-nitrogen uptake will prevent plant growth and reduce yield.

The best treatment of the problem of salinity tolerance in agriculture is by changing farming practices to prevent salinization of the soil, or by implementing plans to repair saline soils (Mark and Romola, 2003).

A counter-defense strategy is the accumulation of proline contents in their cells that help osmotic adjustment, scavenging free radicals and stabilizing sub-cellular structures (Hayat et al., 2012). Moreover, proline accumulation stimulates the genes that respond to salt. Plants under intense the soil salt stress can synthesize several antioxidant enzymes to deal with oxidative stress (Seekin et al., 2009).

Salt tolerance can be defined as the ability of plants to survive and maintain growth under salinity conditions. Thus, the search for strategies that lead to increased plant tolerance is a priority (Estañ et al., 2005 and Martinez-Rodriguez et al., 2008). Yield can be increased in the soil affected by salts, and can maintaining increased plants growth by using some mechanisms that enable them to form part of the remediation process (Mark and Romola, 2003).

Tomato (Lycopersicon esculentum L.) belongs to the Solanaceae family. It is the main crop of vegetables which has achieved tremendous popularity over the last century. It is grown because of its high agricultural and economic value in the world. Also, tomato is one of the best dicotyledonous crops studied to tolerate salt because of its genetics knowledge and effortlessly transforming capabilities (Yin et al., 2017). The plant species and cultivars such as tomatoes differ among it to more tolerance of salinity (Al-Duje, 2018). In addition to, tomato plant is moderately tolerant to salinity by regulating water and ionic homeostasis according to (Pertala et al., 2005 and Martinez-Rodriguez et al., 2008).

The present study investigated the effects of supplemental foliar spray NPK on morphological, yield and nutrients in tomato plants under soil salinity conditions.

2. Material and Methods

Tomato (Solanum lycopersicum L. cv. GS12) were used in this study to be transplanted at late of February in the micronutrients project greenhouse at the NRC, Dokki; Giza, Egypt. This research was conducted during the winter season and started from March 1\textsuperscript{st} to the end of August.

This study investigated the effects of salinity stress on the growth parameters, fruit quality and yield as well as leaf nutrient concentrations of tomato plants cultivated under pot experiments. For salinity treatment, two salt types (NaCl & CaCl) and two levels (2g & 4g L\textsuperscript{-1}) from each type were applied with irrigation in addition to tap water, for two weeks after transplanting of seedlings. The salt was equally concentration a long treatment.

During the whole duration of the experiment, twice monthly fertilizer’s addition is stabilized, whereas foliar application with micronutrients compound was twice added during season as foliar spraying.

2.1. Treatments

The plants were exposed to the two levels salinity stress treatments using a completely randomized design, with three pots per treatment as follows: Control (irrigated tap water), Control + NPK foliar spray, (2g NaCl + 2g CaCl L\textsuperscript{-1}), (2g NaCl + 2g CaCl L\textsuperscript{-1} + NPK), (4g NaCl + 4g CaCl L\textsuperscript{-1}) and (4g NaCl + 4g CaCl L\textsuperscript{-1} + NPK L\textsuperscript{-1}). Each treatment contains 3 replicate. Seedlings were irrigated every week with saline two type’s salts (NaCl and CaCl) at two levels 2g and 4g L\textsuperscript{-1}.

2.2. Plant material

Seedlings (one month old) were individually with uniform seedlings of similar vigor; age and size to transplanted (one seedling per pot) were prepared into plastic pots (30 cm). The plant pots also, filled with loamy sand soil mixture and irrigated with a nutrient solution.
2.3. Soil Analysis

Soil physico-chemical properties were determined at the starting and end of all treatments. Soil samples were analyzed for their texture; pH and electric conductivity (E.C) using water extract (1: 2.5) method. Total calcium carbonate (CaCO$_3$%) was detected by calcimeter, organic matter (O.M %) by potassium dichromate method (Chapman and Pratt, 1978). Phosphorus was extracted using sodium bicarbonate (Olsen et al., 1954); meanwhile potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na) were measured using ammonium acetate (Jackson, 1973). Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were extracted using DTPA, (Lindsay & Norvell, 1978).

2.4. Plant analysis

Leaf samples were taken for measuring nutrients contents. The chemical analysis was done in the leaves to determine the mineral nutrient concentrations using the technique according to (Chapman & Pratt, 1978).

Leaves were determined with dry aching after 4 months from seedlings transplanting, using method of macro- and micronutrient concentrations. Nitrogen was analyzed using the Kjeldahl method (Buresh et al., 1982) and P spectrophotometrically measured by (Olsen et al., 1954) technique, and K, Ca, Mg, Fe, Mn, Zn and Cu were measured by Perkin-Elmer (1100 B) atomic absorption spectrometer (Lindsay and Norvell, 1978).

2.5. Measurements of plant growth

The number of leaves, number of branches, plant height, number of flowers and number of fruits as well as fresh and dry weights (g) of both shoot and root were measured at the end of experiment. At the end of the experimental period, plants were carefully removed from the soil, washed with distilled water, and the plants were partitioned in different tissues fresh weight (leaf, stem, fruits and root/plant). After drying at 70°C in an oven until constant dry weight, mass of leaves, stem, fruits and root dry were determined. These data were used to calculate biomass allocation in leaves, stem, fruits and roots as well as root: shoot ratio, and all the measurement were taken for the samples under treatments.

2.6. Statistical analysis

The whole results were submitted to analysis of variance according to (Snedecor and Cochran, 1967). Differences among treatments means were determined by using the LSD test at a significance level of 0.05 (Waller and Duncan, 1969).

3. Results and Discussion

3.1. Effect of NPK foliar spraying under different salinity levels on

3.1. Soil

3.1.1. Physical characteristics

According to (Ankerman and Large, 1974), data in Table (1) showed that the soil had high pH, low salinity and organic matter, medium content of calcium carbonate.

Table 1: Effect of NPK foliar spraying under irrigated water salinity levels on soil physical characteristics

| Treatment                                | Mechanical analysis (%) | Physical properties |
|------------------------------------------|-------------------------|---------------------|
|                                          | Sand | Silt | Clay | Text. | pH | EC (dS/m) | CaCO$_3$ (%) | O.M (%) |
| Before planting                          | 72.0 | 13.0 | 15.0 | Loamy Sand | 8.56 | 0.13 | 2.23 | 1.51 |
| Control                                  | 73   | 12   | 15   | Loamy Sand | 8.54 | 0.13 | 1.80 | 1.65 |
| Control + NPK foliar spray (2g NaCl + 2g CaCl L$^{-1}$) | 69   | 14   | 17   | Loamy Sand | 8.53 | 0.12 | 1.60 | 1.22 |
| (2g NaCl + 2g CaCl L$^{-1}$) + NPK        | 71   | 13   | 16   | Loamy Sand | 8.75 | 0.18 | 3.20 | 1.60 |
| (4g NaCl + 4g CaCl L$^{-1}$) + NPK        | 73   | 11   | 16   | Loamy Sand | 8.73 | 0.13 | 2.00 | 1.29 |
NPK foliar spraying treatment was had a positive effect on most physical characters of the soil. As the foliar spraying of NPK under salinity stress caused a reduction in pH, EC and CaCO$_3$, which was higher at lower salinity level (2 g L$^{-1}$) than higher salinity, level (4 g L$^{-1}$). Also, EC, pH and CaCO$_3$ were reduced in all foliar spraying treatments at the same salinity level in addition to control treatment.

3.1.2. Soil nutrient contents

Data in Table (2) showed that the soil had medium content of P, Ca, Na and low content of K and micronutrients agreement with (Ankerman and Large, 1974). There are differences in the nutrient concentrations of the soil due to the NPK foliar spraying under salinity levels. The plants received NPK foliar spray were less removed of P, K, Ca, Mg and Na from the soil than the plant without NPK foliar spray which led to improving the soil content of these elements. But, the micronutrients were more removed from the soil with plants received foliar NPK than the soil with plants without foliar NPK, which led to reduce the soil content of these elements under the salinity condition.

| Treatment | Macronutrients (mg/ 100g) | Micronutrients (ppm) |
|-----------|---------------------------|----------------------|
| Control   | 2.63                      | 17.17               |
| Control + NPK foliar spray | 2.96 | 17.86 |
| (2 g NaCl + 2 g CaCl L$^{-1}$) | 2.56 | 16.92 |
| (2 g NaCl + 2 g CaCl L$^{-1}$) + NPK | 2.62 | 18.00 |
| (4 g NaCl + 4 g CaCl L$^{-1}$) | 2.81 | 18.10 |
| (4 g NaCl + 4 g CaCl L$^{-1}$) + NPK | 2.95 | 19.00 |

3.2. Plant development

3.2.1 Growth parameters

3.2.1.1. Morphological characters

The presented data in Table 3 show the effect of NPK foliar spraying on growth characters such as number of leaves, number of branches, plant height, number of flowers and number of fruits of tomato cv. GS12 plant. Data in the same table showed that there are clear differences among NPK foliar spraying treatments for growth parameters under irrigated water salinity levels.

Table 3: Effect of NPK foliar spraying under irrigated water salinity levels on growth characters of tomato plants

| Treatment | No. of leaves | No. of branches | Height (cm) | Fresh weight (g/plant) | Dry weight (g/plant) |
|-----------|---------------|----------------|-------------|------------------------|----------------------|
| Control   | 47.00         | 7.33           | 60.00       | 702.27                 | 93.53                |
| Control + NPK foliar spray | 48.66 | 5.66 | 63.00 | 754.16 | 99.51 |
| (2 g NaCl + 2 g CaCl L$^{-1}$) | 46.33 | 4.66 | 73.00 | 597.17 | 78.85 |
| (2 g NaCl + 2 g CaCl L$^{-1}$) + NPK | 53.66 | 8.00 | 72.70 | 661.65 | 89.41 |
| (4 g NaCl + 4 g CaCl L$^{-1}$) | 28.33 | 4.66 | 53.00 | 495.77 | 61.58 |
| (4 g NaCl + 4 g CaCl L$^{-1}$) + NPK | 28.66 | 4.66 | 51.66 | 472.69 | 57.31 |
| LSD 0.05 % | 4.34 | 1.39 | 8.27 | 19.93 | 2.49 |

NPK foliar spraying led to improvement growth characters in tomato plants under soil salinity conditions. Also, growth characters are at the first level of salinity and control treatment. In addition to, there was a slight increase in the numbers of leaves but there was no increase in the number of branches, as the plant height decreased under the second level of salinity. Also, the table shown irrigation of tomato plant with two irrigated water salinity levels at 2 g and 4 g L$^{-1}$ resulted in significant reductions in growth characters as compared to control treatment (tap water). NPK foliar spray treatments had a pronounced ameliorative as well as growth promoting effect under both saline and non-saline conditions.

The results revealed that salinity water supply significantly reduced growth. Supplemental foliar spray NPK significantly improved the growth characteristics in both salinity levels.
In this regard some researchers such as (Rodriguez et al., 1997 and Najla et al., 2008) found that soil salinity has significantly reduced plant growth throughout all plant stages such as, the number of leaflets per leaf, the leaves area, the leaves internodes and plant height as well as, fruit production as the size and number of fruit in tomato plants, and high salinity negatively affects germination of seeds and inhibits growth and development of fruits in tomatoes (Cuartero et al., 2006). In addition, reduce the water availability as osmotic effect and accumulation of toxic ions, especially Na\(^+\) and Cl\(^-\), concentrations (Tavakkoli et al., 2010).

### 3.2.1.2. Plant fresh and dry weights

The results in the table (3 & 4) also, showed that fresh and dry weights of whole tomato plants were improved by foliar spray NPK under salt stress conditions at the first level 2 g L\(^{-1}\) while fresh and dry weight decreased at the second level of salinity.

The highest dry weights obtained from control + spraying NPK treatment. Also, the highest root dry weight resulted from NaCl + CaCl (4g L\(^{-1}\)) + NPK spray treatment followed by NaCl + CaCl (4g L\(^{-1}\)) treatment at the second level of salinity, but the lowest dry weight resulted from the control treatment without salinity. Also, NPK total as a source of NPK may play an important role in plant metabolism and protein assimilation which is necessary for cell formation and consequently increase fresh and dry matter.

In this respect (Sadak et al., 2015) indicated that NPK might alleviate the imposed salt stress, either via osmotic adjustment or by conferring desiccation resistance to plant cells as reported by other investigators. Salinity is a major abiotic stress which affects tomato growth through reduced water uptake and ion imbalances, which may result in toxicity or deficiency symptoms. In this context (Shabbir et al., 2015) mentioned that foliar spray of NPK in combination was effective in improving wheat growth under both well-watered and water-deficit conditions.

### 3.2.1.3. Root shoot ratio

The effect of salt stress usually occurs when the root is exposed to highly saline conditions, which is similar to a lack of water. Salt stress lead to change in growth, such as the morphology and physiology characters of the root, which in turn will lead to a change in the absorption of water and ions and the production of hormones that can communicate information to the shoot. Thus, the whole plant is affected when the roots grow in salty medium.

**Table 4:** Effect of NPK foliar spraying under irrigated water salinity levels on dry weight root shoot ratio of tomato plants

| Treatment | Leaves | Stems | Fruits | Shoot | Roots | Total | Root/ shoot ratio |
|-----------|--------|-------|--------|-------|-------|-------|------------------|
| Control   | 41.11  | 3.72  | 35.93  | 90.76 | 2.77  | 93.63 | 0.031 |
| Control + NPK foliar spray | 42.37  | 14.12 | 39.64  | 96.13 | 3.38  | 99.51 | 0.035 |
| (2g NaCl + 2g CaCl L\(^{-1}\)) | 35.25  | 8.74  | 31.27  | 75.26 | 3.59  | 78.85 | 0.049 |
| (2g NaCl + 2g CaCl L\(^{-1}\)) + NPK | 41.96  | 10.89 | 32.46  | 70.32 | 4.10  | 74.42 | 0.058 |
| (4g NaCl + 4g CaCl L\(^{-1}\)) | 21.95  | 6.10  | 29.17  | 57.22 | 4.36  | 61.58 | 0.076 |
| (4g NaCl + 4g CaCl L\(^{-1}\)) + NPK | 13.97  | 7.96  | 30.20  | 52.313| 5.18  | 57.31 | 0.099 |
| LSD 0.05 % | 1.88   | 1.88  | 1.99   | 2.98  | 0.16  | 3.14  | 0.054 |

In spite of the negative effect of salt on the root, it appears that the growth of tomato root is less affected by salt compared to the growth, so the ratio of dry weight root/ shoot is higher in plants which grown under salt stress compared to the control treatment, during the growth and development stages (Cruz and Cuarterro, 1990).

The root/ shoot ratio dry weight of tomato plants under salt stress in accompanied by change in the distribution of similar substances between the root and the shoot. Perez-Alfocea et al., (2010) in the case of plants treated with salt, the proportion of root absorption was greater when compared to the proportion of shoot growth than control plants.

When the tomato plant grows in soil with a heterogeneous salt concentration, there is an increase in the root growth and water absorption to a greater than the roots of the plants in a low saline medium. Salinity may cause water deficient in the root zone such as those caused by drought. The continued
growth of tomato root is attributed during periods of water stress due to the osmotic adjustments with sugars and amino acids such as proline as well as inorganic ions such as nitrates, phosphates, sodium and potassium.

The root/shoot ratio was significantly increased with salt stress for (NaCl+CaCl2 4g L⁻¹)+NPK from other treatments. The highest root/shoot resulted from the second level of salinity while; the lowest ratio was recorded with the control treatment.

These results were agreed with many researchers who mentioned that the soil salinity leads to a significant decrease in growth at different plant stages. Also, shoot growth and dry weight as well as, fruit production such as size and number in tomato plants. The inhibition-of plant growth is due to a lack of water availability as an osmotic effect and accumulation of toxic ions, especially, to toxic concentrations (Rodriguez et al., 1997, Najla et al., 2008, and Tavakkoli et al., 2010). Several researchers also reported that shoot growth is more sensitive to salinity than root growth (Shalhevet et al., 1995 and Azevedo Neto and Tabosa, 2000) which is consistent with our findings.

The inhibition of plant growth cannot be estimated by the salt stress of a single physiology process, but the predominant is photosynthesis and growth inhibition observed in many plants exposed to salinity is often associated with a decrease in their visual capacity (Lu et al., 2003). In sensitive species, salt stress can negatively affect the photosynthetic electron transport and inhibit PSII activity due to accumulation of salts (Sudhir and Murthy, 2004) in addition, salinity reduces the net photosynthesis rate (Zhang et al., 2009). In fact, photosynthetic activity decreases with lower water potential of the leaves which can result in stomata.

3.3. Yield

Data in the table (5) indicate that there is a positive effect of NPK foliar spraying on fruit yield and its components such as number of flowers, number of fruits in tomato cv. GS12 plant. Data showed that there are clear differences among treatments under salinity levels.

| Treatments                          | No. of flowers | No. of fruits | Fruit yield (g/ plant) |
|-------------------------------------|----------------|---------------|------------------------|
| Control                             | 3.33           | 6.00          | 384.40                 |
| Control + NPK foliar spray          | 6.33           | 8.00          | 424.20                 |
| (2g NaCl + 2g CaCl₂ L⁻¹)            | 3.66           | 6.66          | 334.61                 |
| (2g NaCl + 2g CaCl₂ L⁻¹) + NPK      | 6.33           | 10.00         | 347.35                 |
| (4g NaCl + 4g CaCl₂ L⁻¹)            | 2.00           | 5.00          | 312.15                 |
| (4g NaCl + 4g CaCl₂ L⁻¹) + NPK      | 2.00           | 6.66          | 323.15                 |
| LSD 0.05 %                          | 1.33           | 2.01          | 14.85                  |

Foliar spraying of NPK on tomato plants led to increase numbers of flowers and fruits as well as fruit yield when compared with the other treatments without spray. Also, flowering characteristics were improved by NPK-fertilizer spraying under salinity levels.

Data revealed that the highest No. of flowers resulted from the control with NPK foliar spray and the first level of salinity with NPK foliar spray, respectively. On the other hand, the lowest No. of flowers resulted from the irrigated water salinity at second level with or without NPK foliar spray. Also, yield weight affected negatively by irrigated water salinity levels.

The highest No. of flowers and fruits resulted from the first level of irrigated water salinity with NPK foliar spray, but the lowest fruit number per plant recorded by the second level without foliar spraying NPK. Also, the highest fruit yield resulted from the control with NPK foliar spray. In economic analysis, the value of increasing the visible fruit quality was affected by decrease in yield as well as smaller fruit number and size.

Salinity stress during the flowering and fruiting stages caused a reduction in tomato yield, which was attributed to a reduction in the fruit produced number rather than the fruit size. In these regard, (Shalhevet and Yaron 1973) mentioned that the yield of tomatoes which grown in artificially salinized, was reduced by 10% for every 1.5 mmhos/ cm increase in ECe above 2.0 mmhos/ cm. Also, salinity enhances the taste of the tomato fruit that results from an increase in both sugars and acids, but it increases the incidence of blossom end rot on fruit (Cuartero and Muñoz, 1988).
3.4. Leaf nutrient concentrations

Leaf analysis appears to use little in tomatoes plant to assess the status of nutrients and determine fertilizer requirements. Leaf analysis is very helpful in confirming or rejecting a visual diagnosis of nutritional problems in tomatoes, providing consistent information on the nutrients concentration involved and distinguishing nutritional defects from those caused by pathogens, or by burning resulting from pesticides application as well as inappropriate cultural practices.

According to (Plank, 1989) the reducing of NPK in plant leaf may be to the soil has high sand and low organic matter content. Also, salts accumulate in the top layers of the soil and cause water stress induces to the closure of the stomata, which leads to a decrease in the photosynthesis rate (Lawlor and Cornic, 2002) and nutritional imbalances which lead to reduce metabolism and cell death (Hasanuzzaman et al., 2013).

Table 6: Effect of NPK foliar spraying on leaf nutrient concentrations (The forth leaf from plant top) under irrigated water salinity levels of tomato plants.

| Treatment | Macronutrients (mg/100g) | Micronutrients (ppm) |
|-----------|--------------------------|----------------------|
|           | N  | P  | K  | Ca | Mg | Na | Fe | Mn | Zn | Cu |
| Control   | 0.40 | 0.098 | 1.97 | 1.51 | 0.83 | 0.52 | 268 | 32 | 45.8 | 5.83 |
| Control + NPK foliar spray | 1.52 | 0.088 | 2.14 | 1.98 | 1.07 | 0.55 | 466 | 49 | 72.3 | 7.20 |
| (2g NaCl + 2g CaCl L⁻¹) | 0.93 | 0.095 | 1.21 | 1.98 | 1.03 | 0.55 | 353 | 48 | 77.8 | 7.83 |
| (2g NaCl + 2g CaCl L⁻¹) + NPK | 1.09 | 0.075 | 2.34 | 1.84 | 0.99 | 0.41 | 497 | 49 | 58.0 | 7.00 |
| (4g NaCl + 2g CaCl L⁻¹) | 0.91 | 0.093 | 1.15 | 1.91 | 0.98 | 0.68 | 259 | 49 | 68.2 | 8.94 |
| (4g NaCl + 2g CaCl L⁻¹) + NPK | 1.75 | 0.110 | 2.40 | 1.96 | 0.99 | 0.66 | 390 | 37 | 54.0 | 6.07 |
| LSD 0.05 % | 0.129 | 0.0082 | 0.215 | 0.129 | 0.057 | 0.122 | 58.39 | 5.09 | 6.9 | 1.53 |

* Stander

Table 6 showed that supplemental foliar spray NPK significantly improved nutrient concentrations with control and two water irrigated salinity levels. Also, the salinity treatments reduced nutrients concentration of P and K.

The foliar spraying of NPK led to increase the nitrogen concentration as compared with control treatment. The highest of nitrogen concentration resulted from control plus NPK foliar spray when compared with control treatment only.

The first level of irrigated water salinity (2g NaCl + 2g CaCl L⁻¹) increased and then decrease at the second level of irrigated water salinity (4g NaCl + 4g CaCl L⁻¹) iron, zinc, and copper concentrations were increased.

The results revealed that irrigated water salinity significantly increased leaf nutrients concentration of K, Ca, Mg and Na. Also, P and Fe at the first level irrigated water salinity. In addition to foliar spray of NPK significantly improved nutrient concentrations of N, K and Ca as well P at the second level of irrigated water salinity and Mg at control and the second level of irrigated water salinity. The foliar spraying of NPK might to elevate salinity stress of some element which had harmful effect such as Na. In this regard, (Cuartero and Muñoz, 1988) pointed out that due to salinity, Na⁺ concentration raises in roots and leaves of tomato plants. On the other hand, Ca²⁺ and K⁺ concentrations in root tomato plants were change little under salinity, but it are greatly reduced in leaves. Also, the plants taking up more Ca²⁺ and K⁺ from the salinized medium will have lower Na⁺/K⁺ and Na⁺/Ca²⁺ ratios and equilibrium of nutrients more similar to the non-salinized plants. Also, root NO⁻³ concentration is maintained for longer periods after salinization or under higher salinity levels than leaf NO⁻³ concentration

The result agreement with (Shabbir et al., 2015) who reported that supplemental foliar fertilization of NPK significantly improved the water relations, gas exchange characteristics and nutrient contents in the genotypes of wheat.

4. Conclusion

Since the salinity of the soil reduces the absorption of the most nutrients, especially NPK by tomato plants which led to significantly reduced most plant growth parameters.
Foliar spray compensates the plants for the lack of absorption of these nutrients especially potassium which is strongly affected when increasing sodium element concentration in soil. In addition, spraying NPK strengthens the root system and thus becomes more capable to absorb the nutrients from the soil. And when the nutrients become more concentrated in the tissues of tomato plants, thus also leads to improved growth and consequently the yield.

References

Albaladejo, I., V. Meco, F. Plasencia, F.B. Flores, M.C. Bolarin and I. Egea, 2017. Unravelling the strategies used by the wild tomato species Soranum pennellii to confront salt stress: From leaf anatomical adaptations to molecular responses. Environ. Exp. Bot., 135: 1-12.

Al-Daej, M.I., 2018. Salt Tolerance of Some Tomato (Sorannum Lycopersicon L.) Cultivars for Salinity under Controlled Conditions. American Journal of Plant Physiology, 13 (2): 58-64.

Ankerma, D. and L. Large, 1974. Soil and Plant Analysis. A&L Agricultural Laboratories. Inc., New York, USA. pp.: 82.

Azevedo Neto, A. and J.N. Tabosa, 2000. Salt stress in maize seedlings II. Distribution of cationic macronutrients and its relation with sodium. Revista Brasileira de Engenharia Agricola e Ambiental, v.4, n.2.p.165-171, 2000 Campina Grande, PB, DEAg/UFPB

Buresh, R.J., E.R. Sustin and E.T. Craswell, 1982. Analytical Methods in N-15 Research. Fert. Res., 3:37–62.

Chapman, H.D. and P.T. Pratt, 1978. Methods of analysis for soils, plants and water. University of California, Dept. Agric. Sci., USA, 320 p.

Chen, T.H.H. and N. Murata, 2002. Enhancement of tolerance of abiotic stress by metabolic engineering of betaines and other compatible solutes. Curr. Opin. Plant Biol., 5: 250-257.

Cruz V. and J. Cuartero, 1990. Effects of salinity at several developmental stages of six genotypes of tomato. In Proceedings of the Xth Eucarpia Meeting Tomato, 1991, 81-86.

Cuartero, J. and R.F. Muñoz 1988. Tomato and salinity. ScientiaHorticulturae,78, 1-4, 83-125.

Cuartero, J., M.C. Bolarin, M.J. Asins and V. Moreno, 2006. Increasing salt tolerance in the tomato. J. Exp. Bot., 57: 1045-1058.

Deinleins, U., A.B. Stephan, T. Horie, W. Luo, G. Xu and J.I. Schroeder, 2014. Plant salt-tolerance mechanisms. Trends Plant Sci., 19: 371-379.

Estañ M.T., M.M. Martinez-Rodriguez, F. Perez-Alfocea, T.J. Flowers and M.C. Bolarin, 2005. Grafting raises the salt tolerance of tomato through limiting the transport of sodium and chloride to the shoot. J. Exp. Bot. 56, 703-712.

Flowers, T.J., R. Munns and T.D. Colmer, 2014. Sodium chloride toxicity and the cellular basis of salt tolerance in halophytes. Ann. Bot., 115: 419-431.

Hasanuzzaman, M., K. Nahar and M. Fujita, 2013. Plant Response to Salt Stress and Role of Exogenous Protectants to Mitigate Salt-Induced Damages. In: Ecophysiology and Responses of Plants under Salt Stress, Ahmad, P., M.M. Azooz and M.N.V. Prasad (Eds.). Chapter 2, Springer, New York, USA, ISBN-13: 9781461447467, 25-87.

Hayat, S., Q. Hayat, M.N. Alyemeni, A.S. Wani, J. Pichtel and A. Ahmad, 2012. Role of proline under changing environments: A review. Plant Signal. Behav. 7: 1456-1466.

Jackson, M.L., 1973. Soil Chemical Analysis. Prentice-Hall of India Private Limited, New Delhi, India. pp: 82-86.

Kalaji, H.M., A. Jajoo, A. Oukarroum, M. Brestic and M. Zivcak, 2016. Chlorophyll a fluorescence as a tool to monitor physiological status of plants under abiotic stress conditions. Acta Physiol. Planta. Vol. 38, No. 4. 10.1007/s11738-016-2113-y.

Lawlor, D.W. and G. Cornic, 2002. Photosynthetic carbon assimilation and associated metabolism in relation to water deficits in higher plants. Plant Cell Environ. 25: 275-294.

Lindsay, W.L. and W.A. Norvell, 1978. Development of a DTPA micronutrient soil tests for Zinc, iron, manganese and copper. Soil Sci. Amer. J., 42: 421-428.

Loukhaich, R.M.E., N. Nadia Belhabib and A. Douira, 2011. Identifying multiple physiological responses associated with salinity-tolerance for evaluating three tomato cultivars selected from Moroccan territory. Journal of Animal & Plant Sciences, 10 (1): 1219- 1231.
Lu, C., N. Qiu, B. Wang and J. Zhang, 2003. Salinity treatment shows no effects on photosystem II photochemistry, but increases the resistance of photosystem II to heat stress in halophyte Suaeda salsa. J. Exp. Bot. 54: 851-860.

Lutts, S., J.M. Kinet and J. Bouharmont, 1996. NaCl-induced senescence in leaves of rice (Oryza sativa L.) cultivars differing in salinity resistance. Ann. Bot. 78: 389-398.

Mark, T. and D. Romola, 2003. Na⁺ tolerance and Na⁺ transport in higher plants. Annals of botany, 91: 503-527.

Martinez-Rodriguez, M.M., M.T. Estan, E. Moyano, J.O. Garcia-Abellan and F.B. Flores et al., 2008. The effectiveness of grafting to improve salt tolerance in tomato when an excluder genotype is used as scion. Environ. Exp. Bot., 63: 392-401.

Munns, R. and M. Gilliham, 2015. Salinity tolerance of crops—what is the cost? New Phytol. 208: 668-673.

Munns, R. and M. Tester, 2008. Mechanisms of salinity tolerance. Annu. Rev. Plant Biol., 59: 651-681.

Najla, S., G. Vercambre, L. Pagès, D. Grasselly, H. Gautier and M. Génard, 2008. Effect of Salinity on Tomato Plant Architecture. ISHS ActaHorticulturae 801: International Symposium on High Technology for Greenhouse System Management: Greensys 2007. 10.17660/ActaHortic.2008.801.144

Olsen, S.R., C.W. Cole, S.S. Watanable and L.A. Dean, 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. Washington: USDA Dept. Agric. Circular No. 939: 1-19.

Perez-Alfocea, F., A. Allbacete, M.E. Ghanem and I.C. Dodd, 2010. Hormonal regulation maintain crop productivity under salinity. A case study of root-to-shoot signaling in tomato. Funct. Plant. Bio.1.37 (7), 592-603 http://doi.org/10.1071/FF10012.

Pichu, R. 2006. World salinization with emphasis on Australia. Journal of Experimental Botany, 57(5):1017–1023.

Plank, C.O. 1989. Plant analysis handbook for Georgia. Athens (GA): University of Georgia Cooperative Extension Service. 64

Rodriguez, P., J. Dell'Amico, D. Morales and M.J. Sanchez Blanco, 1997. Effects of salinity on growth, shoot water relations and root hydraulic conductivity in tomato plants. The Journal of Agricultural Science DOI: https://doi.org/10.1017/S0021859697004309

Ruan, C.J., J.A.T. da Silva, S. Mopper, P. Qin and S. Lutts, 2010. Halophyte improvement for a salinized world. Crit. Rev. Plant Sci., 29: 329-359.

Sadak, M.S.H., M.T. Abdel Hamid and U. Schmidhalter, 2015. Effect of foliar application of amino acids on plant yield and some physiological parameters in bean plants irrigated with seawater. Actabiologica Colomiana, 20 (1): 141-152.

Seckin, B., A.H. Sekmen and I. Turkan, 2009. An enhancing effect of exogenous mannitol on the antioxidant enzyme activities in roots of wheat under salt stress. J. Plant Growth Regul., 28: 12-20.

Shabbir, R.N., M.Y. Ashraf, E.A. Waraich, R. Ahmad and M. Shahbaz, 2015. Combined effects of drought stress and NPK foliar spray on growth, physiological processes and nutrient uptake in wheat. Pak. J. Bot., 47(4): 1207-1216.

Shalhevet, J. and B. Yaron, 1973. Effect of soil and water salinity on tomato growth. Journal article of Plant and Soil, 39(2): 285-292

Shalhevet, D., Y.D. Beever, J.E. Eijik, M.J.T. van, R. Ma, H.R.A. Leelin, H.R. Gaskins, 1995. Genetic mapping of the LMP2 proteasome subunit gene to the BoLA class II region. Immunogenetic, Vol. 41. https://do. Org/10.1007/ BF00188432.

Snedecor, G.W. and W.G. Cochran, 1967. Statistical methods, Iowa State College Press. Iowa, USA, 91-119.

Song, J. and B. Wang, 2014. Using euhalophytes to understand salt tolerance and to develop saline agriculture: Suaeda salsa as a promising model. Ann. Bot., 115: 541-553.

Sudhir P. and S. Murthy, 2004. Effect of salt stress on basic processes of photosynthesis. Photosynthetica 42 (4): 4891-486.
Tavakkoli, E., P. Rengasamy and K.G. McDonald: 2010. High concentrations of Na+ and Cl− ions in soil solution have simultaneous detrimental effects on growth of faba bean under salinity stress. Journal of Experimental Botany 61 (15): 4449-4459.
Waller, R.A. and D.B. Duncan, 1969. A bays rule for the symmetric multiple comparisons problem, J. Amer. Stat Assoc., 64(328):1484-1503.
Yin, W., Z. Hu, J. Hu, Z. Zhu, X. Yu, B. Cui and G. Chen, 2017. Tomato (Solanum Lycopersicon) MADS-box transcription factor SlMBP8 regulates drought, salt tolerance and stress-related genes. Plant Growth Regul. 83: 55-68.
Zhang C., D. Jiang, F. Liu, T. Dai, Q. Jing and W. Cao 2009. Effects of salt and waterlogging stresses and their combination on leaf photosynthesis, chloroplast ATP synthesis, and antioxidant capacity in wheat. Plant Science 176 (4), 575-582.
Zhang, L., L. Song, H. Shao, C. Shao and M. Li, 2014. Spatio-temporal variation of rhizosphere soil microbial abundance and enzyme activities under different vegetation types in the coastal zone, Shandong, China. Plant Biosyst. Int. J. Dealing Aspects Plant Biol., 148: 403-409.