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Maximizing Tomato Yield and its Quality under Salinity Stress in a Newly Reclaimed Soil

Habashy, N.R., Zaki, R.N. and Awatef A. Mahmoud

Soils, Water and Environment Research Institute, Agriculture Research Center, Giza, Egypt.

Abstract: A field experiment was carried out on a newly reclaimed saline soil at Gelbana town Sahl El-Tina cultivated with tomato plants (*lycopersicon esculentum, L* var. 448), and irrigated with saline water derived from El-Salam canal (Nile water mixed with agriculture drainage water, with a ratio of 1:1) during the winter growing season of 2007, to study the potential benefit of some micronutrient forms (*i.e.*,mineral, citrate, EDTA, amino and humic acid) for alleviating the hazardous effect of salinity stress of soil and irrigation water on tomato yield and fruit quality. The micronutrients forms were applied as soil application and the studied parameters Vs. salinity stress were vitamin C, total sugar, proline and ion contents of the dry material with pigment content, chlorophyll a & b, besides residual effect of the available micronutrients status in soil. The obtained result reveal that tomato yield and its components showed, in general, a markedly response with a superior effect for micronutrients soil application. The chelating compounds of humic acid and amino acid recorded the superior increases in the studied tomato parameters, while an inferiority effect was observed with the control treat ment. Both forms of citrate and EDTA were lying in between. The superior effect of amino acids may be due to their more adhesion for chelating micronutrients. The positive effects of applied micronutrient forms, on tomato yield and fruit quality (*i.e.,* vitamin C, total sugar and micronutrient contents) salt stress may be due to decline in the K^+/Na^+ ratio and an increase in the contents of praline. Effects of micronutrients against salt stress on pigment content (Chl content and Chl a/b ratio) greatly affected by specific forms of applied micronutrients. However, humic and amino acids as micronutrients compounds surpassed other applied forms. As for the residual effect, data show a markedly increase in soil available micronutrient content in case of soil application. From aforementioned results, it can be concluded that, the application of micronutrients either in mineral or chelating forms as soil application increased tomato crop yield and its components as well as improved the nutritional status and fruit quality of tomato plants grown on a newly reclaimed soil under salt stress condition, with relatively higher ability for increasing available micronutrients under chelating form than mineral one.

Key word: Tomato, micronutrient forms, salt stress, Egypt

INTRODUCTION

During their growth and development, plants are exposed to a biotic (high and low temperature, salinity, drought, radiation, etc.) and biotic (pathogen, fungus, etc.) stress factors, which decrease their yield and the quality of their products. To date, 20 %, 26 % and 15 % of suitable agricultural areas worldwide are affected by mineral, drought and temperature stresses respectively[9,2,20]. In addition, there is a decay of 2 million ha of world agricultural lands to salinity each year[28,48]. Moreover, over 6 % of the world's total land area is affected by salinity and sodicity[40]. Plants are affected in several ways by increasing salt concentrations. It causes osmotic stress, specific ion toxicity and nutrient deficiencies, thereby affecting a range of physiological processes involved in cell metabolism[38]. Salinity stress is often accompanied by temperature stress. Changes in ambient temperature occur more rapidly than changes in other stress factors and temperature extremes aggravate the adverse effects of other stresses, including salinity, on crop production and quality[4]. It has been reported that environmental stresses lead to many social and economic problems in developing countries[2,45]. Salt stress affects all the major processes such as photosynthesis, protein synthesis, and energy and lipid metabolism[42]. Temperature and salt stresses directly or indirectly affect the photosynthetic functions by changing the structural organization and physico-chemical properties of thylakoid membranes[1,3,32]. The osmotic balance is essential for plants[5]. Plants have to maintain a high K^+

Corresponding Author: Habashy, N.R., Soils, Water and Environment Research Institute, Agriculture Research Center, Giza, Egypt.
E.mail: habashynader@yahoo.com

and a low Na^+ content in the cytosol[42] and a high K^+/Na^+ ratio is important for salt tolerance[22]. Breakdown of the osmotic balance results in loss of turgidity, cell dehydration and consequently cell death[23]. Compatible solutes that do not interfere with normal biochemical reactions are accumulated in the cytoplasm to regulate the ionic balance[26,11]. Glycine betaine and proline play a role in the adaptation to salinity stress, mediating osmotic adjustment and protecting the sub cellular structures in the stressed plants[5].

The essential roles of micronutrients in plant metabolism, as activators or co-factor in all vital processes of a plant, can not be ignored. This leads undoubtedly to an increase in crop production which is considered as the main goal in this respect[14]. Foliar application of Mn to plants as $MnSO_4$[46], $MnSO_4$ or Mn-EDTA[41] increased the yield. El-Naggar[15] stated that several plants can take up and absorb amino acids. He added also that the amino acids can bind with a metal to form a chelated metal. Therefore, the amino acids have used to chelate metal. Szajdak *et al.*,[49] stated that the application of amino acids for foliar use in based on its requirement by plants in general and at critical stage of growth in particular. They added that amino acids can be also supplied to the plants by incorporating them into the soil for improving the microflora and thereby facilitating the assimilation of nutrients. Habashy *et al.*,[25] showed that the chelating compounds of amino acids and citrate recorded the superior increases in plant yield, while an inferiority effect was observed with legnosulphonate. Both forms of EDTA and sulphates were lying in between. The superior effect of amino acids may be due to their more adhesion for chelating micronutrients, and enhancing their absorption and transportation inside the plant in easier status. Moreover, amino acids as micronutrient compounds are found in smaller molecules that are more suitable for cell membrane permeability.

This work aimed at evaluating the potential benefit of applied micronutrient forms for alleviating the hazardous effects of soil and irrigation water salinity as related to tomato yield and fruit quality.

MATERIALS AND METHODS

To achieve the aforementioned target, a field experiment was carried out on a saline soil at Gelbana town, Sahl El-Tina cultivated with tomato plants (*lycopersicon esculentum*, *L* var. 448) irrigated with saline irrigation water derived from El-Salam canal (Nile water mixed with agriculture drainage water, with a ratio of 1:1) during the growing winter season of 2007, to study the potential benefit of applied different forms of micronutrients (*i.e.*, mineral, citrate, EDTA, amino and humic acid) on tomato yield and some fruit quality against salinity stress of soil and irrigation water. The applied treatments of the studied micronutrients Fe, Mn and Zn include:

- Micronutrients as mineral sulphates, (*i.e.,* $FeSO_4$ (19.46% Fe), $MnSO_4$ (24.63% Mn) and $ZnSO_4$ (22.74 %Zn).
- Micronutrients as chelating compounds: a. Amino acids (1.56% Fe, 1.56%Mn and 0.2%Zn), b. EDTA (6.0% Fe, 6.0% Mn and 6.0% Zn) c. Citrate (4% Fe, 4.3% Mn and 4.6% Zn) and d. Humic acid (11.0% Fe, 12.0% Mn and 12.0% Zn).

Both mineral sulphates and chelating compounds were added as soil application, with special reference to the control treatment (an initial nutritional status). The mineral and chelating compounds were sprayed with 400 l/fed at a concentration of 500 mg/l and in a ratio of 3 Fe: 2 Mn: 1 Zn applied among two times, after 45 and 60 days from planting. The experiment was designed in fixed plots with an area of 10.5 m^3 (3x3.5 m) for tomato plants. In addition to the primary field preparation such as soil surface leveling by leaser technique, sub soiling and field drains were establishment at 10 m distance, irrigation was done according to soil leaching requirement calculated.

Urea was added for all treatments to overcome a total applied dose of 100 kg fed^{-1}. Potassium was added as potassium sulphate (48% K_2O) at rate of 48 kg K_2O fed^{-1}. Superphosphate was added at the equivalent to the titratable of 40 kg P_2O_5 fed^{-1}.

The first fruit ripened taken after 73 days of transplanting, and the followed ones were obtained every week. All fruit were picked, weighted to calculate the yield. At this stage the plant parts were determined as fresh and dry weights. The selected youngest fully expanded leaves were taken from each plot for determining nutrient contents (N, P, Fe, Mn and Zn) according to Van Schouwenberg[51]. Also tomato fruits were subjected to the different analysis to estimate (i.e., firmness using fruit pressure tester with a probe diameter of 0.8 cm and values expressed in pounds, total soluble solids using hand held Brix meter, vitamin C and total sugar) using the methods undertaken by Association of Official Analytical Chemistry[6]. Extracts and analysis of proline and ion contents of the dry material carried out using Weimberg's[53] method. The proline content was determined according to Bates *et al.*[7], and the ion contents ($K^+$and Na^+) were assayed using an atomic absorption spectrophotometer[53]. Pigment content as Chlorophyll a & b was determined according to Lichtenthaler[31]. Some soil properties at the initial state

were determined according to Piper[43] and Jackson[27], as shown in Table (1).According to the water salinity and sodicity classes undertaken by FAO[16], data in Table (2) indicated that the used irrigation water derived from El-Salam canal (Nile water mixed with agriculture drainage water) lies in the second category C2S1, where ECiw and SAR values lay within the range < 0.75 dS/m and <6.00, respectively.

At harvest stage, soil samples were taken from all the studied treatments at a depth of 5-10 cm for determining some soil characteristics, i.e., pH, macro and micronutrients. Soil pH was determined in 1:2.5 soil water suspensions according to the standard method described by Richards[44]. Total soluble salt were measured in soil paste extract described by Jackson[27]. Nitrogen was determined by the Kjeldahl method[6] Phosphorus was determined colorimetrically and potassium was determined using Flame-photometer, according to Jackson[27]. Available micronutrients were extracted by DTPA[47] and determined using Atomic Absorption Spectrophotometer.

Statistical Analysis: The experiment was performed using a randomized design. Differences among the treatments were tested using SPSS statistical software (Version 11; SPSS Inc., Chicago, IL). Statistical variance analysis of the data with three replicates was performed using ANOVA and compared with least significant differences (LSD) at the 5 % level[18].

RESULTS AND DISCUSSION

Effect of the Studied Mineral and Chelating Micronutrients at Soil Application on Plant Height, Dry Matter, Tomato Fruit Yield and its Quality Grown under Salinity Stress of Both Soil and Irrigation Water. Data in Table (3) showed that there was a positive increase in tomato plant height imposing micronutrient, however, plant height was significant increased as compared with the control, indicating a rapid response to the applied micronutrient forms by the plants. Under saline conditions, plant height with the control was the lower than the height with the micronutrients soil application. When plants heighs were measured at day 23 after transplanting, their increases as compared with the control plants were 33% for amino acids, 32% for humic acid, 23% for mineral as sulphate, 26% for EDTA and 25% for citrate under salinity condition. The shoot dry weight under salinity condition was significantly reduced by approximately 50% as compared with the plants treated with micronutrients as humic and amino acid. Similarly, fruit fresh yield was also significantly reduced by salinity condition, without added any micronutrients. While, addition of micronutrient forms was significantly increased dry weight and number of flowers per plant, and in turn increment number of fruits and yield per plant, which took a similar trend to the aforementioned treatments. In contrast, shoots dry weight was higher in case of applied amino and humic acids with in significant difference than both mineral and citrate treatments under salinity condition.

It is noteworthy to mention that impact of the applied treatments on total dry matter accumulations was more related to the leaf area index. This is can be interpreted on the fact that higher leaf area index contributed to more photosynthesis and better carbohydrates yield. These findings are in harmony with those obtained by Duncan[13] who obviously cleared the importance of canopy structure in light interception, crop growth and yield.

Effect of Applied Mineral and Chelated Micronutrients to Soil on Tomato Fruit Quality under Salt Stress Condition: Applying micronutrient forms under salt stress condition resulted in an increase in proline content reached 1.3-7.8–folds. Such increment depends on the applied formal of micronutrients and severity of salt stress (Table 4). Proline is thought to play a role as an osmoregulatory solute in plants subjected to hyperosmotic stress[12]. Also, proline is osmotically very active[3], contributes to membrane stability[21] due to its ability to scavenge and/or reduce the production of free radicals[17] and mitigates the disruptive effect of NaCl on cell membranes[35]. It has been claimed that changes in the activity of two enzymes playing a role in proline metabolism – ferredoxin glutamate synthase (synthesis) and proline dehydrogenase (breakdown) – contribute to proline accumulation[10]. Increased ferredoxin glutamate synthase activity may increase the size of the glutamate pool[8]. Delauney and Verma[12] have suggested that glutamate is a basic precursor of proline synthesis.

In addition, the proline contents showed approximately increases at of the micronutrients chelated by humic acid, EDTA, citrate, mineral forms reached 8.0, 4.0, 2.8 and 1.7 folds more than the control treatment, respectively.

The chlorophyll (Chl) content of the tomato leaves increased considerably as the micronutrient forms differed Table (4) with an extent of this increase was strongly chelating type-dependent. The Chl content ranged from 2.15 to 4.91 mg g^{-1} fresh weight (Chl a/b ratio of 1.53 and3.00) for mineral and micronutrients chelated with humic acid, respectively. Also, the relatively decrease in the Chl content associated with those chelated with citrate may due to greatly decrease in the Chl a/b ratio. Looking at the response of the plants to salt level almost every combination of Chl content and Chl a/b ratio can be observed. Parida and Das[42] suggested that the decrease in Chl and

Table 1: Some physical and chemical properties of the experimental soil.

Soil characteristics	Value	Soil characteristics	Value
Particle size distribution%:		Soluble cations (soil paste mmol c L^{-1}):	
Sand	71.5	Ca^{2+}	8.60
Silt	13.8	Mg^{2+}	12.40
Clay	14.7	Na^{+}	44.00
Textural class	Loamy Sand	K^{+}	1.40
Soil chemical properties:		Soluble anions (soil paste,mmol c L^{-1}):	
pH (1.25 soil water suspention)	8.45	CO_3^{2-}	0.00
$CaCO_3$ %	7.9	HCO_3^{-}	4.20
Organic matter %	0.48	Cl^{-}	33.0
ECe (dS/m, soil paste extract)	6.67	SO_4^{2-}	29.2

Available macro & micronutrients (mg/Kg)

N	P	K	Fe	Mn	Zn	Cu
29.35	3.91	176.42	3.83	0.86	0.58	0.49

Table 2: Chemical characteristics of the used irrigation source El-Salam canal (Nile water mixed with agriculture drainage water, with a ratio of 1:1).

Water characteristics	Value	Water characteristics	Value
Soluble cations (mole$_c$ L^{-1}:		*Soluble anions (meq/l:)*	
Ca^{2+}	4.88	CO_3^{2-}	0.00
Mg^{2+}	3.35	HCO_3^{-}	5.25
Na^{+}	13.76	Cl^{-}	12.91
K^{+}	0.54	SO_4^{2-}	4.37
pH	7.23	Sodium absorption ratio (SAR)	6.89
ECiw (dS/m)	2.25	Residual sodium carbonate (RSC)	0.00
Total dissolving salt (mg/l)	864.8	Irrigation water suitability degree	C2S2

Heavy metal contents (mg/L)

	Cd	Pb	B	Fe	Mn	Zn	Cu
Irrigation water	0.032	0.31	0.02	0.42	0.24	0.024	0.053
Critical Level*	0.010	5.00	0.75	5.00	0.011	2.00	0.200

* According to FAO[16].

carotenoid contents of leaves in response to salt stress is a general phenomenon. On the other hand, Wang and Nil[52] showed an increase in pigment content in *Amaranthus* sp.In this respect, the obtained data showed variations in pigment content depending on salt stress (Table 4). In quite a few cases, the chlorophyll content was paralleled by changes in the Chl a/b ratio. The Chl a/b ratio is an indicator of the antenna size of PS I and PS II. The core antenna contains only Chl a, whereas the outer antenna contains both Chl a and Chl b. A higher Chl a/b ratio indicates, therefore, a smaller antenna size and a lower ratio a larger antenna size.

The highest nutritional substances in tomato fruit, *i.e* total sugar and vitamin C, were obtained at all the treatments of micronutrients forms (Table 4). The increase of these characters indicated that the nutritional value of the progeny fruit of the micronutrients forms (mineral and chelated) treated plants were more nutrition's than untreated one. It is noticed that the vitamin C amount increased from

Table 3: Tomato parameters at vegetative growth, flowering and fresh fruit weights of tomato at soil applied with different micronutrient forms under salt stress condition.

Plant height	Shoots dry weight	Leaf area index	No. of flower /plant	
Control	35.5	4.32	1.50	25.6
Mineral	43.7	5.12	2.54	33.5
Citrate	44.7	5.30	3.42	45.6
EDTA	44.4	5.90	3.75	50.6
Amino acids	47.2	6.82	4.00	37.9
Humic acid	47.3	6.72	4.12	38.3
LSD at $_{0.05}$	0.6	0.9	0.20	1.25
Micronutrient form	No. of fruit /plant	Mean fruit weight (g)	Fruit yield (kg/plant)	Fruit yield (ton fed^{-1})
Control	33.7	44.2	1.98	13.3
Mineral	44.8	54.7	2.70	18.1
Citrate	46.9	55.1	2.85	19.3
EDTA	48.3	55.8	2.90	20.6
Amino acids	50.4	56.0	3.00	27.1
Humic acid	54.9	56.7	3.23	26.4
LSD at $_{0.05}$	4.0	0.9	0.31	1.5

Table 4: Some fruit quality parameters of tomato at soil applied with different micronutrients forms under salt stress condition.

Micronutrients form	Tomato quality						
	TSS*	Firmness	Total sugar %	Vitamin C**	Proline***	Total Chl #	Chl a/b ratio
Control	2.58	5.32	1.10	17.3	0.24	0.80	1.23
Mineral	3.50	6.00	1.31	18.2	0.41	2.15	1.53
Citrate	3.75	6.85	1.52	18.5	0.67	2.52	2.07
EDTA	3.89	7.71	1.75	19.0	0.96	2.60	2.28
Amino acids	4.00	8.66	2.11	21.7	1.68	4.91	3.00
Humic acid	4.22	8.98	1.90	21.0	1.90	3.82	3.59
LSD at $_{0.05}$	0.31	0.44	0.28	0.9	0.52	0.35	

* Total soluble solids.**mg 100g^{-1} fresh fruit, ***µmol g^{-1} dry weight, # pigment content (chlorophyll) mg g^{-1} fresh weight

17.3 mg 100g^{-1} fresh fruit (control treatment) to 21.7 mg 100g^{-1} fresh fruit for micronutrients chelated with amino acid without any significant effect difference with humic acid as soil application. The relative increases percentages were 6.1, 6.9, 9.8, 25.4 and 21.4% for mineral sulphate, citrate, EDTA, amino acid and humic acid, respectively. That means the relative increase in fruit vitamin C content no exceed 26% in the best condition. This finding is in agreement with the result obtained by Habashy[24]. On the contrary, total sugar in tomato fruit exhibited a more increase reached 91.8 and 19.1%at the superior cases of amino acid and as chelating form and plants received an equivalent amount of mineral sulphate as compared to the control treatment, respectively. Thus, the addition of micronutrients with amino acid as chelating form plays a vital role for maximizing the nutritional substances in tomato fruit.

Effect of Mineral and Chelating Micronutrients on Some the Contents of Macro and Micronutrients in Tomato Plants Grown under Salt Stress Condition: Result in Table (5) indicated that N, P and K contents in tomato leaf tissues as affected by mineral and chelating compounds applied as soil application showed pronounced increases followed an order of those chelated with humic acids>amino acids EDTA>citrate> mineral sulphate>the control treatment. Data showed also, that the highest increments of Fe, Mn, and Zn contents by tomato were occurred when the plants were treated with micronutrients chelated with humic acids and amino acids as soil application.

Table 5: Tomato leaf nutrient contents as affected by the soil application of micronutrients at different forms under salt stress condition.

Micronutrients form	Macronutrients (%)						
	N	P	K	Na	Ca	Mg	K^+/Na^+
Control	0.81	0.28	0.58	2.25	99	85	0.26
Mineral	1.97	0.30	1.77	4.87	110	88	0.37
Citrate	2.57	0.36	1.89	4.39	155	98	0.43
EDTA	2.61	0.40	1.95	3.55	176	110	0.55
Amino acids	2.82	0.42	2.01	3.09	194	129	0.65
Humic acid	3.01	0.50	2.33	3.33	215	133	0.70
LSD at $_{0.05}$	0.20	0.09	0.35	0.37	23.0	6.0	

	Micronutrients (mg kg^{-1})		
	Fe	Mn	Zn
Control	56.5	68.4	29.1
Mineral	75.9	70.5	33.7
Citrate	88.9	81.7	37.2
EDTA	90.2	85.4	40.5
Amino acids	98.9	95.7	45.9
Humic acid	99.5	100.5	49.5
LSD at $_{0.05}$	1.9	6.9	5.1

Table 6: Effect of mineral and chealating compounds of micronutrients on their availability in soil under salt stress condition

Micronutrient forms	Soil availability (mg/kg soil)		
	Fe	Mn	Zn
Control	1.99	1.04	0.49
Mineral	2.74	1.55	0.72
Citrate	2.95	1.66	0.75
EDTA	2.85	1.72	0.78
Amino acids	3.17	1.80	0.81
Humic acid	3.06	1.85	0.85
LSD at $_{0.05}$	1.20	0.07	0.05

	Critical levels of micronutreants in mg kg^{-1} *		
Critical limits	Fe	Mn	Zn
Low	< 4.0	< 2.0	< 0.5
Medium	4.0-6.0	2.0-5.0	0.5-1.0
High	> 6.0	> 5.0	> 1.0

* Critical levels of micronutrients after Lindsay and Norvell[33].

The corresponding increases in the case of humic acid treatment for the aforementioned three micronutrients reached 99.5, 100.5 and 49.5 mg kg^{-1} over the control treatment, respectively. The relative lesser increases of micronutrients were associated with mineral sulphates treatment, which reached 75.9, 70.5 and 33.7 mg kg^{-1} over the control treatment, respectively.

A similar tendency in the concentrations of Na, K, Ca, and Mg was noticed for leaves. Applied micronutrients as amino and humic acid caused a significant decrease in the Na concentration in the tomato leaves regardless of the foliar fertilization treatments. Salinity increased or did not change the concentration of nutrients (Ca and Mg)

in leaf tissues, whereas the application of foliar fertilization did not influence these tendencies. In contrast, addition of micronutrients forms reduced or did not significantly change the concentration of K, Ca and Mg tomato leaves.

Condition of salt stress significantly affected the K^+/Na^+ ratio (Table 5), however, as the salt stress became more severe the Na^+ content increased significantly and therefore the K^+/Na^+ ratio decreased. As the most micronutrients chelating form under salt stress conditions, the K^+/Na^+ ratio a below 1 in the humic acid and amino acid. Low salt concentrations may stimulate plant growth and development and some studies support this idea[50,36,29]. A decrease in the proline content was observed for some applied of micronutrients and then salt stress caused an increase in leaf thickness.

Salt stress condition affects plants in three different ways: it reduces the water potential, it may cause ion imbalance and it may disturb ion homeostasis[42]. Factors affecting the uptake and distribution of Na^+ within the plants can have a predominant role in the response to salt stress[39,54]. Significant entry of Na^+ resulted in a severe growth reduction or death of sensitive or glycophytic species[34] such as soya bean[50] and barley[19]. In this study, the Na^+ content was significantly increased about 2-3 folds higher than in the control plants. This increase caused greatly decline in the K^+/Na^+ ratio. As the plant, Na^+ and K^+ are competing ions. K^+ plays an important role in all kinds of cellular processes, so that metabolic processes that depend on the presence of K^+ become inhibited. The capacity of plants to maintain a high cytosolic K^+/Na^+ ratio is likely to be one of the key determinants of the ability of plants to tolerate salt stress. In plants, a K^+/Na^+ ratio of around 1 is thought to represent a minimum value below which K^+ deficiency sets in[34].

Residual Effect of Soil Applied Mineral and Chelating Micronutrients on Available Micronutrients under Salt Stress Condition: The magnitudes of available micronutrients in the studied soil under salt stress condition as affected by the applied treatments are shown in Table (6). The obtained data show that the studied Fe, Mn and Zn lay within the low-medium range according to the critical levels of micronutrients undertaken by Lindsay and Norvell[33] for tomato at all applied treatments. In general, this is true since these soils are not only poor in the nutrients bearing minerals, but also in organic and inorganic colloids, which are considered a storehouse for the essential plant nutrients.

On the other hand, the results obtained from the treated plants showed a progressive increase in the available micronutrients content, with a significantly effect between each of the micronutrients forms, with the high significant effect was associated with those chelated with both humic acid and amino acid as compared to the other tested treatments.

Conclusion: Salinity stress significantly decreased leaf growth in terms of length and weight, confirming findings from earlier studies that leaf growth in the seedling stage is highly sensitive to this stress. Reduced plant growth caused by and salinity may be attributed to a disturbance in the nutrients, resulting in the decreased uptake of K, Ca, Mg, P and N. Aside from lowering nutrient availability in soil, a reduced plant nutrients uptake may also be attributed to a decreased transpiration rate to transport nutrients from roots to shoots. Sodium toxicity is one of the major factors limiting plant growth. Furthermore, the higher accumulation of macronutrients in the leaves of salinized tomato plants might be because of the physiological mechanisms involved osmoregulation. This may be due to osmoregulation under saline conditions can use ions from the soil. According to the two-phase model proposed by Munns[37], plant growth is inhibited under salinity during the first phase, which was associated water deficit although there was a reduction in tomato growth in shoot and leaf fresh and dry weights, as well as fruit quality under salinity stress. Yet an increase or no change in the nutrient concentrations in leaves was occurred.

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