Response of Tomato Plant to Compost Application and Inoculation with Mycorrhizal Fungi Under Salt Stress Conditions

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ABSTRACT : Pot experiments using calcareous soil, were carried out to study the influence of irrigation with diluted seawater on tomato (Strain B) plants growth as affected by compost application and mycorrhhiza inoculation during summer 2011 season. Four different irrigation water salinity levels (0.44, 2.70, 6.20, 12.50 dS/m), three different mycorrhizal treatments (control, *Glomus macrocarpium, Glomus intraradices*) and three compost rates (0, 20, 40 g/kg soil) were used. Dry matter production in shoots of tomato plants was significantly decreased by increasing water salinity. Tomato plants were, adversely, affected only by high water salinity levels (6.20, 12.50 dS/m). However, a substantial increase in shoot dry weight of tomato plant of salt stressed tomato was observed with the compost application and arbuscular mycorrhiza fungi (AMF) inoculation. The N and P contents in shoot tomato plants were significantly increased as salinity increased from 0.44 to 6.20 dS/m. Sodium ion content was significantly increased with increasing the salinity of irrigation water from 0.44 to 12.5 dS/m. On another hand, K content decreased with increasing water salinity. Sodium reduced the contents and uptake of potassium due to ion antagonism. The enhancement in Mn, Zn, Cu, and Fe acquisition or increasing of shoot, dry wehight due to AMF inoculation was more pronounced with *Glomus macrocarpium* than *Glomus intraradiaces* under saline conditions. This is further confirmation that compost application and mycorrhizal inoculation are beneficial for tomato plant grown under adverse conditions such as salinity stress.

Key words: Mycorrhiza fungi , compost, salinity water, irrigation water, calcareous soil

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is considered a major vegetable crop in many parts of the world and mostly grown under irrigation, both in protected and open field conditions (Al-Karaki, 2006). Tomato is a moderately sensitive to salinity. It is necessary to conduct the extensive research on growth conditions under moderate salinity to produce vegetative growth.

Nevertheless, salinization of soil is a serious problem and is increasing steadily in many parts of the world, particularly in arid and semi-arid areas. At present, out of 1.5 billion hectares (ha) of cultivated land around the world, about 77 million ha (5%) is affected by excess salt content (Sheng *et al*., 2008). Salt accumulates in soil predominantly as a result of strong winds, high temperatures that cause rates of evaporation to exceed precipitation near coastal areas, utilization of salt-rich industrial wastewater for irrigation, over-pumping of groundwater, excessive use of chemical fertilizers and intensive crop production (Singh *et al.*, 2011).

The effect of salinity on plant growth has been salt studies in different tomato cultivars. Salinity adversely affected the vegetative growth of tomato (Adler and Wilcor, 1987). It had also been reported that high salinity reduces the fresh and dry weights of shoots and roots of tomato plants (Omar *et al.,* 1982). Incorporating or applying factors that enable plants to better withstand salt stress could help improve crop production under saline conditions.

Arbuscular mycorhizal fungi (AMF) widely occur in saline soils (Aliasgharzadeh *et al.,* 2001). Salinity negatively affects the formation and function of mycorrhiazl symbiosis (Juniper and Bott, 1993). The root colonization by AMF involves a series of morphphysiological and biochemical events that are regulated as well as by environmental factors. The improving salt tolerance of arbuscular-mycorhizall-inoculated plants, are still unclear, although, the improved nutrition uptake may be one of the reasons (Poss *et al.,* 1985). In recent years, some studies have indicated that AMF can enhance the plant growth and uptake of nutrients, decrease yield losses of tomato under saline conditions and improved salt tolerance of tomato (Abdel Latef and Chaoxing, 2011). The use of organic composts in agricultural areas is increasing because these improve soil health and nutrient status (Pandey and Shukla, 2006). Varindepal *et al*., (2006) reported that, incorporation of organic compost decreased P adsorption, maximum buffering capacity, bonding energy, and increased P concentration in solution. Herencia *et al.* (2007) demonstrated that long-term use of organic compost in greenhouse soil improved soil fertility, the use of organic fertilizer resulted in higher soil organic matter, soil N content, and available P and K. Kavvadias *et al*. (2011) reported that organic matter application to soil can resulted in some beneficial soil chemical and physical characteristics, such as increases in organic matter, organic carbon, major nutrients (e.g N, K), water-holding capacity and porosity. Hence, this study was conducted to determine if inoculation of seedling with endo mycorrhiza (VAM) fungi and amendement with compost alleviates soil salinity stress on growth and mineral acquisition of tomato cultivar.

MATERIALS AND METHODS

Surface calcareous soil sample (0-15 cm) was taken from El-Zohoor village (Banger El-Sokhar) which is a new reclaimed soil. The sample was air-dried, ground to pass through 2mm sieve and thoroughly mixed before using. The characteristics of this soil are presented in Table1. The methods used for soil analysis were those described by Page *et al*. (1982)**.**

The used compost sample is representative of the compost produced in Egypt, and it was analyzed according to method outlined by Page *et al*. (1982). The chemical and physical properties of the compost are presented in Table 2.

Four different saline irrigation water (0.44, 2.7, 6.2 and 12.5 dS/m) were prepared by dilution of the sea water using distilled water. The chemical properties of the used saline irrigation water are presented in Table 3. Tap water was used as the control (0.44 dS/m).

Two arbuscular-mycorrhizal (AM) species belonging to the genus *Glomus* were used in this study. These species were *Glomus macrocarpium* and *Glomus intraradiaces*. The first species was obtained from Department of Plant Nutrition at Göttingen-University Germany and the second one was supplied from Department of Plant Pathology at Hanover University in Germany. The spores of mycorrhizae *Glomus spp* (mixed) was isolated from the soil by wet sieving and decanting method as described by Gerdemann and Nicolson (1963).

Table (1). Some initial soil physical and chemical characteristics of the experimental soil

Soil properties	Value
Partical-size distribution	
Sand %	51.62
Silt %	25.50
Clay %	22.88
Texture class	Sandy
pH (1:1 Soil:Water)	Loam
EC (1:1 Soil:Water), dS/m	8.10
Total $CaCO_3$ %	1.66
Water soluble cations, meq/L	32.0
Ca^{2+}	
Mg^{2+}	7.20
Na^{+}	0.20
K^{+}	9.90
Water soluble anions, meq/L	0.42
$CO_3^{=}$	
HCO_3^{-}	n.d.
Cl^{-}	6.30
$SO_4^{=}$	3.80
	8.02

n.d.= not detected

Table (2). Chemical analysis of the compost sample

Characters	Value
pH (1:2)	7.02
EC (1:2), dS/m	4.10
O.M, %	52.80
Total P, %	0.44
Total N, %	0.92
Water soluble cations, meq/L	
Ca^{2+}	18.20
Mg^{2+}	9.80
Na^{+}	6.50
K^{+}	2.30
Water soluble anions, meq/L	
HCO_3^{-}	10.20
Cl^{-}	13.00
$SO_4^{=}$	13.60

A pot experiments were carried out at the green house of the Faculty of Agriculture (Saba bacha), Alexandria University, Egypt during 2011 growing season using plastic pots. The pots were 30 cm deep and 13cm in diameter with holes in their bottom, The pots were filled with 1 kg of air- dried soil leaving the upper 5 cm without soil. Seeds of tomato (Strain B) were planted in each pot. This experiment was designed as split – split plot with three replicates. The main plots were for irrigation water salinity types (0.44, 2.7, 6.2 and 12.5 dS/m), the sub plots for compost rates (0, 20 and 40 g/kg soil) and the sub sub plots for mycorrhiza inoculation (without, *Glomus intraradiaces* (GC) and *Glomus macrocarpium* (GM)). About fifty grams of inoculum *Glomus intraradiaces* and 100 ml of an inoculum suspension (involving spores and colonized root segments) for the other species *Glomus macrocarpium*, were placed 2 cm below the seeds.

Table (3). The chemical characteristic of saline irrigation water

Paremeter	**Water Salinity, (dS/m)**		
	2.7	**6.2**	**12.5**
pH	8.08	8.18	8.89
<u>Water soluble cations, meq/L</u>			
Ca^{2+}	1.32	2.86	4.60
Mg^{2+}	2.3	4.60	8.10
Na^{+}	23.0	52.8	106.5
K^{+}	0.83	1.91	3.85
<u>Water soluble anions, meq/L</u>			
HCO_3^{-}	11.7	20.8	34.40
Cl^{-}	11.88	38.3	46.10
$SO_4^{=}$	4.50	6.90	45.10

Four seeds of Tomato were planted into each pot and after two weeks from emergence the plants were thinned to two plants. The experiment was carried out in a sunlight green-house with natural light, a day/night temperature 30 ºC /22 ºC , and a relative humidity 50-70%. The soil of each pot was fertilized with 200 mg N kg^{-1} soil in the form of $(NH_2)_2CO$ (46% N), 410 mg/ kg^{-1} soil in the form of K_2SO_4 (48% K_2O) and 200 mg P_2O_5 kg^{-1} soil (15.5% P_2O_5) in the form of Ca $(H_2PO_4)_2$. All pots were irrigated every day to keep the soil at 70% of its field capacity by regular weighing of pots. After 7 weeks of growth, shoot of plants were taken from each pot and washed with running tap water, and then with distilled water. The samples were air dried for few hours and then oven dried at 70 ºC for 48 hours, grounded after recording the dry weight of the plant parts (shoot). After dryness, the plant samples were milled well and kept in plastic container for chemical analysis. Samples of the dried plant material (0.5 g) were wet-digested with H_2SO_4 - H_2O_2 digest (Lowther, 1980) and the P, K, Na, Cu, Zn, Mn and Fe were determined in the digested solution, according to Jackson (1973). Phosphorus was measured in the digested solution using vanado-molydate color reaction according to the method described by Jackson (1973). Potassium and sodium were measured in the digested suspension using flamephotometer. The micronutrients were determined by atomic absorption spectrophotometer. Also, nitrogen content was determined by micro-Kjeldahl method according to Bermner and Mulvaney, (1982). All data were subjected to analysis of variance or regression analysis according to Snedecor and Cochran (1972) and L.S.D test at 0.05 level of probability was used to compare between means.

RESULTS AND DISCUSION

The obtained results in (Table 4). revealed that the average shoot dry weight of tomato plant due to compost and AMF inoculation was significantly decreased gradually by increasing salinity of irrigation water. The significance of soil salinity on agricultural yield is enormous as stated by Tester and Davenport (2003). The salinity generally affects the establishment growth and development of plants leading to losses in productivity (Mathur *et al.*, 2007). This effect was pronounced in plants grown under higher salinity levels of irrigation water (6.2 and 12.5 dS/m) as compared with the control.

Table (4). Mean effects of irrigation water salinity, compost rate and mycorrhiza incoluation on shoot dry weight of tomato plant

Treatments	Dry weight, (g/pot)
Salinity levels, dS/m	
0.44	5.01
2.70	4.60
6.20	4.41
12.50	4.13
$LSD_{0.05}$	0.037
Compost rate, g/kg soil	
0	4.31
20	4.57
40	4.74
LSD0.05	0.022
Mycorrhiza inoculation	
Without	3.77
GC	4.86
GM	4.98
$LSD_{0.05}$	0.033

The direct effects of salts on plant growth may involve: (*a*) reduction in the osmotic potential of the soil solution that reduces the amount of water available to the plant causing physiological drought (Feng *et al.*, 2002; Jahromi *et al.*, 2008); (*b*) toxicity of excessive Na and Cl ions towards the cell (Feng *et al.*, 2002); and (*c*) nutrient imbalance in the plant caused by nutrient uptake and/or transport to the shoot leading to ion deficiencies (Adiku *et al.* 2001). Gunies *et al*.(1996) reported that under saline conditions, the plants failed to maintain the required balance of organic and inorganic constituents leading to suppress the plant growth. This result is in line with those obtained by Ahmed *et al*., (2001) on *Ambrosia maritime*, Arshi *et al.* (2002) on senna plants, Shalan *et al*. (2006) on *Majarana hortensis*, L. and Abdel-Mawgoud *et al*. (2010) on green bean plants.

To deal with irrigation by saline water and minimize crop loss, scientists have searched for incorporating or applying factors that enable plants to better withstand salt stress such as compost application and or AMF inoculation which could help to improve crop production under saline conditions.

Data concerning the effect of compost application rates showed that, the highest significant values of shoot dry weight of tomato plant produce from 40 g compost /kg soil. The shoot dry weight of tomato plants gradually increased by increasing compost rate (Table 5). It has been demonstrated that the application of compost to soil improves some physical properties such as porosity, water-holding capacity and bulk density. It also promotes buffering capacity of the soil and increases the percentage of organic matter and cation exchange capacity (Soheil *et al.*, 2012). Likewise, the organic composts improve soil health and nutrient status (Pandey and Shukla, 2006). Varindepal *et al*., (2006) reported that, incorporation of organic compost decreased P adsorption, maximum buffering capacity, bonding energy, and increased P concentration in solution. Kavvadias *et al*. (2011) reported that organic matter application to soil can lead to some beneficial soil chemical and physical characteristics, such as increases in organic matter, organic carbon, major nutrients (e.g N, K), water-holding capacity and porosity. The obtained results are in line of those obtained by Vendrame *et al*.(2005) on some ornamental plant and Atif *et al*.(2008) on *zinnia elegans.*

Table (5). The interaction effect between irrigation water salinity (S) and compost rate (C) on shoot dry weight of tomato plants

Irrigation water salinity, dS/m	Compost rate (g/kg soil)	Dry weight (g/pot)
0.44	0	4.579
	20	5.089
	40	5.361
2.7	0	4.167
	20	4.707
	40	4.928
6.2	0	4.433
	20	4.348
	40	4.440
12.5	0	4.045
	20	4.119
	40	4.238
$LSD_{0.05}$		0.092

The application of organic matter to saline soils or soil irrigated with saline waters can have different effects such as speeding up of NaCl leaching, decrease of the exchangeable sodium percentage and electrical conductivity and increase of water infiltration (El- Shakweer, *et al*., 1998). The beneficial effect of OM have been attributed to release root exudates such as organic acids which regulate soil pH and decrease the harmful effect of increasing salt concentration of soil and to improve soil physical properties and nutrient availability (Deluca and Deluca 1987).

The second approach is the inoculation with arbuscular mycorrhizal fungi. The results in Table 6 indicated that, the inoculation of AM fungi caused in significant increase in shoot dry weight per pot when compared to the uninoculated plants at all levels of irrigation water salinity and and compost rates.The *Glomus macrocarpium* was more effective than *Glomus intraradiaces*. Mycorrhizal colonization is common in tomato plants and well documented a mycotrophic plant (Kubota *et al*., 2005). Many studies were conducted to assess the response of tomato seedlings with the inoculation of AMF. The inoculated seedlings showed better performance due to its higher shoot fresh weight (Oseni *et al*., 2010). Arbuscular mycorrhizal fungi promote salinity tolerance by employing various mechanisms, such as enhancing nutrient acquisition (Al-Karaki and Al-Raddad, 1997), producing plant growth hormones, improving rhizospheric and soil conditions (Lindermann, 1994), altering the physiological and biochemical properties of the host (Smith and Read, 1995) and defending roots against soil-borne pathogens (Dehne, 1982). In addition, AMF can improve host physiological processes like water absorption capacity of plants by increasing root hydraulic conductivity and favourably adjusting the osmotic balance and composition of carbohydrates (Ruiz -Lozano, 2003).

With regard to the interaction between salinity of irrigation water and compost rate, data presented in Table (5) revealed that compost rates under salinity stress significantly increased shoot dry weight of tomato plant compared to that without compost. The interaction between irrigation water salinity and mycorrhizal inoculation (SxM) had a significant effect on shoot dry weight, (Table 6). The highest value of shoot dry weight was obtained through 0.44 dS/m irrigation water with GM inoculation, while the lowest value was obtained with 12.5 dS/m irrigation water salinity without AMF inoculation. The interaction between compost rate and mycorrhizal inoculation (CxM) had highly significant effect on dry weight (Table 7).The highest value of shoot dry weight was obtained due to applying 40 g compost per kg soil with *Glomus macrocarpiu.*

The second-order interaction between irrigation water salinity, compost rate and mycorrhizal inoculation (S x C x M) had significant effect on shoot dry weight (Fig 1). The highest value of dry weight was obtained from 0.44 dS/m irrigation water salinity, 40 g compost/kg soil and *Glomus macrocarpium.*

The dry weight of tomato shoot (Y) without mycorrhizal inoculation was regressed against the irrigation water salinity (X_1), and compost rate (X_2). The regression equation for the relationship was:

$$Y = 3.961 - 0.071 X_1 + 0.010 X_2$$
$$R^2 = 0.868^{**} \qquad P < 0.01$$

The comparison of the slopes of each variable in the equation (0.071: 0.01) gives a quantitative estimate for the efficiency of one variable to the other. Thus the efficiency of salinity irrigation water and compost rate would be equal to (1: 0.141). The dry weight of tomato shoot (Y) With *Glomus macrocarpium* inoculation was also regressed with the two variables. The regression equation for the relationship was:

Table (6).The interaction effect between irrigation water salinity (S) and Mycorrhiza inculation (M) on shoot dry weight of tomato plants

Irrigation water salinity, dS/m	Mycorrhiza oculation	Dry weight (g/pot)
0.44	Without	4.233
	GC	5.325
	GM	5.470
2.7	Without	3.827
	GC	4.963
	GM	5.011
6.2	Without	3.435
	GC	4.617
	GM	4.836
12.5	Without	3.265
	GC	4.531
	GM	4.606
$LSD_{0.05}$		0.133

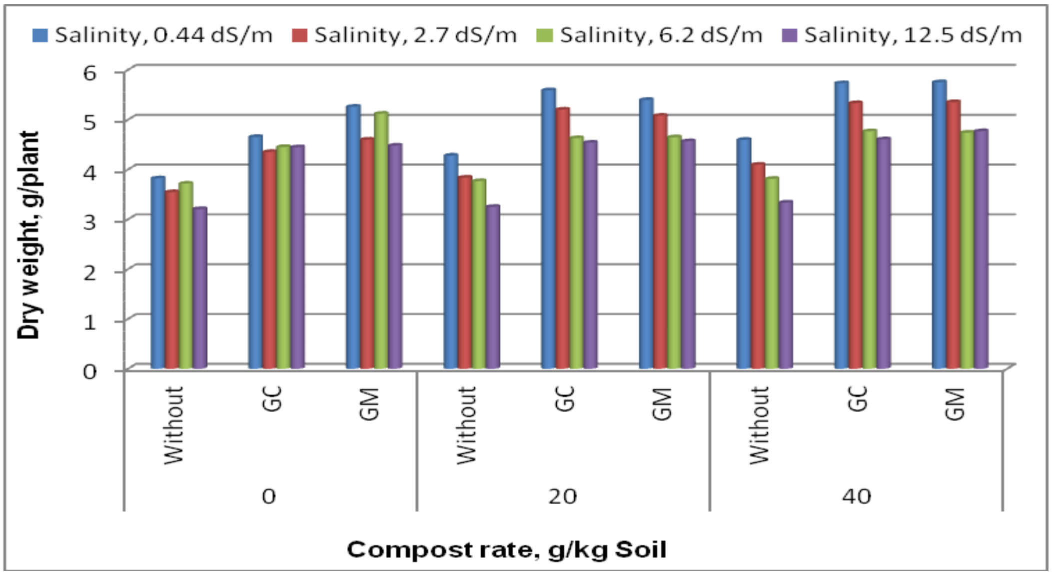

Fig (1): The effect of irrigation water salinity, compost rate and mycorrhizal inoculation on dry weight of shoot tomato plant

Table (7). The interaction effect between compost rate (C) and Mycorrhiza inculation (M) on shoot dry weight of tomato plants

Compost rates,g/kg soil	Mycorrhiza inoculation	Dry weight (g/pot)
0	Without	3.574
	GC	4,477
	GM	4.865
20	Without	3.780
	GC	4.991
	GM	4.923
40	Without	3.961
	GC	5.110
	GM	5.154
$LSD_{0.05}$		0.110

the dry weight of tomato shoot (Y) with *Glomus intraradiaces* inoculation was regressed with salinity irrigation water (X_l) and compost rates (X_2) and the regression equation for the relationship was:

$$\mathbf{Y = 4.868 - 0.061\,X_1 + 0.016\,X_2}$$
$$\mathbf{R^2 = 0.709 \qquad P < 0.01}$$

Thus the efficiency of irrigation water salinity: compost rate would be equal to 0.061: 0.016 or 1: 0.262. These analyses indicated that dry weight of tomato shoot was strongly affected by both variables especially by irrigation water salinity.

The effects of compost rate and mycorrhizal inoculation in relation to irrigation water salinity on elemental composition of tomato plant are presented in Tables (8, 10). The results in Table (8) represent the mean values of N, P, K, and Na contents. In the same table, the N, P contents of shoot tomato plants were significantly increased as salinity increased from o.44 to 6.2 dS/m. In Table the same Table, Na ion content was significantly increased with increasing the salinity of irrigation water from 0.44 to 12.5 dS/m. On the other hand the K ion content decreased with increasing water salinity up to 12.5 dS/m.

Gomea *et al*. (1996) reported an increase in Na concentration and decrease in K concentration in the leaves with increasing salinity. These results may be due to a possible antagonism between K and Na. This antagonism could be due to the direct competition between K and Na at the sites of ion uptake at plasmalemma. Accordingly, the increase in Na concentration in plant with salinity may be a result of the ability of plant to use Na to maintain an adequate osmotic potential gradient between the plant tissues and external solution (Glenn, 1987).

Table (8). Mean effect of irrigation water salinity, compost rate and mycorrhiza incoluation on nitrogen, phosphours, potassium and sodium contents in shoot of tomato plant

Treatments	Nitrogen	Phosphorus	Potassium	Sodium
%				
Salinity levels, dS/m				
0.44	2.78	0.131	0.735	1.35
2.70	3.00	0.151	0.717	1.46
6.20	3.15	0.165	0.693	1.59
12.50	2.92	0.164	0.653	1.70
$LSD_{0.05}$	0.105	8.98E-03	0.014	0.040
Compost rate, g/kg soil				
0	2.75	0.141	0.684	1.42
20	2.96	0.146	0.698	1.52
40	3.17	0.171	0.717	1.64
LSD0.05	0.049	4.58E-03	N.S.	0.039
Mycorrhiza inoculation				
Without	2.96	0.141	0.676	1.45
GC	2.96	0.156	0.733	1.57
GM	2.97	0.162	0.690	1.57
$LSD_{0.05}$	N.S.	5.31E-03	9.72E-03	0.040

Regarding the effect of compost rate on N, P, k and Na contents of shoot of tomato plant in Table 8, the increment of these nutrients could be attributed to their availability in compost which increased with increasing compost rates. Also, this may be due to the ability of organic matter in rendering soil nutrients more available and chelating of these elements. This helps to increase the respiration rate, metabolism and growth of plant that causing the plant required to more nutrients from soil and fertilizers. Similar results were obtained by Shehata (2001) and Ewais *et al*. (2005).

The present study showed also, an increase in the contents of N, P, K, and Na in the shoot of mycorrhizal fungi inoculated plants than in the shoot of the uninoculated plants (Table 8). AM inoculated plants recorded higher contents of N, P, K, and Na elements and this may be due to AM hyphae net work which is substantiated by the observed increase in nutrients content (Bolan *et al*., 1994). The interaction between salinity of irrigation water and mycorrhizal inoculation (SxM) had significant effect on N contents in shoot tomato plants (Table 9). The highest value of N content was obtained through 6.2 dS/m irrigation water salinity with *Glomus macrocarpium,* while the lowest value was obtained through o.44 dS/m irrigation water salinity without mycorrhizal inoculation.

Table (9).The interaction between irrigation water salinity (S) and ycorrhiza inculation (M) on nitrogen content (%) in shoot of tomato plant.

Irrigation water salinity dS/m	Mycorrhiza	N %
0.44	Without	2.709
	GC	2.866
	GM	2.768
2.7	Without	2.967
	GC	3.029
	GM	3.089
6.2	Without	3.067
	GC	3.124
	GM	3.247
12.5	Without	3.102
	GC	2.815
	GM	2.844
$LSD_{0.05}$		0.172

Data in Table (10) revaled the average values of the micronutrients (Fe, Zn, Mn and Cu) contents in shoot of tomato plants as affected by irrigation water salinity, compost rates and mycorrhizal inoculation. It is clear that Zn, Mn and Cu contents in shoots of tomato plants were significantly increased as salinity of irrigation water increased from 0.44 to 6.2 dS/m. Table (10) showed also, the effect of compost rates on Fe, Zn, Mn and Cu in shoot of tomato plant. The results showed that there werehighly significance variations in Zn, Mn and Cu contents. The highest values of Fe, Zn, Mn and Cu were produced with 40 g compost /kg soil. Data in Table 10 showed that inoculation with AM fungi significantly increased Fe, Zn, Mn and Cu contentsin shoot of tomato plant as compared to the non-mycorrhizal tomato plants. The inoculation with *Glomus macrocarpium* was more effective than with *Glomus intradiaces* for Zn, Mn and Cu.

The interaction between salinity of irrigation water and compost rate (S x C) had significant effect on Zn content in shoot tomato plants (Table 11). The highest value of Zn was obtained through 6.2 dS/m irrigation water salinity using 40g compost / kg soil, while the lowest value of Zn was obtained through 0.44 dS/m irrigation water salinity without compost. Also, the interaction between compost rates and mycorrhizal inoculatin (C x M) significantly effectd Zn and Mn contents in shoot of tomato plants (12). The highest values of Zn and Mn were obtained through 40 g compost /kg soil with *Glomus macrocarpium.*

Salinity interferes with nitrogen (N) acquisition and utilization by influencing different stages of N metabolism, such as NO_3 ion uptake and reduction and protein synthesis (Frechill *et al.,* 2001). Application of AMF can help in better assimilation of nitrogen in the host plant. Giri and Mukerji (2004) recorded higher accumulation of N in shoots of mycorrhizal *Sesbania grandiflora* and *S*. aegyptiaca than in non-mycorrhizal control plants. The extra radical mycelia take up inorganic nitrogen from the soil in the form of nitrate and assimilated it via nitrate reductase, located in the arbuscule-containing cells (Kaldorf *et al.,* 1998). Cliquet and Stewart (1993) observed increased of N uptake in an AMF inoculated plant due to a change in N metabolism brought about by changes in the enzymes associated with N metabolism (Mathur and Vyas, 1996). Severals studies have reported that improved N nutrition may help to reduce the toxic effects of Na ions by reducing its uptake and this may indirectly help in maintaining the chlorophyll content of the plant.

Table (10). Mean effect of irrigation water salinity, compost rate and mycorrhiza incoluation on iron, zinc, manganese and copper contents in shoot of tomato plants

Treatments	Iron	Zinc	Manganese	Copper
mg/kg D.W.				
Salinity levels, dS/m				
0.44	270.04	89.48	40.89	49.44
2.70	213.19	103.04	47.67	53.56
6.20	228.78	113.74	53.33	58.44
12.5	207.30	102.22	46.59	51.78
$LSD_{0.05}$	N.S.	1.868	2.278	0.655
Compost rate, g/kg soil				
0	245.69	94.81	41.97	50.56
20	213.78	101.00	47.11	52.28
40	230.00	110.56	52.28	57.08
LSD0.05	N.S.	1.465	1.65	0.659
Mycorrhiza inoculation				
Without	144.67	85.06	39.08	44.86
GC	295.14	105.83	46.67	54.69
GM	249.67	115.47	55.61	60.36
$LSD_{0.05}$	42.16	1.916	1.14	1.145

When Na or salt concentration in the soil is high, plants tend to take up more Na resulting in decreased K uptake. Na ions compete with K for binding sites essential for various cellular functions. Potassium plays a key role in plant metabolism. It activates a range of enzymes, and plays an important role in stomatal movements and protein synthesis. High concentrations of K are required in protein synthesis as is used in the binding of tRNA to the ribosomes (Blaha *et al.,* 2000). These functions cannot be replaced by Na ions (Giri *et al.,* 2007).

Mycorrhizal colonization can enhance K absorption under saline conditions (Giri *et al.,* 2007; Zuccarini and Okurowska, 2008) while, it can decrease Na translocation to shoot tissues. Na uptake may also be influenced by the synthesis and storage of polyphosphate (Olrovich and Ashford, 1993) as well as by other cations, particularly K (Giri *et al.,* 2003).

Arbuscular mycorrhizal fungi also improve micronutrient acquisition by increasing the surface area of soil explored by mycorrhizal roots and increasing the solubility of metals by producing metal-chelators (Szaniszlo *et al.* 1981). AMF improves the absorption of copper (Gildon and Tinker, 1983), zinc (Faber *et al.*, 1990; Gildon and Tinker, 1983) and iron (Al-Karaki, 2006).

Table(11).The interaction effect between irrigation water salinity(S) and compost rate (C) on Zinc content in shoot of tomato plants

Irrigation water salinity, dS/m	Compost rate (g/kg soil)	Zn (mg/kg D.w.)
0.44	0	80.33
	20	84.67
	40	103.45
2.7	0	93.67
	20	102.00
	40	113.45
6.2	0	105.67
	20	113.78
	40	121.78
12.5	0	99.56
	20	104.22
	40	103.56
$LSD_{0.05}$		6.214

Table (12). The interaction effect between compost rate (C) and Mycorrhiza inculation (M) on zinc and manganese contents in shoot of tomato plants

Compost rates, g/kg soil	Mycorrhiza	Zn (mg/kg D.w)	Mn (mg/kg D.w.)
0	Without	81.75	33.00
	GC	94.08	39.16
	GM	108.58	53.75
20	Without	84.92	40.42
	GC	106.33	46.17
	GM	111.75	54.75
40	Without	88.50	43.83
	GC	117.08	54.67
	GM	126.08	58.33
$LSD_{0.05}$		6.671	3.983

CONCLUSION: The AM fungal represented by *Glomus macrocarpium or Glomus intraradiaces* with compost application can benefit against potentially salt stress conditions.The *Glomus macrocarpium* was more effective, in general, than *Glomus intraradiaces.* These is further confirmation that compost application and mycorrhizal symbiosis are especially beneficial for plant growth under soil salinity stress. Thus it is needed to develop more exact tests through more exploratory experiments on several tomato cultivares and AMF species to drive more pruise results when we irrigate with saline waters.

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الملخص العربي

استجابة الطماطم للتلقيح بفطر الميكوريزا وإضافة الكمبوست تحت حالة الإجهاد الملحي

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تم اجراء تجربة اصص بأستخدام تربة جيرية لدراسة تأثير الري بمياه ملحية محضرة بتخفيف مياه البحر علي نباتات الطماطم (سلالة B) الملقحة بالميكوريزا مع إضافة الكمبوست خلال الموسم الصيفي 2011. وقد تم استخدام اربع مستويات من مياه الري (0,44 ، 2,70 ، 6,20 و 12,50 ديسى سيمنز/ م) وثلاث معاملات ميكوريزا هى الكنترول (بدون ميكوريزا) ونوعين من الميكوريزا هما *Glomus macrocarpium* و *Glomus intraradiaces* وثلاث معدلات من الكمبوست (صفر ، 20 و40 جم / كجم تربة). وكانت أهم النتائج هى إنخفاض إنتاج المادة الجافة معنويا للجزء الخضري للنباتات بزيادة ملوحة مياه الري . وقد تأثرت نباتات الطماطم بشدة بالمستويات العالية لملوحة مياه الري (6,20 و12,5 ديسى سيمنز / م) . ومع ذلك فقد لوحظ زيادة فى المادة الجافة لنبات الطماطم المتأثره بملحية ماء الرى بسبب إضافة الكمبوست والتلقيح بالميكوريزا . كما زاد المحتوى من النيتروجين والفوسفور بصورة معنوية بزيادة ملوحة مياه الرى من 0,44 إلي 6,20 ديسى سيمنز / م. وقد زاد محتوى الصوديوم فى المادة الجافة لنبات الطماطم مع زيادة الملوحة فى ماء الرى من 0,44 إلي 12,50 ديسي سيمنز / م. ومن ناحية أخرى فقد إنخفض محتوى النباتات من البوتاسيوم. فإمتصاص الصوديوم أدى الى إنخفاض البوتاسيوم بسبب ظاهرة التضاد. والزيادة فى تركيز المنجنيز والزنك والنحاس والحديد مع الزيادة فى المادة الجافة للجزء الخضري بسبب التلقيح بالميكوريزا و كان واضحا مع التلقيح بالميكوريزا *Glomus macrocarpium* أكثر من *Glomus intraradiaces* تحت ظروف الاجهاد الملحى. هذة النتائج تدعم أهمية إضافة الكمبوست والتلقيح بالميكوريزا لإفادة نباتات الطماطم النامية تحت ظروف صعبة مثل الإجهاد الملحى.