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Halophytes and Foliar Fertilization as a Useful Technique for Growing Processing Tomatoes in the Saline Affected Soils

Mahmoud M. Shaaban, Mohamed M. El-Fouly, El-Zanaty,
A.A. Abou El-Nour and Abdel-Wahab A. Abdel-Maguid
Department of Plant Nutrition, National Research Centre, Dokki, Cairo, Egypt

Abstract: A field experiment was conducted to grow processing tomatoes (*Lycopersicon esculentum* L. var. Heinz) in saline-affected soil of Suez, Egypt compared to others grown on non-saline soil. The work was dimensioned to take advantage of the high potentiality of the wild grown halophyte *Zygophyllum coccinium* in reducing soil salinity to a tolerable level for tomatoes to produce a satisfactory yield. To avoid salinity increase by adding macronutrient fertilizers to soil, tomato plants grown after *Zygophyllum* harvest were sprayed with NPK as a complementary technique to meet the plant nutritional requirements. Results showed that growing Zygophyllum sown two months before tomato transplanting could reduce 72.2% of the total soluble salts of the surface layer, lowering EC of the soil suspension by 67.3% and Mg^{++}, Na^{+} and Cl^{-}ion-concentrations by 77.3, 65 and 69.4%, respectively. As the plants received NPK as foliar fertilization, concentrations of K, Ca and Mg in stems and leaves as well as K and Ca in the fruits were increased. Macronutrients foliar feeding could also decrease concentrations of the harmful ions Na^{+} and Cl^{-} in the tissues of plants grown on saline affected soil compared to those received no fertilization. Plants grown under saline affected soil conditions produced nearly one-half of the yield produced by those grown under the same soil conditions but received NPK foliar treatments or those grown under non-saline soil conditions and received no fertilization. However, the highest yield was obtained by the plants grown on non-saline soil and received NPK-foliar feeding.

Key words: Tomatoes, halophytes, NPK-foliar feeding, detrimental ions, yield

INTRODUCTION

Limited water resources and/or using of saline-water for irrigation induced dramatic increase of soil salinity in vast areas in the Mediterranean region. Dispersive cations like sodium was reported to deteriorate soil physical properties led to crop failure[1]. On the other hand, osmotic dehydration and impact of the accumulation of toxic ions (e.g. sodium, magnesium, boron, sulfate and chloride) cause deleterious effects on the plant physiological processes.

Tomato is one of the most important vegetable crops, where yield and quality are significantly reduced by soil salinity[2]. Among soil factors affecting tomato productivity, salinity was reported to inhibit absorption of essential cations, especially calcium[3,4]. When calcium or potassium were applied, growth and yield of tomatoes were significantly positively affected[5,6,7].

The idea behind the present work was to lower salinity of the soil surface to a tolerable level for processing tomatoes using a fast huge canopy forming halophyte. To avoid salinity increase in the root medium, our experimental system included supplying the required essential nutrients to the growing plants through foliar feeding.

MATERIALS AND METHODS

This field experiment was carried out with processing tomatoes (*Lycopersicon esculentum* L. var. Heinze) under Suez saline affected soils.

Halophyte used: To lower salinity of soil surface, the halophyte *Zygophyllum coccinium* was used. The plant was found to naturally grown in Suez saline-affected soils at EC ranged 8.0-10.0 dS/m. Two months before tomato transplanting (mid-August), *Zygophyllum* seeds collected from the previous grown plants were spread on the soil surface and slightly irrigated. The plants were rapid-grown forming a huge canopy and were not irrigated any more until harvesting (mid-October).

Experimental design and tomato transplanting: After *Zygophyllum* harvest, soil surface was hoed, equally

Corresponding Author: Prof. Dr. Mahmoud M. Shaaban, National Research Centre, El-Tahrir St., Dokki, Cairo Egypt. Ph. &Fax #: ++(202) 3361230, E-mail: Mahaaban1@hotmail.com

leveled, divided into 15 m^2 blocks and lined at 100 cm distance. Vigor processing tomato seedlings of about 15 cm long were selected and transplanted at 25 cm distance in the rate of 16/m^2. The same practices were applied at an equal area of non-saline near-by area. The experiment was planned according to the following design:

Saline soil		Non-saline soil	
$T_1 R_1$	$T_2 R_1$	$T_3 R_1$	$T_4 R_1$
$T_1 R_2$	$T_2 R_2$	$T_3 R_2$	$T_4 R_2$
$T_1 R_3$	$T_2 R_3$	$T_3 R_3$	$T_4 R_3$
$T_1 R_4$	$T_2 R_4$	$T_3 R_4$	$T_4 R_4$

Treatments:

Treatment 1 (T_1): Plants transplanted into saline soil without adding fertilizers.

Treatment 2 (T_2): Plants transplanted into saline soil and two times foliar fertilized (at 4.11 and 19/11/2001) with: 1.0 g l^{-1} ammonium sulfate 20.6% N, 0.5 g l^{-1} super mono-phosphate 15.5% P_2O_5 and 1.0 g l^{-1} potassium sulfate 48.5% K_2O in the spray solution.

Treatment 3 (T_3): Plants transplanted into non-saline soil without fertilization

Treatment 4 (T_4): Plants transplanted into non-saline soil and treated with the same treatments as (T_2) at the same times.

Irrigation: the plants were irrigated in the rate of 50 ml/plant/day.

Harvest: fruits were collected 4 times (4-5 days intervals)

Sampling

Soil: Soil samples were taken from the saline affected soils before sowing of *Zygophyllum* and after its harvest. Representative samples were also taken from the normal soil used. The samples were sun dried; sieved using 2.0 mm bores sieve and prepared for physical characteristics and nutrient content.

Plant: Plant samples were taken as a whole plant at 15 days after the last foliar spray. The plants were washed with tap water, distilled water, divided into leaves, stems and roots. Then the tissues were oven dried at 70°C, ground and analyzed for potassium, calcium, magnesium, sodium and chlorine.

Fruits: Fruits were randomly chosen, washed by tap water and distilled water. The fruits then divided into small pieces using a stainless steel knife on a clean plastic sheet, oven dried at 70°C, ground and prepared to be analyze for the same elements as for plant samples.

Analysis

Soil samples: Soil mechanical analysis was carried out using hydrometer method[8]; pH and E.C (electric conductivity): soil/water suspension (1:2.5)[9]; Total calcium carbonate ($CaCO_3$): Calcimeter method[10]; Organic matter (O.M.): potassium dichromate method[11].

Plant and fruit materials: One-gram sample was dry-ashed in a muffle furnace at 550°C for 6 h. The residue was then dissolved in 2.0 N HCl[12].

Soil phosphorus was extracted using sodium bicarbonate[13]. Potassium (K) and magnesium (Mg) were extracted using ammonium acetate at pH 7.0 (9), while Fe, Mn, Zn and Cu were extracted using DTPA[14].

Measurements: Phosphorus was determined photometrically using the Molybdate-Vanadate method and measured using the UV-VIS spectrophotometer (Perkin-Elmer Lambda2). Potassium and calcium were measured in the extract using flamephotometer (Jenway PFP7). Magnesium, iron, manganese, zinc and copper were measured using the atomic absorption spectrophotometer (Zeiss PMQ3). Chlorine was extracted with hot bidistilled water (100°C) and determined by silver nitrate titration.

Data analysis: Data were statistically analyzed using Costate Statistical Package[15].

RESULTS AND DISCUSSION

Halophyte potential in lowering soil salinity: Physical and elemental-content of the soil surface layer (0-30 cm) before sowing of *Zygophyllum coccinium* and after its harvest are shown in Table 1. It is clearly shown that *Zygophyllum* could decrease soil salinity expressed as EC (dS/m) from 9.8 to 3.2 (67.3%) and total soluble salts from 1.8 to 0.5 g 100^{-1} g soil (72.2%). That is because the plant proved to have a good mechanism to absorb salt elements such as magnesium, sodium and chlorine from the soil. Concentrations of these elements in the surface layer decreased after its harvest in the order of 77.3, 65 and 69.4%, respectively. In the same time concentrations of other elements may affect the nutrient imbalance in the soil solution such as potassium, iron, manganese zinc and copper, were also decreased to be in the normal values found in the non-saline soil.

Cultivation of halophytes showed such potential to eliminate soil salinity and absorb the harmful elements

Table 1: Physical and chemical characteristics of the soil before sowing and after harvest of the halophyte *Zygophyllum coccinium*

					Element concentrations		
Physical characteristics	Before sowing	After harvest	Decrease%	Elements	Before sowing	After harvest	Decrease%
pH (1:2.5)	9.5	9.0	5.3	P (g 100^{-1} g soil)	1.2	0.8	33.3
EC. (dS/m)	9.8	3.2	67.3	K (g 100^{-1} g soil)	42.0	22.6	46.2
$CaCO_3$%	15.1	14.7	2.6	Mg (g 100^{-1} g soil)	111	25.2	77.3
O.M.%	1.6	1.8		Ca (g 100^{-1} g soil)	1509	1488	1.4
Texture	Silty loam			Na (ppm)	1814	634	65.0
				Fe (ppm)	8.0	6.2	22.5
				Mn (ppm)	13.5	4.9	63.7
				Zn (ppm)	5.9	3.8	35.6
				Cu (ppm)	1.8	0.98	47.2
				Cl (ppm)	5135	1570	69.4
				Total soluble salts (g/100g soil)	1.8	0.5	72.2

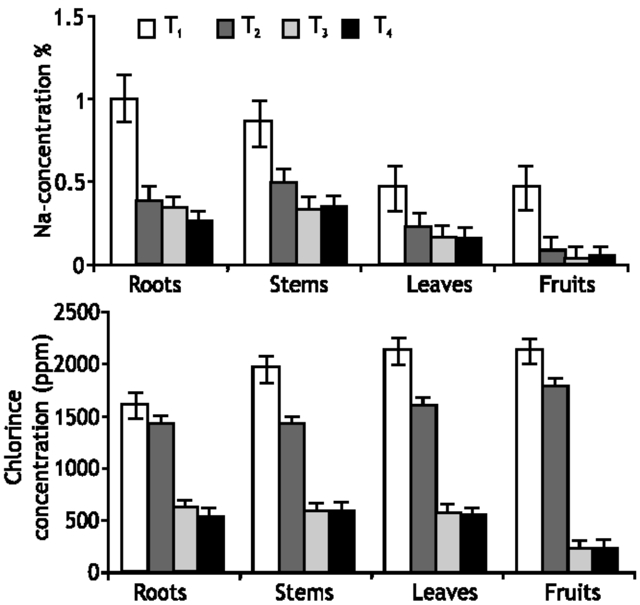

Fig. 1: Sodium and chlorine concentrations in tomato tissues as affected by NPK foliar feeding

seem to be beneficial in reclamation of the saline affected soils to restore them to be crop productive[16].

Effect of NPK foliar fertilization

On sodium and chlorine concentrations: Macronutrients foliar fertilization could also decrease concentrations of saline detrimental elements in tomato tissues (Fig. 1). Sodium and chlorine concentrations in roots, stems, leaves and fruits of tomato plants grown on the saline soil were highly decreased as the plants treated with macronutrients through leaves. However, decrease of sodium concentrations seemed to be more than that of chlorine. Presence of fertilizer elements in the leaves and stems suggested to create certain nutrient balance in the plant tissues and energize the physiological processes acting for nutrient selectivity on the membrane level of the root[17]. Moreover, synthesates located in the cell vacuole to capture harmful elements[18] are expected to abundantly formed as the plants received foliar feeding, preventing detrimental effects of such elements on the cell physiology and biochemistry[19].

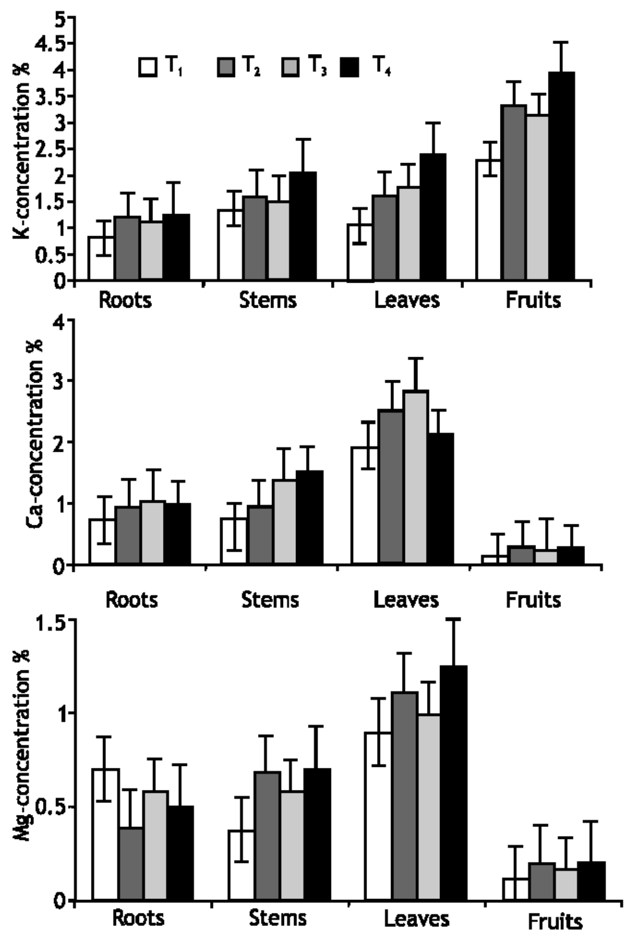

Fig. 2: Concentrations of potassium, calcium and magnesium in tomato plant parts as affected by NPK foliar feeding

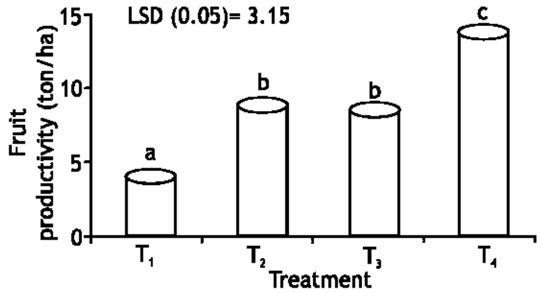

Fig. 3: Fruit yield of Heinz tomato grown on saline and non-saline affected soil as responded to foliar feeding with macronutrients (bars with the same letters are not significantly different, P = 0.05)

On some nutrient concentrations: Tomato plants were only foliar fertilized with NPK. This technique supposed to have the advantage that no more salinity to be added to the soil solution through soil fertilization. This treatment could increase concentrations of K, Ca and Mg in roots, stems and leaves of the treated tomato plants grown on saline soil or non-saline soil conditions (Fig. 2). Treatments could also increase both K and Ca-concentrations in the fruit tissues that should increase their market-quality. Similar results were found by El-Fouly *et al.*[20] with micronutrients foliar fertilization.

On yield: The average yields of Heinz processing tomato grown on saline or non-saline soils as responded to foliar feeding with macronutrients (Fig. 3). Yield was significantly increased as the plants received NPK as foliar nutrition. Taking the productivity of (T_1) as a base, foliar feeding found to nearly double the yield of the plants grown under the same conditions and equal to the yield of the plants grown under non-saline soil conditions but lacked to the proper macronutrients. However, yield of plants grown under saline soil was less than those grown on non-saline soil conditions. Despite nutritional status of the plants was improvement by NPK foliar fertilization that enabled them to withstand salinity stress, plants grown in saline soil may continued suffering from the effects of detrimental ions (i.e. Na and Cl), which were reported to lower tomato fruit yield and quality[19,20].

From the results of the present experiment, it can be concluded that: Halophytes of good potential to absorb salt ions can be used as a useful tool to reduce soil salinity and eliminating the detrimental effects of those ions.

Macronutrients foliar feeding as a complementary technique can improve nutritional status in the plant tissues and create certain nutrient balance that enable plants to withstand salinity stress conditions and produce satisfactory yields.

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