The Role of the Compost in Protecting Tomato (*Lycopersicon esculentum* Mill.) Plants Against Salt Stress

Tartoura, K. A. H.
Botany Department, Faculty of Agriculture, Suez Canal University, 41522, Ismailia, Egypt,

Received: *16/12/2009*

Abstract: Salt stress adversely affects plant growth and development. The present study aimed to investigate the effects of compost derived from a mixture of cow and chicken manure and wheat straw at ratio of 3:1:1 (v/v), respectively, on protection of tomato plants against salt stress. Tomato plants were grown in pots with sandy soil and sandy soil with compost, which was incorporated into soil at rate of 20% (v/v). At 21-days old, untreated (T2) and compost-treated (T3) plants were subjected to 150 mM NaCl for 15 days. Plants without any treatments (T1) were used as control treatment. Salinity treatment decreased plant fresh weight (FW) and dry weight (DW) in comparison to the control treatment, but under salt stress conditions, compost-treated plants grew better than untreated ones. Salinity elevated the free radicals superoxide radicals ($O_2^{\cdot-}$), hydrogen peroxide (H_2O_2), and malondialdehyde (MDA), the product of membrane lipid peroxidation, as well as electrolyte leakage percentage (ELP) compared to the control treatment, suggesting that oxidative stress was induced in tomato leaves. However, compost-treated plants under salinity had a significant reduction in such free radical and lipid peroxidation levels, indicating less oxidative damage in response to compost. In addition, under salinity, activities of antioxidant enzymes, i.e. superoxide dismutase (SOD), catalase (CAT), guaiacol peroxidase (G-PER), ascorbate peroxidase (A-PER) and glutathione reductase (GR)] were significantly higher in compost-treated plants than untreated ones. Further, free radical, 2,2-diphenyl-1-picrylhydrazyl (DPPH), scavenging activity test showed similar trends to those recorded for enzymatic activities. All these changes in compost-treated plants might contribute to protect tomato leaves from oxidative stress as indicated by low peroxidized lipid and ELP levels. It can be concluded that compost derived from cow and chicken manure and wheat straw alleviates salt stress of tomato by improving plant growth and inducing higher enzymatic and non-enzymatic antioxidants, thereby reducing membrane peroxidation and denaturation of biomolecules.

Keywords*:* Antioxidant defense systems, salt stress; compost, *Lycopersicon esculentum* Mill.

INTRODUCTION

Growth inhibition in plants exposed to salinity stress is associated with oxidative damage caused by reactive oxygen species (ROS) at cellular level. Salinity induces generation of ROS such as singlet oxygen ($^1O_2$), superoxide anion ($O_2^{\cdot-}$), hydroxyl radicals ($OH^{\cdot}$) and concomitantly H_2O_2. The superoxide radical ($O_2^{\cdot-}$) and hydrogen peroxide (H_2O_2) are deleterious to the cellular constituent and further potentiate production of hydroxyl radicals. These ROS are necessary for inter- and intracellular signaling but at high concentrations they disrupt normal metabolism through peroxidating lipids, denaturing proteins and nucleic acids. Lipid peroxidation associated with malondialdehyde (MDA) accumulation causes degradation and impairment of structural components. This leads to change in selective permeability of bio-membranes and thereby membrane leakage and change in activity of enzymes bound to membrane. These hasten the loss of membrane integrity and cell metabolites, such as sugar, protein, phenols. MDA, a decomposition product of polyunsaturated fatty acids, is an indicator of membrane damage. Therefore, the cell membrane stability has been widely used to differentiate stress tolerant and susceptible cultivars of crops (Liang *et al.*, 2003) and linked with better crop performance (Sudhakar *et al.*, 2001; Sairam and Srivastava, 2002; Bor *et al.*, 2003; Bartels and Sunkar, 2005).

To minimize oxidative damage, plants have developed complex antioxidant defense systems that protect against these potentially cytotoxic ROS. Superoxide dismutase (SOD) converts $O_2^{\cdot-}$ to H_2O_2, Catalase (CAT) and peroxidase (PER) catalyze the breakdown of H_2O_2. Hydrogen peroxide could be detoxified through the ascorbate–glutathione cycle via ascorbate peroxidase (A-PER) and glutathione reductase (GR). Hence, the potential of antioxidant enzymes to quench $O_2^{\cdot-}$ and H_2O_2 is related to stress tolerance of plants. Non-enzymatic antioxidant tests could be based on the evaluation of lipid peroxidation or on the measurement of free radical scavenging potency (hydrogen-donating ability). The radical scavengers donate hydrogen to free radicals, leading to non toxic species and therefore to inhibition of the propagation phase of lipid oxidation. Recently, The use of 2,2-Diphenyl-1- picrylhydrazyl (DPPH) radical scavenging activity provides an easy, rapid and convenient method to evaluate the antioxidants and radical scavengers (Soler-Rivas *et al.*, 2000; Kansci *et al.*, 2003). High DPPH-radical scavenging potency corresponded with the level of plant stress tolerance (Kang and Saltveit, 2002; Sairam and Srivastava, 2002; Jebara *et al.*, 2005).

A major challenge in agricultural practice and research today is how to cope with plant salt stress in an economical and an environmentally sustainable approach. Composted organic matters (OM) can improve crop tolerance and increase plant growth by providing better soil structure, supply of nutrients, and by building up antagonistic micro-organisms (Raviv *et al.*, 2004; Bayu *et al.*, 2005; Heather *et al.*, 2006; Termorshuizen *et al.*, 2006; Pilon-Smits *et al.*, 2009; Tejada *et al.*, 2009). Therefore, supplementation of composted OM to soils influences a wide array of agronomic and physiological characteristics and is, therefore, a crucial component for any sustainable

e-mail: tartoura@msu.edu

agriculture system (Brady and Weil, 2000). Scientific understanding of the metabolic processes by which organic amendment influenced the outcome of physiological responses is still marginal, owing in part to the inherent complexities of the heterogeneous organic mixtures (Kavroulakis *et al.*, 2005). To date, studies about environmental stresses in compost-amended soils have been scarce (Mata-González *et al.*, 2002)

The objectives of the present investigation were to study the physiological impacts of compost application on tomato (*Lycopersicon esculentum* Mill. cv. Super Strain B) plants against salt stress by measuring plant biomass production in terms of FW and DW, membrane-damage-related parameters, and activities of enzymatic and non-enzymatic antioxidants. The overall aim of this work was to gain insight into the mechanism by which compost contributes to protection of tomato plants against salt stress.

MATERIALS AND METHODS

Analyses of soil and compost properties:

The soil used was sandy soil collected from soil layer (0-25 cm depth) of the Faculty of Agriculture farm, Suez Canal University, Ismailia, Egypt. Compost was prepared from a coarse (>1 mm) fraction of a mixture of cow manure, chicken manure and wheat straw at a ratio of 3:1:1 (v/v), respectively. The organic materials were mixed and decomposed in a pile. Moisture content was measured twice a week and was maintained at 50-60% throughout the active composting period. The mixtures were turned at three-day intervals to maintain porosity. The thermophilic stage (>50°C) lasted for 55 days. After 130 days of composting, the temperatures reached the ambient level. The compost was then left for curing about 4 weeks to be suitable as a culture medium. The most significant characteristics of soil and compost are presented in Table 1. Organic matter and nitrogen content were determined in dried samples using Walkley–Black and Kjeldahl methods, methods, respectively. Phosphorus and potassium were analyzed by Olsen method and flame spectrometry, respectively.

Plant material and treatments:

Seeds of tomato (*Lycopersicon esculentum* Mill. cv. Super Strain B) were germinated in peat-filled trays. At the second true leaf stage, the seedlings were transplanted into free draining pots (3 pot^{-1}) containing sandy soil (T2) or compost (T3), which was incorporated into sandy soil at rate of 20% by volume. The pre-planting irrigation was applied 15 days before planting. The plastic pots (30 pots of compost-treated and 30 untreated) were maintained in the greenhouse and watered when needed. Pot experiments were carried-out under natural light, with an average temperature of 25/20°C day/night and a relative humidity of 65/80%. Diluted nutrient solution (Hewitt, 1966) providing macro and micronutrients were incorporated to the sandy soil in first two irrigation procedure, where seedling plants received the same quantity of nutrients. At 21 days old, untreated (T2) and compost-treated (T3) plants were subjected to 150 mM NaCl for 15 days. NaCl application occurred after withholding water from the plants for 2 days (without observable plant wilting). Thirty pots containing plants without any treatments (T1) were used as control treatment for comparison. Water content of the pots was maintained at 80% field capacity for the period of the experiment. At 7 d after initiation of salt stress, the upper-most fully expanded leaves of uniform plants were collected and immediately frozen in liquid N_2 and stored at – 70°C until analysis. Electrolyte leakage percentage was done in fresh samples. However, at 15 d after salt application, fresh weights of 15 randomly selected plants per treatment were recorded after removing all precipitates from the root surface. Samples were oven-dried at 80°C to a constant weight, and dry weights were recorded.

Superoxide ($O_2^{\cdot-}$) anion and H_2O_2 determinations:

The superoxide radical ($O_2^{\cdot-}$) was measured by monitoring nitrite formation from hydroxylamine following the method of Elstner and Heuper (1976). Leaf tissues of 0.5 g were homogenized in an ice bath in 4.0 mL of 50 mM sodium phosphate buffer (pH 7.8) and centrifuged at 12,000g for 15 min at 4°C. The supernatant was immediately assayed for $O_2^{\cdot-}$. A standard curve with NO_2^- was used to estimate the production rate of $O_2^{\cdot-}$. Production of H_2O_2 was measured by homogenizing leaf tissues (0.4 g) in 3.0 mL of 100 mM sodium phosphate buffer containing 1% polyvinyl pyrollidone (PVP). The homogenate was centrifuged at 12,000g for 20 min at 4°C, and the resulting supernatant was used for estimating H_2O_2 according to the method described by Trinder (1996).

Membrane damage determination:

Lipid peroxidation in leaf tissue was determined by measuring the amount of MDA using thiobarbituric acid. Fresh leaf tissue (0.5 g) was homogenized in 4.0 mL of 10% trichloroacetic acid and centrifuged at 5000g for 10 min at 4°C. The supernatant was assayed for MDA following the method of Qing and Bing (2004). Electrolyte leakage percentage (ELP) was measured using an electrical conductivity meter as described in Liu *et al.* (1985).

DPPH scavenging activity determination:

DPPH-radical scavenging activity was estimated following the procedure described by Kang and Saltveit (2002). Fresh leaves (0.5 g) of each sample were homogenized in 4.0 mL of absolute ethanol at 4°C. After centrifugation, 0.2 mL of the supernatant was mixed with 0.8 mL absolute ethanol, 1 mL 0.5mM DPPH in ethanol, and 2 mL 100 mM acetate buffer (pH 5.5). After standing for 30 min, absorbance of the mixture was measured at 517 nm. The DPPH-radical scavenging effect (%) was calculated according to Yen and Chen (1995).

Antioxidant enzymatic activity assay:

Leaf tissue (0.5 g) was homogenized in 4 mL of 50 mM sodium phosphate buffer (pH 7.0), 0.1 mM EDTA-Na_2, 1 mM L-isoascorbic acid, 1% (w/v) PVP, and 0.05% (w/v) Triton X-100 in an ice bath. The

homogenate was centrifuged at 12,000g for 15 min at 4°C. The resulting supernatant was used for assays of the activities of SOD (EC 1.15.1.1), CAT (EC 1.11.1.6), guaiacol-PER (EC 1.11.1.7), ascorbate-PER (EC 1.11.1.11), and GR (EC 1.6.4.2) according to the procedure described in Parida *et al.* (2004). Protein contents in the enzyme extract were determined by the method of Bradford (1976) using bovine serum albumin as the standard.

Statistical analysis:

Values presented were means ± standard deviation. The data were subjected to statistical analysis by analysis of variance using costat computer package (CoHort Software, Berkeley, CA, USA). The significance of differences between mean values was compared by the least significant difference (LSD) test. Differences at a 0.05 probability level were considered significant.

RESULTS

Seedling biomass production:

Both fresh and dry weights of tomato seedling were decreased by salt treatment (Fig. 1A& B). Compost treatment under salinity-stress conditions increased the FW and DW of tomato plants by 61.5 and 41%, respectively, compared with NaCl-treated plants grown in non-amended soil. Similar plant biomass production were similar in compost-treated and control plants (Fig. 1A& B).

Free radicals production:

Salt treatment significantly increased $O_2^{\cdot-}$ production and H_2O_2 in leaves of tomato seedlings (Fig. 2A& B) by 183 and 200%, respectively, compared with the control. Under salinity-stress conditions, compost treatment reduced $O_2^{\cdot-}$ production and H_2O_2 by 54.7 and 84.2%, respectively, compared with NaCl-treated plants grown in non-amended sandy soil, as shown in Figure 2A& B.

Non-enzymatic antioxidants and membrane damage:

Non-enzymatic antioxidant tests could be based on the evaluation of lipid peroxidation or on the measurement of free radical scavenging potency (hydrogen-donating ability). Lipid peroxidation and electrolyte leakage percentage were measured to asses the membrane damage. Oxidative damage of lipids was estimated by measuring malondialdehyde, which is one of the decomposition products of polyunsaturated fatty acids of biomembranes. In the present work, salt treatment increased leaf MDA content and ELP, compared with the control plants (Fig. 2C& D). Under salinity-stress condition, compost application led to a significant reduction in leaf MDA and ELP by 56.8 and 70%, respectively, compared with untreated plants, as shown in Figure 2C& D.

The free radical scavengers donate hydrogen to free radicals, leading to non toxic species and therefore to inhibition of the propagation phase of lipid oxidation. The presented data indicate that DPPH scavenging effect was increased by 17% due to salinity stress in untreated plants, but the increase was further increased to 64% under salinity in compost-treated plants (Figure 3A), indicating that compost resulted in increasing the activities of non-enzymatic antioxidants.

Enzymatic antioxidants:

The enzymatic antioxidants in higher plant cells can protect their cells from oxidative damage by scavenging ROS. The activities of some antioxidant enzymes in tomato leaves are shown in Figure 3. Salinity stress increased SOD, CAT, A-PER, and GR activities by 12.9, 16, 50, and 62%, respectively, compared with the Control plants. Under salinity stress, activities of SOD, CAT, A-PER, and GR were further increased by 98.7, 62.9%, 145, 162%, respectively, in response to compost treatment, as shown in Fig. 3B,C,E& F. However, G-PER was considerably decreased by salinity stress in untreated plants and compost treatment alleviated the reduction in its activity of NaCl-treated plants (Fig. 3D).

DISCUSSION

It is well understand that compost applied to soil improve its quality by altering the chemical and physical properties, increase organic matter content, water holding capacity, overall diversity of microbes, provide macro- and micronutrients essential for plant growth and suppress diseases which indirectly contribute to plant growth enhancement (see Introduction section). Certain microorganisms present in the compost such as *Trichoderma, Rhizobacteria and fluorescent Pseudomonas* are also known to stimulate plant growth (Dinesh *et al.*, 2000; Sylvia, 2004; Ros *et al.*, 2006). These microbes benefit plants through different mechanisms of action, including the production of secondary metabolites such as antibiotics and hormone-like substances, the production of siderophores, antagonistic to soil-borne root pathogens, and phosphate solublization (Dubeikovsky *et al.*, 1993). Collectively, these changes in response to compost application under salinity conditions often resulted in increased plant growth of tomato plants in terms of FW and DW production in comparison to untreated ones, which was evident in the present work (Fig. 1A& B).

Salinity-induced inhibition of plant growth may produce oxidative stress, which occurs when the generation of ROS overwhelms the antioxidant defenses. Salinity caused reduction in plant biomass production in terms of FW and DW (Fig. 2) was parallel to increased $O_2^{\cdot-}$ anion, H_2O_2, MDA and ELP levels (Fig. 2 A,B,C& D) in leaf tissues which were reversed significantly by compost application. Results reveal that oxidative damage occurs in tomato leaves of untreated plants and were confirmed by high levels of peroxidized membrane lipids and electrolyte leakage percentage. In agreement with the data presented here, Lee *et al.* (2001), Liang *et al.* (2003), and Jebara *et al.* (2005) reported that elevated levels of $O_2^{\cdot-}$ anion radicals and H_2O_2 accumulation under salinity lead to change in selective permeability of bio-membranes and thereby membrane leakage. According to Hernandez and Almansa (2002), the peroxidation of membrane lipids which leads to membrane damage is due to ROS. increased membrane peroxidation might have resulted

from enhanced stomatal closure causing a decrease in the CO_2 concentration of $NADP^+$ available to accept electrons from photosystems 1 and 2 and thus initiate O_2 reduction with the concomitant generation of ROS.

Plant cells possess both enzymatic and non-enzymatic defense systems to maintain the cellular redox state and to mitigate the damage caused by oxidative stress (reviewed by Parida and Das, 2005; Munns and Tester, 2008). In addition to crucial roles in defense system and as enzyme cofactors, antioxidants influence higher plant growth and development by modifying processes from mitosis and cell elongation to senescence and death. Most importantly, they provide essential information on cellular redox state, and regulate gene expression associated with biotic and abiotic stress responses to optimize defense and survival (Shao *et al.*, 2008). Present results showed that NaCl treatment slightly increased DPPH scavenging effect, relative to the control, but under these conditions, leaves of compost-treated plants had higher level of radical scavenging activity (Fig. 3A) in comparison to untreated ones. This suggests that compost may act in increasing the non-enzymatic antioxidants, which estimated as radical DPPH scavenging activity. Such antioxidant system having potential to quench ROS were implicated in stress tolerance, as also reported by (Kang and Saltveit, 2002; Sairam and Srivastava, 2002).

As stated, antioxidant enzymes are capable of removing ROS. Main enzymes are SOD, CAT, A-PER and GR. Compost-treated plants subjected to salinity exhibited higher activity levels of antioxidant enzymes (SOD, CAT, G-PER, A-PER, GR), as assayed *in vitro*, than untreated ones (Fig. 3B,C,D,E& F). This finding suggests that compost might be activating antioxidant enzymes and elevating antioxidants, thereby controlling free radical generation of biomolecules, hence preventing membrane peroxidation and denaturation of biomolecules resulting into improved plant growth under salinity. The controlling of ROS level are considered to be the way of plant to tolerate the stress condition, as also suggested by Chattopadhyay *et al.* (2002) and Bor *et al.* (2003). A correlation between the intracellular antioxidant capability to reduce the ROS and NaCl tolerance has been demonstrated in a wide range of plant species (Noctor and Foyer, 1998; Badawi *et al.*, 2004; Mandhania *et al.*, 2006; Baltruschat *et al.*, 2008; Xue and Liu, 2008). Thus, the higher non-enzymatic and enzymatic antioxidants in compost-treated plants indicate their better tolerance than untreated ones.

The modes of compost action in protecting tomato plants against salt stress may be related to the beneficial effect of compost application that is a result of many components that may work synergistically at different concentrations. It is known that compost represents a good source of all macro- and micronutrients, organic matters, humic substances, hormone-like substances and many others, which played important roles in stimulating metabolic processes, promoting growth, and increasing the synthesis and accumulation of more metabolites in plant tissues; thereby alleviating abiotic environmental stresses including salinity stress, as also reported by Knight *et al.* (1997), Shibli *et al.* (2001), Akiyama and Tsuruta (2003), Li *et al.* (2004), Hussein *et al.* (2006) Ashraf *et al.* (2009). Although the effects of the compost on the later stages of growth and yields of tomato have not been investigated, composts have the potential influence to increase plant growth and to reduce yield losses under stressful conditions. It is concluded that soil amended with the compost derived from cow and chicken manure and wheat straw mitigates oxidative damage generated by salt stress and boosts the resistance capability of the tomato plants against stress conditions via improving plant growth and activating the antioxidant defense systems, thereby reducing membrane peroxidation and denaturation of biomolecules.

ACKNOWLEDGMENTS

Financial support from the Department of the Community Service and Environmental Affairs, Suez canal university (project # 127/2008) is gratefully acknowledged. The author thanks Professor El-Sayed Meleigy, Faculty of Science, Suez Canal Univ., Ismailia, Egypt, for his technical reading of the manuscript.

Table (1): Chemical characteristics of sandy soil and compost after 160 days of composting under study.

Parameter	Soil	Compost
pH[a]	7.9	6.8
EC (dSm^{-1})[a]	1.1	4.4
Total organic matter (%)	0.50	75.6
Total C ($g\ Kg^{-1}$)	2.90	450
Total N (g Kg-1)	0.3	27.0
C/N ratio	9.67	16.67
Total-P ($g\ Kg^{-1}$)	n.d.	9.40
Total-K ($g\ Kg^{-1}$)	0.025	25.2

[a] The pH and electric conductivity were measured in aqueous solutions 1:2.5, and 1:10 dilutions in terms of soil and compost, respectively.

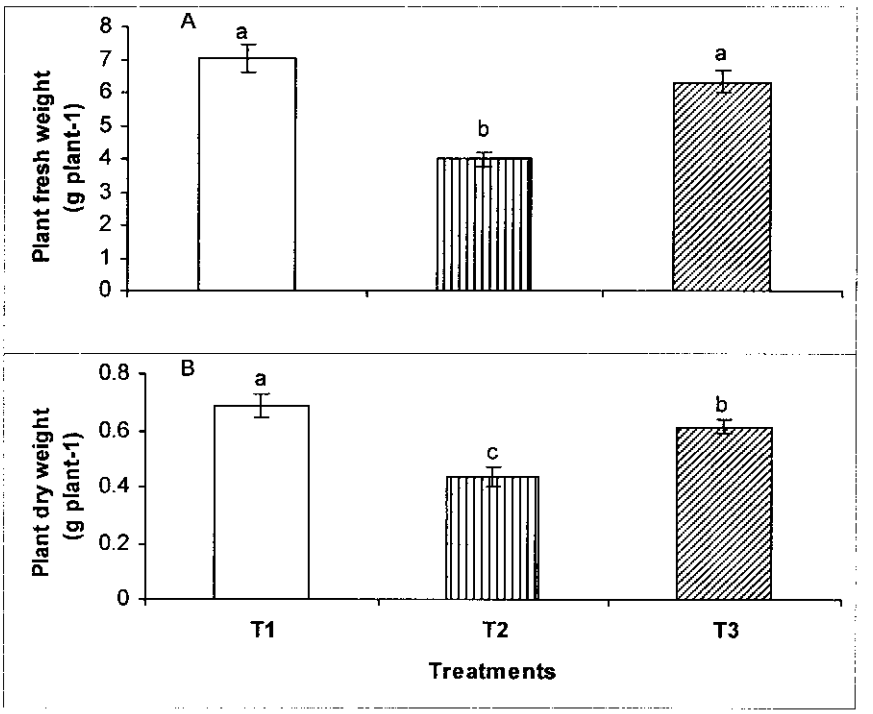

Fig. (1): Effects of compost on plant fresh weight (A), and Plant dry weight (B) of tomato plants subjected to salt stress for 15 days. T1, control plants without any treatments; T2 and T3, untreated and compost-treated subjected to salt stress; T3, compost-treated plants and subjected to salt stress. Data are mean values ± SD from three independent experiments. Bar with the same letters are not significantly different at the 0.05 levels.

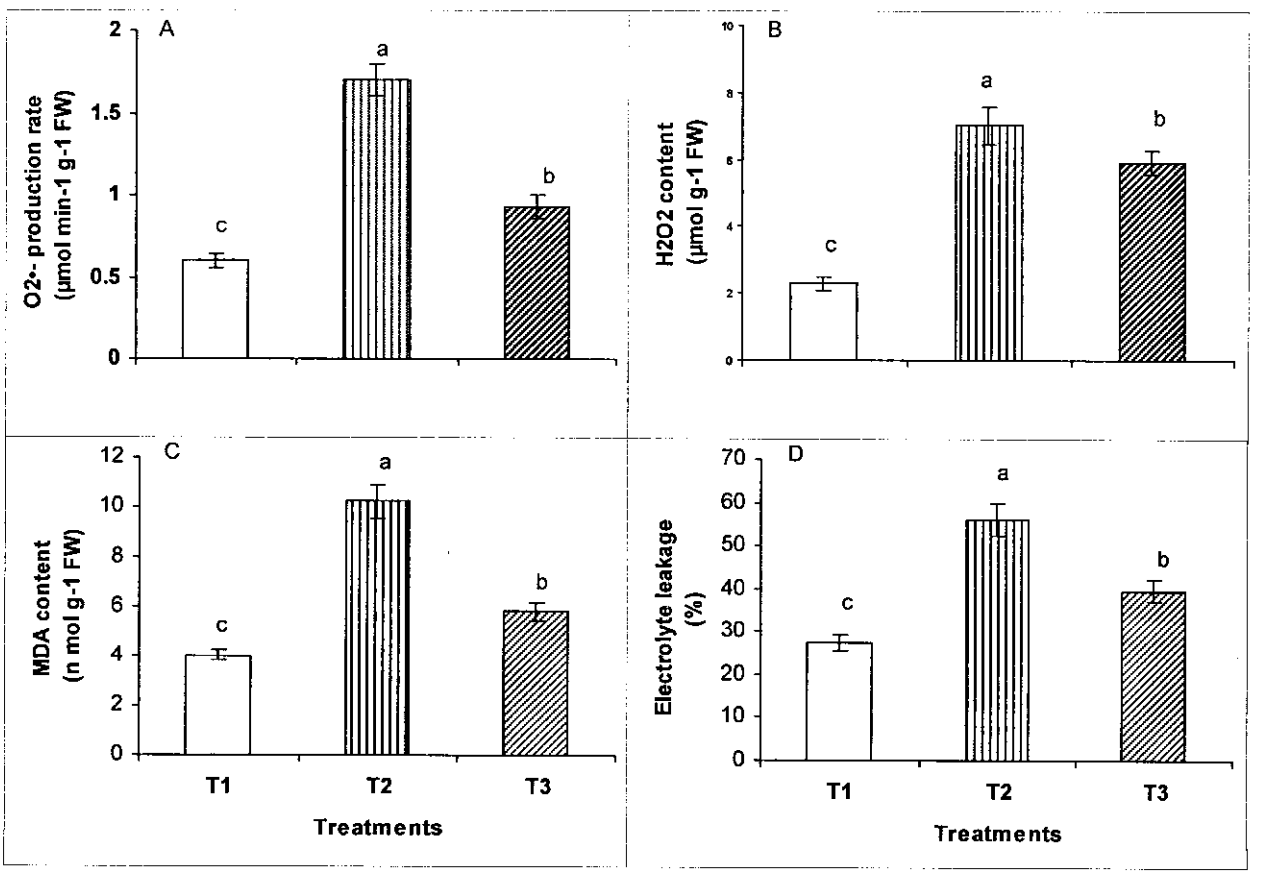

Fig. (2): Effects of compost on the levels of $O_2^{\bullet-}$ production rate (A), H_2O_2 (B), MDA (C), and ELP (D) of tomato plants subjected to salt stress for 7 days. Rest legend is the same as in Figure 1.

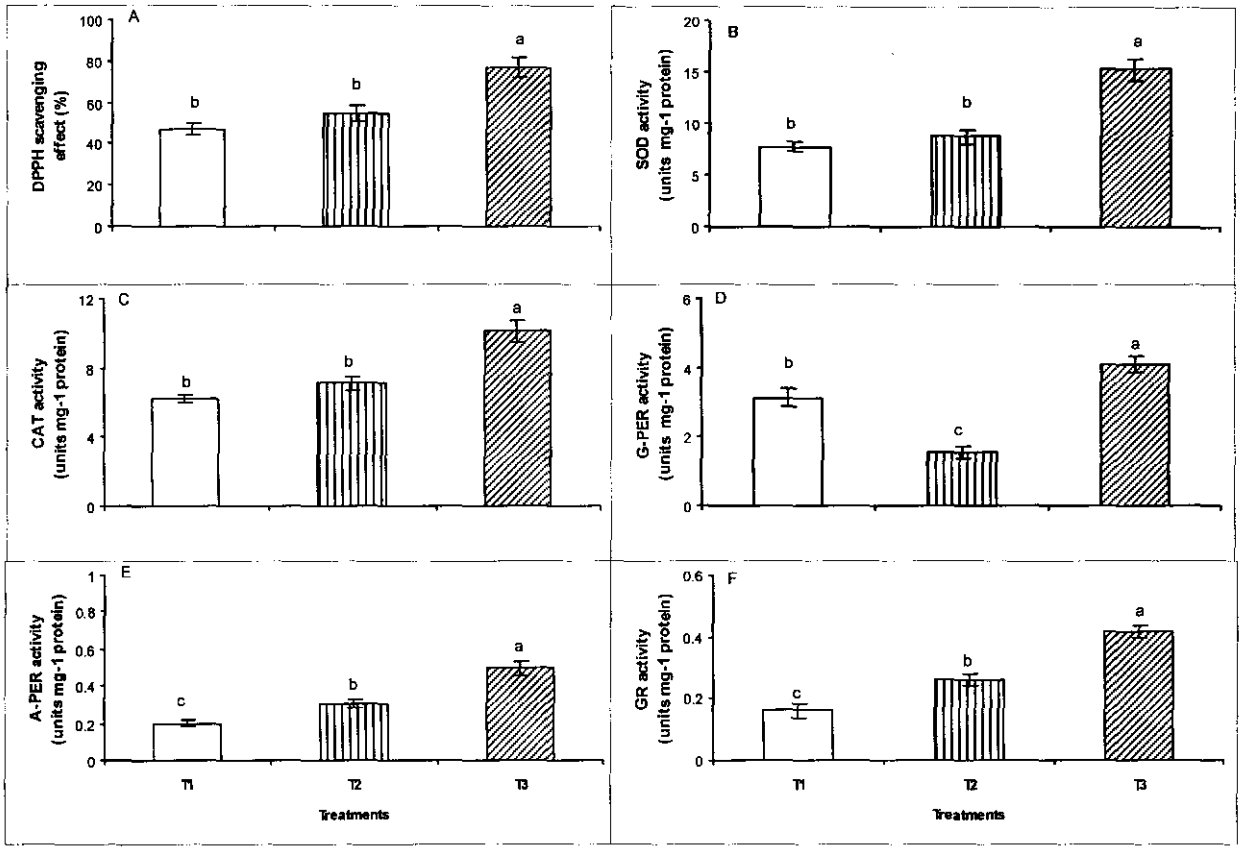

Fig. (3): Effect of compost on DPPH radical scavenging activity (A), SOD (B), CAT (C), G-PER (D), A-PER (E), and GR (F), of tomato plants subjected to salt stress for 7 days. Rest legend is the same as in Figure 1.

REFERENCES

Akiyama, H. and H. Tsuruta (2003). Nitrous oxide, nitric oxide, and nitrogen dioxide fluxes from soils after manure and urea application. J. Environ. Quality 32: 423–431.

Ashraf, M., R. Rahmatullah, M. Ahmad, M. A. Afzal1, T. S. Kanwal and M. A. Maqsood (2009). Potassium and silicon improve yield and juice quality in sugarcane (*Saccharum officinarum* L.) under salt stress. J. Agron. Crop Sci. 195: 284-291.

Badawi, G. H., Y. Yamauchi, E. Shimada, R. Sasaki, N. Kawano and K. Tanaka (2004). Enhanced tolerance to salt stress and water deficit by overexpressing superoxide dismutase in tobacco (*Nicotiana tabacum*) chloroplasts. Plant Sci. 166: 919-928.

Baltruschat, H., J. Fodor, B. D. Harrach, E. Niemczyk, B. Barna, G. Gullner, A. Janeczko, K. Koge, P. Schäfer, I. Schwarczinger, A. Zuccaro and A. Skoczowski (2008). Salt tolerance of barley induced by the root endophyte *Piriformospora indica* is associated with a strong increase in antioxidants. New Phytol. 180: 501-510.

Bartels, D. and R. Sunkar (2005). Drought and salt tolerance in plants. Cri. Rev. Plant Sci. 24: 23-58.

Bayu, W., N. F. G. Rethman and P. S. Hammes (2005). The Role of animal manure in sustainable soil fertility management in sub-saharan africa: A review. J. Sustain. Agric. 25: 113-136.

Bor, M., F. Özdemir and I. Türkan (2003). The effect of salt stress on lipid peroxidation and antioxidants in leaves of sugarbeet *Beta vulgaris* L. and wild beet *Beta maritima* L. Plant Sci.164:77–84.

Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal. Biol. Chem. 72: 248–254.

Brady, N. C. and R. R. Weil (2000). The nature and properties of soils, Upper Saddle River, NJ: Prentice Hall.

Chattopadhyay, M. K., B. S. Tiwari, G. Chattopadhyay, A. Bose, D. N. Sengupta and B. Ghosh (2002). Protective role of exogenous polyamines on salinity-stressed rice (*Oryza sativa*) plants. Physiol. Plant 116:192–199.

Dinesh, R., R. P. Dubey, A. N. Ganeshamurthy and G. S. Prasad (2000). Organic manuring in rice-based cropping system: effects on soil microbial biomass and selected enzyme activities. Curr. Sci. 79: 1716–1720.

Dubeikovsky, A. N., E. A. Mordukhova, V. V. Kochetkov, F. Y. Polikarpova and A. M. Boronin (1993). Growth promotion of blackcurrant softwood cuttings by recombinant strain *Pseudomonas fluorescens* BSP53a synthesizing

an increased amount of indole-3-acetic acid. Soil Biol. Biochem. 25: 1277-1281.

Elstner, E. F. and A. Heupel (1976). Inhibition of nitrate formation from hydroxylammonium chloride: a simple assay for superoxide dismutase. Anal Biochem. 70: 616-20.

Heather, M. D., G. S. Alexandra and P. D. Richard (2006). Compost and manure mediated impacts on soilborne pathogens and soil quality. Soil Sci. Soc. Am. J. 70: 347-358.

Hernandez, J.A., and M.S. Almansa (2002). Short-term effects of salt stress on antioxidant systems and leaf water relations of pea leaves. Physiol. Plant. 115: 251-257.

Hewitt, E. J. (1966). Sand and water culture methods used in the study of plant nutrition. Commonw. Bur. Hort. Tech. Commun. 22: 431–446.

Hussein, M. S., S. E. El-Sherbeny, M. Y. Khalil, N. Y. Naguib and S. M. Aly (2006). Growth characters and chemical constituents of *Dracocephalum moldavica* L. plants in relation to compost fertilizer and planting distance. Sci. Hortic. 108: 322–331.

Jebara, S., M. Jebara, F. Limam, M. E. Aouani (2005). Changes in ascorbate peroxidase, catalase, guaiacol peroxidase and superoxide dismutase activities in common bean (*Phaseolus vulgaris*) nodules under salt stress. J. Plant Physiol. 162: 929–936.

Kang, H. M. and M. E. Saltveit (2002). Effect of chilling on antioxidant enzymes and DPPH-radical scavenging activity of high and low-vigour cucumber seedling radicles. Plant Cell Environ. 25: 1233–1238.

Kansci, G., E. Dongo and C. Genot (2003). 2,2-Diphenyl-1- picrylhydrazyl (DPPH) test demonstrates antiradical activity of *Dorstenia psilurus* and *Dorstenia ciliate* plant extracts. *Nahrug/Food*, 47: 434-437.

Kavroulakis, N., C. Ehaliotis, S. Ntougias, G. I. Zervakis, K. Kalliope and K. K. Papadopoulou (2005). Local and systemic resistance against fungal pathogens of tomato plants elicited by a compost derived from agricultural residues. Physiol. Mol. Plant Pathol. 66: 163-174.

Knight, H., A. J. Trewavas and M. R. Knight (1997). Calcium signaling in *Arabidopsis thaliana* responding to drought and salinity. Plant J. 12: 1067–1078.

Lee, D. H., Y. S. Kim and C. B. Lee (2001). The inductive responses of the antioxidant enzymes by salt stress in the rice (*Oryza sativa* L.). J. Plant Physiol. 158:737–45.

Li, M., G. X. Wang and J. Sh. Lin (2004). Calcium stimulates the adaptation of cultured liquorice cells to PEG-induced water stress. Russ. J. Plant Physiol. 51: 518-524.

Liang, Y. C., Q. Chen, Q. Liu, W. Zhang and R. Ding (2003). Exogenous silicon (Si) increases antioxidant enzyme activity and reduce lipid peroxidation in roots of salt-stressed barley (*Hordeum vulgare* L.). J. Plant Physiol. 160: 1157–1164.

Liu, H. X., S. X. Zeng, Y. R. Wang, P. Li, D. F. Chen and J. Y. Guo (1985). The effect of low temperature on superoxide dismutase in various organelles of cucumber seedling cotyledons with different cold tolerance. Acta Phytol. Physiol. Sin. 1: 48–57.

Mandhania, S., S. Madan and V. Sawhney (2006). Antioxidant defense mechanism under salt stress in wheat seedlings. Biol. Plant. 50: 227-231.

Mata-González, R., R. E. Sosebee, C. Wan (2002). Physiological impacts of biosolids application in desert grasses. Environ. Exp. Bot. 48: 139–148.

Munns, R. and M. Tester (2008). Mechanisms of Salinity Tolerance. Annu. Rev. Plant Biol. 59: 651-681

Noctor, G. and C. H. Foyer (1998). Ascorbate and glutathione: keeping active oxygen under control. Annu. Rev. Plant Physiol. Plant Mol. Biol. 49: 249-279.

Parida, A. K., and A. B. Das (2005). Salt tolerance and salinity effects on plants: a review. Ecotoxicol. Environ. Safety 60: 324-349.

Parida, A. K., A. B. Das and P. Mohanty (2004). Defense potentials to NaCl in a mangrove, *Bruguiera parviflora*: differential changes of isoforms of some antioxidative enzymes. J. Plant Physiol. 161: 531–542.

Pilon-Smits, E. A. H., C. F. Quinn, W. Tapken, M. Malagoli and M. Schiavon (2009) Physiological functions of beneficial elements. Curr. Opin. Plant Biol. 12: 267–274.

Qing, Z. X. and R. H. Bing (2004). Antioxidant metabolism associated with summer leaf senescence and turf quality decline for creeping bentgrass. Crop Sci. 44: 553–60.

Raviv, M., S. Medina, A. Krasnovsky and H. Ziada (2004). Organic matter and nitrogen conservation in manure compost for organic agriculture. Compost Sci. Util. 12: 6–10.

Ros, M., S. Klammer, B. Knapp, K. Aichberger and H. Insam (2006). Long term effects of compost amendment of soil on functional and structural diversity and microbial activity. Soil Use Manag. 22: 209–218.

Sairam, P. K. and G. C. Srivastava (2002). Changes in antioxidant activity in sub-cellular fractions of tolerant and susceptible wheat genotypes in response to long term salt stress. Plant Sci. 162: 897–904.

Shao, H-B., L-Y Chu, Z-H Lu, C-M Kang (2008). Primary antioxidant free radical scavenging and redox signaling pathways in higher plant cells. Int. J. Bioll. Sci. 4: 8-14.

Shibli, R. A., J. Sawwan, I. Swaidat and M. Tahat (2001). Increased phosphorus mitigates the adverse effects of salinity in tissue culture. Communic. Soil Sci. Plant Anal. 32: 429–440.

Smirnoff, N. (1993). The role of active oxygen in the response of plants to water deficit and desiccation. New Phytol. 125: 27–58.

Soler-Rivas, C., J. C. Espin and H. Wichers (2000). An easy and fast test to compare total free radical scavenger capacity of foodstuffs. *Phytochem. Analysis*, 11: 1-9.

Suárez-Estrella, F., M. C. Vargas-García, M. J. López, C. Capel and J. Moreno (2007). Antagonistic activity of bacteria and fungi from horticultural compost against *Fusarium oxysporum* f. sp. *melonis*. Crop Prot. 26: 46–53.

Sudhakar, C., A. Lakshmi and S. Giridarakumar (2001) Changes in the antioxidant enzyme efficacy in two high yielding genotypes of mulberry (*Morus alba* L.) under NaCl salinity. Plant Sci. 161: 613–619.

Sylvia, E. W. (2004). The effect of compost extract on the yield of strawberries and severity of *Botrytis cinerea*. J. Sustain. Agric. 25:57-68.

Tejada, M., M. T. Hernandez and C. Garcia (2009). Soil restoration using composted plant residues: Effect on soil properties. Soil Tillage Res. 102: 109–117.

Termorshuizen, A. J., E. van Rijn, D. J. van der Gaag, C. Alabouvette, Y. Chen, J. Lagerlf, A. A. Malandrakis, E. J. Paplomatas, B. Rämert, J. Ryckeboer, C. Steinberg and S. Zmora-Nahum (2006). Suppressiveness of 18 composts against 7 pathosystems: variability in pathogen response. Soil Biol. Biochem. 38: 2461–2477.

Trinder, P. (1996). Determination of blood glucose using 4-aminophenazone as oxygen acceptor. J. Clin. Pathol. 22: 246.

Xue, Y. F. and Zh.P. Liu (2008). Antioxidant enzymes and physiological characteristics in two Jerusalem artichoke cultivars under Salt Stress. Rus. J. Plant Physiol. 55: 766-781.

Yen, G. C. and H. Y. Chen (1995). Antioxidant activity of various tea extracts in relation to their antimutagencity. J. Agric. Food Chem. 43: 27–32.

دور الكمبوست فى حماية نباتات الطماطم ضد الاجهاد الملحى

كامل أحمد أحمد حسين طرطورة

قسم النبات- كلية الزراعة- جامعة قناة السويس- ٤١٥٢٢ الإسماعيلية- جمهورية مصر العربية

يؤثر الاجهاد الملحى تأثيرا سلبيا على نمو وتطور النباتات المختلفة. تهدف الدراسة الحالية لبحث تأثيرات الكمبوست الناتج من خليط مخلفات الماشية، والدواجن وقش القمح بنسب ١:١:٣ (حجم/حجم) فى حماية نباتات الطماطم ضد الاجهاد الملحى. تم انبات بذور الطماطم اما فى تربة رملية أو فى تربة رملية مضاف اليها الكمبوست بنسبة ٢٠% حجما. تم معاملة نباتات الطماطم عمر ٢١ يوما بتركيز ١٥٠ ملليمولار بمحلول كلوريد الصوديوم لمدة ٧ أيام بالنسبة للتحليلات البيوكيماوية ولمدة ١٥ يوما بالنسبة لكل من الوزن الطازج والجاف لكل من النباتات المعاملة وغير المعاملة. تم دراسة تأثيرات معاملة الاجهاد الملحى على كل من الصفات التالية: [الوزن الطازج والجاف، تكوين الشقوق الحرة لكل من (H_2O_2) hydrogen peroxide & ($O_2^{\bullet-}$) superoxide anion، ناتج أكسدة ليبيدات الأغشية الحيوية malondialdehyde (MDA)، النسبة المئوية للتسرب الالكتروليتى electroyte leakage percentage (ELP)، ونشاط ازالة الشقوق الحرة لمركب 1,1-diphenyl-2-picrylhydrazyl (DPPH)، وأخيرا أنشطة انزيمات مضادات الأكسدة الانزيمية لكل من الـ superoxide dismutase (SOD), catalase (CAT), guaiacol peroxidase (G-PER), ascorbate peroxidase (A-PER) and glutathione reductase (GR). أظهرت النتائج أن معاملة الاجهاد الملحى لكلوريد الصوديوم ادت الى نقص معنوى لكل من الوزن الطازج والجاف لنباتات الطماطم غير المعاملة بالكمبوست مقارنة بنباتات الكونترول النامية تحت الظروف الطبيعية. وقد وجد أيضا أن معاملة الاجهاد الملحى أدت الى زيادة معنوية فى تكوين الشقوق الحرة لكل من H_2O_2 & $O_2^{\bullet-}$ وأيضا MDA& ELP دليلا على حدوث اجهاد تأكسدى لخلايا أنسجة نباتات الطماطم. وبالاضافة الى ما سبق أظهرت نتائج البحث أيضا أن هناك زيادة بدرجات متفاوتة فى انشطة مضادات الأكسدة غير الانزيمية ومضادات الأكسدة الانزيمية باستثناء انزيم الـG-PER كاستجابة لمعاملة نباتات الطماطم للاجهاد الملحى. على عكس ما سبق أدت معاملة نباتات الطماطم بالكمبوست تحت ظروف الاجهاد الملحى الى زيادة كل من الوزن الطازج والجاف لنباتات الطماطم والى انخفاض معدل تكوين الشقوق الحرة وتثبيط أكسدة ليبيدات الأغشية وانخفاض الـELP وزيادة الأنشطة لكل من مضادات الأكسدة غير الانزيمية وأيضا مضادات الأكسدة الانزيمية السابق ذكرها دليلا على انخفاض معنوى للتلف التأكسدى لخلايا أنسجة الطماطم.

بناء على ما سبق يمكن استنتاج أن معاملة نباتات الطماطم تحت ظروف الاجهاد الملحى بكمبوست المخلفات الحيوانية والنباتية المشار اليها سابقا ادت الى تخفيف حدة التأثيرات السلبية لمعاملة الاجهاد الملحى على نمو نباتات الطماطم نتيجة تنشيط مضادات الأكسدة الانزيمية وغير الانزيمية وقد انعكس ذلك واضحا فى انخفاض مستوى الشقوق الحرة و تثبيط أكسدة الليبيدات وبالتالى بقاء الأغشية البلازمية ومكوناتها الجزيئية بحيويتها.