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Impact of treated wastewater and salicylic acid on physiological performance, malformation and yield of two mango cultivars

Mohamed Naser Helaly[a], Nabil Ibrahim El-Sheery[b], Hanan El-Hoseiny[c], Anshu Rastogi[d,*], Hazem M. Kalaji[e,f,**], Magdalena Zabochnicka-Świątek[g]

[a] Agricultural Botany Department, Faculty of Agriculture, Mansoura University, El-Mansoura, Egypt
[b] Agricultural Botany Department, Faculty of Agriculture, Tanta University, Tanta, Egypt
[c] Horticultural Research Institute, Agricultural Research Center, Giza, Egypt
[d] Department of Meteorology, Poznan University of Life Sciences, Piątkowska 94, 60-649 Poznan, Poland
[e] Department of Plant Physiology, Faculty of Agriculture and Biology, Warsaw University of Life Science – SGGW, Nowoursynowska 159, 02-776 Warsaw, Poland
[f] Institute of Technology and Life Sciences (ITP), Falenty, Al. Hrabska 3, 05-090 Raszyn, Poland
[g] Institute of Environmental Engineering, Czestochowa University of Technology, Brzeźnicka 60a, 42-200 Częstochowa, Poland

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ABSTRACT

Limitation of fresh water for agriculture irrigation is a worldwide problem, especially in countries located in the arid region like Egypt. This work demonstrates the impact of treated wastewater on two mango cultivars, cv. “Keitt” and cv. “Ewais”. Treated wastewater contains comparatively more contaminant than fresh water, therefore salicylic acid (SA) was added to the treated wastewater to study their combined impact on mango cultivars. Observation indicated that both cultivars positively responded to treated wastewater and/or SA in a similar manner regarding growth, yield and fruit quality parameters. Obtained data revealed that treated wastewater and/or SA promoted vegetative growth and exhibited inhibitory role on the occurrence of malformation and fruitlet abscission. Studied biochemical features related to lipid peroxidation and oxidative system were differently affected. Cultivar “Keitt” had higher activity of catalase, peroxidase, and superoxide dismutase. as compared to cv. “Ewais”. In the resistant cv. “Keitt” the constitutive level of lipid peroxidation was lower, but the activity of enzymatic antioxidants and non-enzymatic antioxidants was higher than the susceptible cultivar “Ewais”. Similarly, Nitrogen metabolism enzymes and photosynthetic performance were inherently higher in cv. “Keitt”. The comparative analysis between the two mango cultivars, based on malformation percentage analysis, indicated that cv. “Keitt” can be categorized into the tolerant group (1–10%), whereas cv. “Ewais” into susceptible ones (20–40%). Our results suggested that cv. “Keitt” possess better protection mechanisms against oxidative damage as compared to the relatively susceptible cultivar “Ewais”. It is based on maintaining higher inherited and increased activity of the antioxidant system. Our work underlines the relation between malformation tolerance and antioxidant defence system. In this work, we suggest the performance of antioxidant defence system as a potential biochemical indicator for screening mango genotypes for malformation behaviour.

1. Introduction

Water covers about 70% of our planet, among that less than 0.5% water is available as the fresh water in the form of groundwater, or surface water in lakes, rivers, ponds and other water reservoirs (Cunningham and Saigo, 1995). With increasing urbanization, industrialization and human population, the world must dispose of an ever increasing amount of treated wastewater (WW) both from home and industries (Solaimalai et al., 2003). Apart from the importance in enhancing the crop production, use of WW is of much wider importance, when judged for the preservation of productivity of agricultural land and environment. The fresh water problem is very serious in Egypt and there is an increasing demand for it in day by day activities such as agriculture, industries, domestic and electricity generation. Moreover, the use of water in home and industries have adversely affected the water quality.

Wastewater (WW) is also placed under the organic manuring to some extent, as chemical fertilizers cannot contribute to the

* Corresponding author.
** Corresponding author at: Department of Plant Physiology, Faculty of Agriculture and Biology, Warsaw University of Life Science – SGGW, Nowoursynowska 159, 02-776 Warsaw, Poland.
E-mail addresses: anshusls@gmail.com (A. Rastogi), hazem_kalaji@sggw.pl (H.M. Kalaji).

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maintenance of soil environment capable of stimulating favorable biological activities. In addition, WW can improve the physical condition of the soil and aggregation of its particles. Such manurial liquid wastes may, therefore, be necessary for agricultural soils in the countries where the chemical fertilizers are not easily available and became costly and normally beyond the reach of common poor small farmers. Thus, WW offers one of the suitable options for agricultural irrigation. In rich and technologically advanced countries WW treatment processes developed that utilize highly mechanized or energy consuming plants. These treatment plants are neither sufficient nor financially affordable in developing countries like Egypt. In developing countries, WW often poses problems of environment friendly disposal and the mounting stress for irrigation purposes in agriculture (Wang et al., 2001). Alternative methods are assuming paramount importance to solve these problems. However, farmers of today are readily willing to opt for greater consumptions of WW in their cultivation where this water is available. It contains valuable plant nutrients and their use in agriculture may be not only a means for preventing environmental pollution but also are the important source of irrigation water.

Irrigation with WW may generate reactive oxygen species (ROS) like other stress which oxidize important chemical compounds in the plant cell, especially photosynthetic pigments (Wang et al., 2001). Nucleic acids and protein synthesis can be blocked, due to enzymes inhibition by ROS (Munns and Tester, 2008). However, several investigators at Bari (Italy) studied different plant species under tertiary membrane filtered municipal WW as an alternative to natural fresh water (Lonigro et al., 2007). They considered membrane filtration as a viable technology to reclaim WW for irrigation, the presence of microbes, heavy metal and their impact on crops and soil was also studied. They used the WW by drip irrigation on certain plant species. It was observed that microbial content of the soil and the crops did not show any relevant differences in relation to the two types of water and the measured values and filtered WW never caused an increase of bacterial concentration in the soil nor on edible part of crops. Therefore, they suggested that the tertiary filtered municipal WW can be considered as a valid alternative source of water for vegetable crop irrigation and other crops (Lonigro et al., 2007). In this context Javaid et al. (2004) and Javed (2003) worked on sewage WW found that WW promotes growth, yield, content of minerals, chlorophylls as well as water use efficiency and photosynthetic rate in black gram plants.

Mango (*Mangifera indica*, L) tree is a considered as a king fruit, being the most popular fruits in Egypt, is very rich in minerals, total sugars, total soluble solids, and vitamins. Therefore, the mango has high nutritional values. It is popular in the domestic market for fresh consumption and used in making cocoa butter, juice, jams, pickles, chutney, bread and puddings. It has great adaptability and thrives in a wide range of climate and soil conditions (Mutlu et al., 2013). In Egypt, the mango cultivated area reached 130000 Ha in 2009 producing about 450000 tons of fruits annually (FAO, 2011). More than 40% of mango producing areas exist in Ismailia governorate nearest the main sink of WW. Mangoes yield worldwide faces poor fruit set, high fruitlet abscission, irregular bearing, low productivity and malformation disease (Sayed et al., 2009). Increasing growth and yield by WW undoubtedly saves fertilizers, fresh water shortage, and expenditure but the whole question of productivity cannot be viewed firm the narrow angle of immediate yields and the amount saved. Using plant growth substances especially those acting as an antioxidant like salicylic acid (SA), ascorbic acid (AsA) and others were very favorable for improving growth nutritional status, yield and fruit quality in different fruit trees (Mutlu et al., 2013). Antioxidants have an important role in protecting the plant cells from senescence and death, preventing the free radicals from lipid peroxidation and plasma membrane with the loss of permeability as well as their effects in enhancing cell division, building up of organic acids, the biosynthesis of organic foods and controlling the incidence of fungal attack (Prusky et al., 1988). The positive action of antioxidants in chelating these hazard radicals could result in extending the shelf–life of plant cells and producing vigorous plants (Orth et al., 2006). Thus, it was expected that spraying with antioxidant may play a definite role in solving the problem with poor yield. Hayat et al. (2007) reported that salicylic acid (SA) is an endogenous plant growth regulator that plays miscellaneous physiological roles in plants and potentially alleviates the disturbing effect generated by various biotic and abiotic stress and their effects on the generation of ROS. On the other hand, application of fungicides is limited due to the development of their resistance by pathogens, public concern about their residues in food and potentially harmful effects on the environment and human (Lise et al., 2005). It has been documented that disease resistance can be triggered by elicitors such as SA in seedling or leaves of annual plants such as Arabidopsis, tobacco, cucumber, tomato, rice, and beans (Sticher et al., 1997). SA is a simple phenolic compound naturally produced by many plants and has been considered as signal endogenous hormone molecules in the signal translocation pathway in plants (Sticher et al., 1997). Few studies have shown that disease resistance in fruits could be induced by SA (Qin et al., 2003). However, little is known about how disease resistance in the harvested fruit of woody plants may be affected by SA treatment. Thus, the present investigation aimed to evaluate the suitability of using treated WW as a source of irrigation and nutrients and its effects along with SA on growth, malformation%, chemical composition as well as yield and fruit quality of two mango cultivars grown in Egypt.

2. Materials and methods

This study was carried out through three successive growth seasons (2014–2016) at east Suez at Ismailia governorate (Egypt) on 48 uniform in vigour budded Mango (*Mangifera indica* L.) tress. Two cultivars "Keitt" and "Ewais" were studied. Ismailia has an area of 1442 sq.m. and is situated at latitude 30° 36′ N, longitude 32° 14′ E, at altitude of 10 m above the sea level. The climate is semi-arid and sub-tropical with hot days during summer and cold-warm ones during the winter. The winter season extends from 21st December to the 22nd March. The mean temperature for December and January (the coldest months) goes down to 12 °C. The average temperature during the two hottest months of summer (July and August) goes up to 46 °C. The average values of the maximum and minimum temperature during the course of the experiment (of the three seasons) were 32.5 and 12.5 °C, respectively. The annual rainfall was about 37 mm. More than 85% of the total rainfall occurred during December and January, and nearly 10–15% during March. The 15-year-old trees were grown in a sandy soil (Table 1) and irrigated by a drip system. Trees grown apart at 2 × 3 m for cv. "Keitt" and 4 × 5 m for cv. "Ewais" under the same environmental conditions and similar management practices that are usually followed in the orchard, except those regarding the experimental factors. The soil of the experimental location is extremely poor in all nutrients and organic matter. Samples were taken at three depths, mixed and analysed according to Jackson (1973) and the data are prescribed in Table 1. The soil was fertilized with a fertilizer mixture that contain most major nutrients and several micro nutrients. During the study period, each experimental tree was fertilized by 2–3 kg of the following mixture (components percentage): 11.8% N, 6% P, 15.6% K, 0.05% Cu, 0.05% Zn, 0.13% Ca, 17% Mg, and 8.3% S. Two dosages were applied. The first fertilizer application was done at the beginning of winter season (23rd December) and the second application was at the time of fruit setting (15th August). The experiments were designed in factorial completely randomized system. Six various treatments (four replicate, one tree for each) were applied on each cultivar.

2.1. Treatments

Comparative effect of WW at two concentrations (50% and 100% WW), in addition to fresh water (FW) as a control, was evaluated. The WW was obtained from El-Salam water channel. It contains a mixture of