Sustainable Production under Bio-Nanofertilizers of Selenium and Copper

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Nanofertilizers indicates nanomaterials that include the plant nutrient itself or the plant nutrient as a carrier and macro-nutrient nanofertilizers, nano-zeolite, nano-hydroxyapatite, and nano-biofertilizers. Nanofertilizers are considered promising materials that display unique properties of nanoparticles at the nano-scale.

water quality nanofertilizers catalase peroxidase hydrogenase enzymes

1. Introduction

Conventional fertilizers have caused many environmental problems such as inducing food contamination and soil degradation due to intensive use of these mineral fertilizers and pesticides [1]. Because of the poor conventional fertilizer use efficiency (ranging from 20 to 40%), a big amount of these fertilizers leached to groundwater and then rivers, causing economic damage, eutrophication phenomena, and problems for human health [2].

Many studies reported benefits that resulted from nanofertilizers applied to cultivated crops such as alfalfa [3], soybean [4], potato [5], cabbage [6], maize [7], and wheat [8]. These benefits of nanofertilizers may include improving fruit quality, productivity, and shelf life and reducing the leaching of nutrients into soil after the harvesting of crops [6][8]. The most common nutrients that are already applied as nutrient-based nanofertilizers include iron [6], copper [3][9][10], selenium [11][12], and zinc [8][13][14].

The quality of irrigation water is a limiting factor in producing agricultural crops, which have some irrigation water quality guidelines such as salinity and sodium adsorption ratio (SAR), calcium, magnesium, sodium [15], and heavy metals such as As, Cd, Cr, Cu, Pb, Fe, Mn, and Zn [16]. When the used water in irrigation contains a high content of salts and heavy metals, these cause a low quality of the water and accumulate in both agricultural soil and cultivated plants [17]. This problem was aggravated by the intensive use of wastewater (low water quality) in the irrigation of cultivated plants, which contains many transferred pollutants to the food chain of humans and animals causing potential health risks in the long term [18]. Several studies reported the problems of saline and low water quality and their impacts on cultivated plants [18][19], soil quality [20][21], and projected human health [16][17]. Many materials have been applied to remediate this low water quality such as hydrogel [22], biochar [23], magnetic bentonite [24], and nanomaterials or nanoparticles [25][26]. Nanomaterials have been used in removing pollutants from contaminated water such as arsenic [26] and chromium [27][28], whereas the role of nanofertilizers in enhancing the productivity of cultivated plants irrigated with low water quality still needs more research.

Tomato plants (*Solanum lycopersicum* L.) are considered one of the main vegetable crops worldwide due to their high dietary and commercial value, besides their nutritional value (rich in vitamin A and C, phosphorus, iron, beta-carotene, anthocyanins, and lycopene). Therefore, tomato is naturally high in antioxidants and may protect against prostate cancer and protect the human skin from UV radiation due to its high content of lycopene [29]. This crop has a long-growth season with high water requirements and could produce under different stresses such as salt stress [13][30], drought [29], copper toxicity [14], continuous irrigation using saline water [31], and nano-toxicity [32][33][34][35]. Few studies have been published about the impact of nanoparticles on cultivated tomato under low water quality irrigation such as nano-TiO_2 [36] and nano-carbon [31], whereas there are no published articles on the effect of combined applied nanofertilizers on the productivity of tomato seedlings under irrigation with low-saline water.

2. Tomato Growth, Yield, and Its Quality

The production of tomato crop needs many growth factors especially proper and enough nutrients as well as the quality of irrigation water. When the cultivated tomato suffers from a problem in supplying nutrients or irrigation water, plant production will decline due to the stressful conditions. Under the global water crisis, there is an urgent need to utilize low-quality water sources in agricultural irrigation as an effective method for water shortage [37]. The main problems of low-quality water are represented by high levels of heavy metals, salts, and other pollutants, which may bring many environmental risks to soil and cultivated plants and consequences for human health.

In spite of the high quality of tomato fruits under the low quality of irrigation water in Baltim, the accumulation of heavy metals may threaten human health. Ma et al. [38] found that irrigation with wastewater led to an accumulation of some heavy metals such as Cr and Pb [38].

3. Irrigation Water Stress on Tomato Production

Low irrigation water quality causes stress on cultivated tomato plants, which was reflected by enzymatic antioxidants. Shoaib et al. [39] observed elevation in the antioxidant enzyme activities such as SOD, POX, and CAT which are strongly correlated to salt endurance in many plants [39].

The role of nano-Se or nano-Cu in improving tomato growth has been discussed in some recent studies such as nano-Se under salinity stress [40], nano-Cu under salinity stress [41][42][43], and both nano-Se and nano-Cu for biotic stress on tomato [44]. Soil enzyme activities are responsible for the biogeochemical cycles of many elements and are particularly sensitive to soil ecological changes; hence they have been commonly utilized as indicators to assess soil health and the level of contamination among the many soil properties [38]. It was found that irrigation with mine wastewater caused negative effects on the soil enzyme activity especially at the flowering stage due to the accumulation of heavy metals. Based on the biological impact of Se or Cu in ameliorating the stress on cultivated plants, these elements are components or co-factors of many plant enzymes such as CAT and POX, which work as enzymatic antioxidants.

4. Conclusions

The water crisis is a serious problem in several places all over the world, which need alternative sources. Therefore, the water of the Kitchener drain, as one of the biggest drains in the north Delta of Egypt, was used for irrigation in many rural areas in the Nile Delta of Egypt. However, the continued use of the low-quality water has led to the accumulation of a significant amount of salts and a high content of heavy metals and other toxins, which causes many environmental problems. The most important finding is the crucial role of bio-nano-Cu in enhancing the yield and quality of tomato fruits under irrigation with low water quality. In addition, the low quality of irrigation water led to the accumulation of salts, organic matter, and $CaCO_3$ in the soil. Due to the salinity stress of irrigation water, plant enzymatic antioxidants and soil biological activity decreased. After 30 days from transplanting, all studied soil biological parameters (soil microbial counts and enzymes) were higher than the same parameters at harvesting after 80 days under different water qualities. The soil biological parameters were also decreased by increasing water salinity, which is considered an important issue for future research.

Therefore, the use of a bio-nanofertilizer is promising in enhancing the productivity and quality of cultivated crops, especially under stress conditions. However, there are still many unanswered questions concerning different applied doses of these nanofertilizers for further studies that could take the following variables into account: the expected impact of low water quality of irrigation on the yield of other crops, on the one hand, and its impact on soil biological parameters under applied nanofertilizers, on the other hand.

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