Chemicals Mitigate Copper Toxicity on Seed Germination and Plant Growth

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Abstract

The present mini review aimed to explain the potential protective role of some chemicals against Copper (Cu) toxicity in plant. Many studies suggest that the exogenous supply of effectors such as nitric oxide, polyamines, organic acids and growth regulators to germinating seeds can be a promising alternative to improve plant response to heavy metal stress.

Introduction

Heavy metal stress is one of the environmental pollution situations affecting plant growth and productivity. Copper is an essential oligo-element, but can be toxic to most plants, even at very low concentration [1,2]. Due to its wide use in fungicides, pesticides and fertilizers, pollution by Cu has become increasingly a major environmental problem: inhibition of plant growth [3], resulting from numerous physiological and metabolic disturbances, is generally reported as a consequence of an excess of Cu [1]. Copper is readily absorbed by plants, leading to toxic symptoms of physiological and biochemical dysfunctions, such as disorders in mineral nutrition [4] and photosynthesis [5], deterioration of membrane integrity and, in general, induction of oxidative stress due to overproduction of reactive oxygen species (ROS) [1,2].

ROS are considered to be both (i) harmful to cells [6] and (ii) ubiquitous signaling molecules participating in the stress response of plants [7]. Like other environmental stresses, Cu excess results in changes in

a) antioxidant enzyme activities, such as superoxide dismutase, catalase and peroxidases, and

b) contents of low-molecular-weight non-enzymatic antioxidants, such as ascorbic acid and glutathione.

Most of the abiotic stress impact studies in plants have been carried out for individually applied pollutants, although contamination, which really involves soils and plants, is multiple rather than simple. Soils are often contaminated with several pollutants at the same time. In such situations, contaminants can interact with one another in a synergistic, additive or protective manner [8].

Several researchers suggested that it would be important to develop practical techniques to mitigate the effects of heavy metal stress, such as the simultaneous application of nitric oxide [9], polyamines [10], sulfur [11], calcium [12], citrate [1], hydrogen peroxide [13], growth regulators [14], and hydrogen sulfide [15,16], which neutralize the toxic effect of heavy metals on germination and plant growth and thereby improve plant resistance.
Many chemicals have the capacity to trap and sequester metal cations inside cells. The strong affinity to the binding of heavy metals is due to the electronegativity of functions in these molecules; in particular carboxyl groups (-COO-). This is the case with EDTA [17] and organic acids (malic, oxalic, citric, benzoic) [1,18,19].

However, the action of the chelators remains controversial. These compounds can improve the solubility of metal cations in the rhizosphere and, as a result, their uptake by roots. In this case, they are useful in ongoing phytoextraction programs that are relevant to the phytoremediation stream [17,20].

Chelators also participate in intracellular detoxification: vacuolar shuttles in the form of “metal-organic acid” complexes eliminate the heavy metals from the cytoplasm [18,21]. A third possibility would be an indirect action of certain carboxylic acids (citrate) in improving the antioxidant capacities of plants previously contaminated with heavy metals [18,22,23].

**Conclusion**

Clarification of why Cu phytotoxicity could be mitigated by exogenous effectors application should provide a basis for early monitoring and assessment of contamination of the plant environment. At least in part, the protection of plants against the toxicity of heavy metals is associated with the control of their removal.

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