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Physiological and Antioxidative Responses of Medicinal Plants Exposed to Heavy Metals Stress

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Abstract

Soil heavy metal contamination is a widespread phenomenon that occurs naturally or as a result of anthropogenic activities such as mining, smelting, fossil fuel combustion and agriculture. Heavy metal accumulation in agricultural soils is a major environmental constraint leading to lower crop productivity, and reduced food/feed safety. Among the non-food crops, medicinal and aromatics plants have been proposed as alternative crops in heavy metal contaminated soils, where an environmental obstacle such as heavy metal can be exploited to elicit the biosynthesis of invaluable secondary metabolites. Plants use different strategies to cope with the heavy metals entered their cells. Tolerance to a specific heavy metal is controlled by a complex inter-related cascade of morphological, physiological, biochemical, and genetic mechanisms. Heavy metal ions bind to the protein groups and are able to replace specific cations in binding sites, resulting in the inactivation of enzymes and production of reactive oxygen species (ROS), which can cause oxidative stresses such as membrane lipid peroxidation, damage to RNA and DNA, inhibition of key enzymes, degradation of proteins and oxidation of amino acids. The ROS include hydrogen peroxide (H_2O_2), singlet oxygen ($^1O_2$), superoxide anion ($O_2^{\bullet -}$), hydroxyl ($HO^{\bullet}$), alkoxyl ($RO^{\bullet}$), peroxyl ($RO_2^{\bullet}$) radicals, and organic hydroperoxide (ROOH). Inside plants, ROS can be scavenged by both enzymatic and non-enzymatic antioxidant defense systems. Among the non-enzymatic antioxidants, phenolic compounds, ascorbic acid,