Physiological Effects and Functions of Zinc in Plant Systems

Ross M. Welch[1]

[1]Department of Crop and Soil Sciences, Robert W. Holley Center for Agriculture and Health, 538 Tower Road, Cornell University, Ithaca, NY 14853 USA (rmw1@cornell.edu)

OVERVIEW

Zinc deficiency in food crops is widespread with about 50% of the productive agricultural soil types being zinc deficient (Sillanpaa, 1982;Sillanpaa, 1990). Additionally, about 50% of the world's human population is also zinc deficient (Hotz and Brown, 2004). Thus, zinc deficiency is a major problem for both plant and human health. Understanding the physiological effects and functions of zinc in plant systems is needed to find effective ways to increase the available levels of zinc in soils to improve crop productivity and to increase the bioavailable levels of zinc in edible portions of food crops that feed the world's resource-poor people.

This review will focus on the roles that zinc plays in abiotic and biotic stress resistance in plants. Zinc's function in cell membrane integrity will also be discussed especially for root cells along with its role in suppressing free radical damage to cells (Cakmak, 2000).

Root cells require a soil solution level of free ionic zinc to perform optimally under various soil stresses including drought, low temperature, high salinity, high levels of various potentially toxic elements (cadmium, boron, etc.) and certain pathogenic organisms (Welch, 1995). Identifying ways to meet this need by increasing ionic zinc activity to subsoil roots growing in zinc deficient soils that are efficient and cost effective are also needed.

Zinc is second only to iron in abundance of transition metals in living organisms playing roles in all six classes of enzymes (oxidoreductases, transferases, hydrolases, lysases, isomerases and ligases Reactivity and the function of zinc-containing enzymes are influenced by the binding and spatial aspects of zinc ligands with three primary zinc binding sites recognized including structural, catalytic and co-catalytic sites. Zinc also interacts with numerous other proteins in plants affecting their structure and function. The largest class of proteins containing zinc is the zinc finger proteins. Zinc also interacts with membrane lipids and in DNA/RNA binding playing a role in regulation of transcription, chromatin structure, protein-protein interactions and RNA metabolism. (Broadley et al., 2007)

The role of zinc in stabilizing cell membranes is still not completely clear but appears to be related to zincs ability to protect membrane protein sulfhydryl groups in cysteine residues from oxidation by other transition metals (such as Fe and Cu) to the disulfide amino acid, cystine. More research is needed to understand this important function of zinc in plant cell membrane (Welch, 1995).

Further knowledge is also needed to increase the levels of zinc in seeds and grains to levels that will significantly enhance the bioavailable levels of zinc in edible portions of these plant foods. This includes identifying the mechanisms involved in solubilizing available forms of zinc in the rhizosphere, the genes and transporters needed to move zinc from roots to stems and leaves, retranslocation to reproductive organs and accumulation in seeds (Broadley et al., 2007;Grotz and Guerinot2006; Waters and Sankaran, 2011). The major forms of zinc in these tissues should also be identified along with their bioavailability to humans (Welch, 1993).

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