Journal Home: www.bioticainternational.com

Popular Article

Article: RT0295

Biotica Research Today

Vol 2:8 2020

823 / 825

How to cite this article?

Yuvaraj and Subramanian, 2020. Significance of Zinc in Plant Nutrition. Biotica Research Today 2(8): 823-825.

Significance of Zinc in Plant Nutrition

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Keywords

Biofortification, Deficiency, Enrichment, Zinc

Article History

Received in 20th August 2020

Received in revised form 26th August 2020

Accepted in final form 27th August 2020

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Abstract

Zinc is plant micronutrient which is involved in many physiological functions its inadequate supply will reduce crop yields. Zinc deficiency is the most wide spread micronutrient deficiency problem, almost all crops and calcareous, sandy soils, peat soils, and soils with high phosphorus and silicon are expected to be deficient. Zinc deficiencies can affect plant by stunting its growth, decreasing number of tillers, chlorosis and smaller leaves, increasing crop maturity period, spikelet sterility and inferior quality of harvested products. Beside its role in crop production Zn plays a part in the basic roles of cellular functions in all living organisms and is involved in improving the human immune system, due to its insufficient intake, human body will suffer from hair and memory loss, skin problems and weakness in body muscles.

Introduction

Availability of Zn to plant is hampered by its immobile nature and adverse soil conditions. Thus, Zn deficiency is observed even though high amount is available in soil. Root-shoot barrier, a major controller of zinc transport in plant is highly affected by changes in the anatomical structure of conducting tissue and adverse soil conditions like pH, clay content, calcium carbonate content, etc. Zn deficiency results in severe yield losses and in acute cases plant death. Zn deficiency in edible plant parts results in micronutrient malnutrition leading to stunted growth and improper sexual development in humans. To overcome this problem several strategies have been used to enrich Zn availability in edible plant parts, including nutrient management, biotechnological tools, and classical and molecular breeding approaches. There is a synergistic effect between applied zinc in rice because Zn is very dependent on the size of plant available Zn pools in soil, in most parts of cereal growing areas, soils have less availability of Zn to plant roots (Debnath *et al.,* 2019).

Role of Zinc in Plants

The Zn plays very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome. Plant enzymes activated by Zn are involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of auxin synthesis and pollen formation. The regulation and maintenance of the gene expression required for the tolerance of environmental stresses in plants are Zn dependent. Its deficiency results in the development of abnormalities in plants which become visible as deficiency symptoms such as stunted growth, chlorosis and smaller leaves, spikelet sterility. Micronutrient Zn deficiency can also adversely affect the quality of harvested products; plants susceptibility to injury by high light or temperature intensity and to infection by fungal diseases can also increase. Zinc seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effects of short periods of heat and salt stress. As Zn is required for the synthesis of tryptophan which is a precursor of IAA, it also has an active role in the production of an essential growth hormone auxin. The Zn is required for integrity of cellular membranes to preserve the structural orientation of macromolecules and ion transport systems. Its interaction with phospholipids and sulphydryl groups of membrane proteins contributes for the maintenance of membranes (Goto *et al.,* 1999).

Zinc Deficiency in Soil

Zinc deficiency can be found in every part of the world and almost all crops respond positively to application of Zn. Normal soils inherit their trace elements which include Zn primarily from the rocks through geochemical and pedochemical weathering processes. Besides mineralogical composition of the parent material, the total amount of Zn present in the soil is also dependent on the type, intensity of weathering, climate and numerous other predominating factors during the process of soil formation. Meanwhile, high pH and high contents of $CaCO_3$, organic matter, clay and phosphate can fix Zn in the soil and give rise to the reduction of available Zn. Soils derived from granite and gneiss can be low in total Zn. Generally, Zn deficiency is expected in calcareous soils, sandy soils, peat soils, and soils with high phosphorus and silicon. The submerged soils are well recognized for the lack of Zn availability to the plants; particularly due to the reaction of Zn with free sulphide. Flooding and submergence bring about a decline in available Zn because of the changes in pH value and the formation of insoluble Zn compounds. Meanwhile, the insoluble Zn compounds formed are likely to be with Mn and Fe hydroxides from the breakdown of oxides and adsorption on carbonates, specifically magnesium carbonate. Under the submerged conditions for rice cultivation, Zn is transformed into amorphous sesquioxide precipitates or franklinite; $ZnFe_2O_4$.

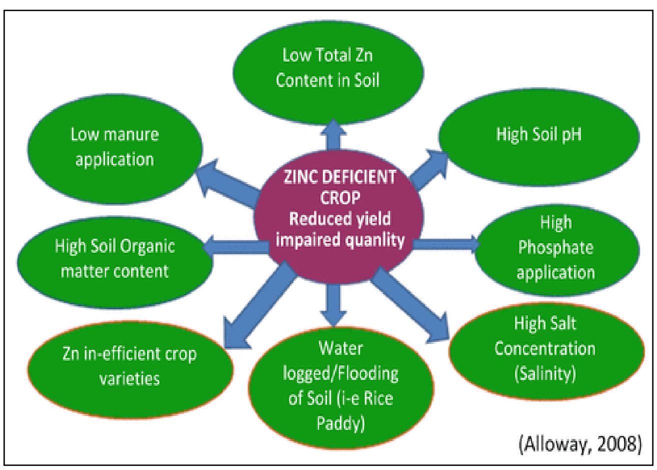

Figure 1: Causes of zinc deficiency in crops

Zinc Interaction with Other Nutrients

Interactions occur between the micronutrients and some macronutrients. 'Interaction' may be defined as "an influence, a mutual or reciprocal action of one element upon another in relation to plant growth". Another factor is the differential response of plants to one element in combination with varying levels of a second element applied simultaneously i.e. the two elements combine to produce an added effect not due to each of them acting alone. Such interactions may take place in the soil and within the plant. These interactions should be taken into account when providing adequate micronutrient supply to plants. Other nutrients may interact with Zn by affecting its availability from soils and its status in the plant throughout the growth process, especially Zn absorption, distribution or utilization. These interactions may enhance or reduce plant growth as a response to Zn. Where an interaction does occur, it is necessary for the diagnosis and treatment of Zn deficiency to identify the factors and its sites and modes of action.

Zinc Efficiency

Zinc efficiency can be defined as "the ability of plants to maintain high yields in soils with low Zn availability". Many mechanisms are perhaps involved in Zn efficiency. Depending on the nature of experiments and plant species, the most significant mechanisms may be Zn utilization in tissues and Zn uptake. Under Zn deficiency, Zn-efficient genotypes have a high activity of Cu/Zn anhydrase and carbonic anhydrase. Zn efficiency and Zn uptake are very susceptible for plant growth and its total content in soil is influenced by several soil properties like pH, $CaCO_3$, organic matter content, crop, as well as cultivars and nutrient interactions in soil environment. There is no precise mechanism used in determining Zn efficiency is available so far however, several crops have been evaluated for their Zn efficiency like beans, wheat and rice.

Zinc Enrichment

During the push of the green revolution towards food security through increasing the yield of staples, little thought was given to human health and the nutritional value of diets. However, most of the research on plant breeding over the past few decades has concentrated on increasing resistance to environmental stresses, pests and pathogens. Genetic engineering has even been used to improve the sensory appeal of agricultural products, such as tomatoes. However, the recent application of plant biotechnology to improve the nutritional content of staple food crops has perhaps the greatest potential to benefit global health. Because poverty limits food access for much of the developing world's population, it is important that affordable staple foods be as nutritious as possible.

Biofortification

Plant derived foods provide an important source of dietary minerals. This is especially true for developing countries where plant foods are a predominant portion of the diet. The concentration of some minerals, especially Zn is inherently low in plants as opposed to animal derived foods, resulting in severe problem of micronutrient malnutrition. Biofortification is a recent approach aimed at increasing the bio available nutrients such as Fe and Zn, in these staple crops rather than using fortificants or supplements. The quantities of minerals in seeds depends on uptake from the rhizosphere into the roots, translocation to the transpiring shoots in the xylem, transfer into leaves or other tissues, and finally, translocation into the seeds in the phloem. A major challenge of biofortification is an incomplete understanding of the pathways and the rate limiting steps involved in translocating minerals to the seeds.

Conclusion

Zinc is very essential plant nutrient for all types of crops. It is deficient in all parts of the globe with different types of soils. Under these conditions application of Zn fertilizer is necessary for healthy crop growth and higher yields. Soil and foliar applications of Zn fertilizer are recommended for correcting deficiencies. Soil dressings of Zn chelates, sulfates and oxides should be broadcast and mixed in the soil.

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