Needs for an Adequate Zinc Fertilization of Crops

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INTRODUCTION

Yield losses and low product quality in areas with agricultural land low in chemical availability of zinc (Zn) require strategies to improve farmers' efforts for better contributing to their field work. This is particularly needed for a better human health in these affected, mainly rural areas with wide-spread Zn malnutrition. In this review, aspects of Zn in soils and crops and the possible strategies for improvement of agronomic and genetic biofortification of food crops with Zn will be discussed.

ZINC IN SOILS AND ACQUISITION BY PLANTS

Agricultural soils with low Zn availability are wide spread in the world (Alloway, 2008). There are two main causes for such a low Zn availability in soils: i) an absolute low Zn content in a soil such as in sandy and calcareous soils (e.g., 15 or 25 mg Zn kg^{-1} soil, respectively) or ii) a low Zn solubility caused mainly due to a high soil pH in calcareous soils (DTPA extractable Zn lower than 0.5 mg kg^{-1} soil). There are estimates that more than 30% of agricultural soils globally cause Zn deficiency in main crops cultivated on these soils (Alloway, 2008). Adverse soil conditions, such as increasing occurrence of drought spells or salinity aggravate this Zn deficiency problem in crop plants (Bagci et al., 2007). Main causes for those observations are impeded growth and activities of roots under these adverse soil conditions, resulting in an inhibited spatial availability of Zn. As a consequence a hidden Zn deficiency in crops can result in severe deficiency with very low Zn concentrations in crops, particularly in grains of cereals as a main food resource in many developing countries.

ZINC IN HUMAN HEALTH AND BIOFORTIFICATION

Zinc deficiency has been recognized as one of the top micronutrient deficiencies in human populations which affect nearly 1/3 of the world's population (Hotz and Brown, 2004). Low dietary intake of Zn represents main cause of Zn malnutrition problem. Interestingly, there is a close relationship between areas with a low Zn availability in soils and areas with human health problems. This wide spread, severe human health problem in mind, science as well as the agrochemical industry together with the farmers are forced to find practicable and cost-effective solutions to improve the Zn status of human beings in such areas affected by Zn deficiency (Cakmak, 2008).

It is nowadays widely accepted that improving Zn status of humans through biofortification of food crops with Zn is the most reliable and cost-effective approach. In biofortification, genetic (breeding) and the agronomic biofortification strategies are of great importance, and these strategies are not competing but rather complementary strategies with different time windows. Both strategies require further support and research in order to maximize Zn accumulation in food crops. Particularly the agronomic biofortification with the application of Zn fertilizers to soils and/or leaves can have big short-term improvements in both human health and crop productivity depending on the severity of soil Zn deficiency. Foliar application of Zn sulfate has been often shown superior over ZnEDTA and over a soil application within an on-going HARVEST PLUS program (www.harvestplus.org) in various developing countries (Cakmak, 2008). However, also the genetic biofortification as a long-term strategy has its justification with a promising outlook as a cost-effective solution in the near future.

AGRONOMIC ADVANTAGES OF ZN FERTILIZATION

Besides the high affectivity of Zn applications in areas affected by Zn deficiency on an improved Zn density of grains for human health there are also two main positive agronomic advantages for farmers which have to be considered in many areas for crop production: first an increase in grain yield and second an alleviation of abiotic and biotic stress events in crops of farmers' fields. The latter gets increasing importance as consequence of global climate changes. On soils with visible Zn deficiency symptoms such as in various areas of India or in Central Anatolia application of Zn results in higher yields and a better fertilizer and water use. But also in soils with a hidden Zn deficiency such Zn application can result in substantial yield increases, but particularly under adverse soil conditions such as drought as a wide spread abiotic stress (Bagci et al., 2007). Under these adverse soil conditions foliar applications are superior over soil applications and a supplementation with a small doses urea can improve the affectivity of such foliar Zn application. In this line are also the well-known observations that an improved Zn status of crop plants by an adequate Zn fertilization can mitigate plant damages by high sun light intensity as another abiotic stress event (Cakmak, 2000). However, not only under abiotic stress conditions an improved Zn status by an adequate Zn supply is of relevance for farmers but also for suppression of various diseases as biotic stress such as Rhizoctonia in barley or crown rot in wheat (Huber and Graham, 1999).

DISSEMINATION OF SCIENTIFIC KNOWLEDGE

The functions of Zn in the various distinct physiological processes of stress mitigation are well studied. But this knowledge is hardly disseminated to farmers for a site-specific and plant developmental stage-dependent application of Zn fertilizers by using an appropriate technology. Often there is only a distinct temporal requirement for an enhanced Zn supply. Thus, innovative fertilization strategies with adapted technologies for Zn application are urgently needed for farmers practice in near future. Such innovative strategies will include, for example Zn seed dressing, placement with stabilized ammonium, intercropping with Zn-efficient crops and inoculation with Zn efficient bio-effectors. In this regard also a general improved root growth for a better spatial Zn acquisition which has to include appropriate soil water content by irrigation must be considered.

CONCLUSION

World-wide agricultural land with a low or marginal Zn status together with increasing stress events requires short-term, innovative strategies for an adapted Zn fertilization practice. This will help to achieve a better crop yield even under environmental stress conditions by an appropriate dissemination of scientific knowledge to farmers' practice. In addition, applying effective Zn fertilization practices can substantially improve grain Zn densities for better human health. Long-term breeding programs as complementary strategy for a high grain density seem to be highly promising and require further support and research with staying power.

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