Plant Soil (2012) 361:1–2
DOI 10.1007/s11104-012-1504-0

EDITORIAL

Zinc for the improvement of crop production and human health

Ismail Cakmak · Ellis Hoffland

Received: 11 October 2012 / Accepted: 15 October 2012 / Published online: 21 October 2012

Zinc (Zn) is an exceptional micronutrient regarding its relevance in biological systems because it is the only trace metal represented in all classes of enzymes (Broadley et al. 2007). A large diversity of essential cellular functions and metabolic pathways are directly influenced by Zn including function and structural stability of proteins, integrity of biological membranes and protection against reactive oxygen species (Cakmak, 2000). Nearly 2800 proteins in biological systems require Zn for their activity and structural stability (Andreini et al. 2009).

It is, therefore, not surprising that crop plants show rapid and particular disturbances in growth and development when they are growing on low Zn soils. At least one-third of the cultivated soils globally is estimated to contain too low amounts of bioavailable Zn (Sillanpää and Vlek 1985) for optimal crop production. Low bioavailability of Zn not only reduces plant productivity, it also impairs nutritional quality of the harvested products by lowering Zn density in seeds/grains.

Responsible Editor: Fangjie Zhao.

I. Cakmak (✉)
Faculty of Engineering and Natural Sciences,
Sabanci University,
34956 Istanbul, Turkey
e-mail: cakmak@sabanciuniv.edu

E. Hoffland
Department of Soil Quality, Wageningen University,
P.O.Box 47, 6700 AA Wageningen, the Netherlands

These problems in crop production, food quality and human health associated with Zn deficiency and the environmental issues related to Zn were addressed at the 3rd International Zinc Symposium held in Hyderabad, India, 10–14 October, 2011, with 195 participants from 30 countries. The event was jointly organized by the International Zinc Association (IZA), the International Fertilizer Industry Association (IFA), Fertilizer Association of India (FAI) and HarvestPlus.

The symposium consisted of 6 sessions devoted to the following topics.

- human nutrition and health,
- soil and crop management,
- zinc fertilizers and crop nutrition,
- plant physiology
- genetics and molecular biology
- environmental issues

This short article summarizes the main findings of this symposium. Details of the findings and conclusions can be found in the articles in this special issue.

Low Zn supply by soils to crops is becoming more prominent due to the use of high yielding cultivars and/or application of macronutrient fertilizers unbalanced by Zn fertilization. In cropping areas with intensified farming, additional management practices (e.g., Zn fertilization) are often required to avoid Zn depletion of soils to sustain crop productivity and nutritional quality of the harvested product. The determination of soil bioavailable Zn, however, is not

straight forward. Commonly used extraction methods and their associated critical deficiency values are not always adequately predicting Zn fertilizer response, and cultivars used can vary in their capacity to mobilise Zn. Evidence is accumulating that application of fertilizers to low Zn soils results in a yield response rather than an increase in grain Zn concentration. This was shown for a variety of crops including major staple food crops such as wheat and rice. There are specific formulations of Zn fertilizers showing variable effects in correcting Zn deficiency, and soil types greatly affect the agronomic effectiveness of the Zn fertilizers. Care should be taken about interactions with macronutrients, as P in soil or N within the plant could interfere with uptake, root-shoot transport and seed deposition of Zn.

Awareness is growing that in areas with relatively low input of chemical fertilizers, soil Zn may be depleted, and thus Zn is becoming a yield-limiting factor. In these areas, with little access to Zn fertilizers, fortification of accessible fertilizers with Zn, organic matter management or reuse of waste Zn rich materials could alleviate Zn deficiency problems. These issues have been discussed in some of the articles of this special issue.

Staple food crops, especially cereals, are inherently low in Zn compared to fish, meat and poultry. So, human populations especially in the developing world, that mainly rely on cereals are highly vulnerable to Zn deficiency. Management strategies targeting grain Zn densities are urgently needed to fight Zn deficiency in human populations and also in livestock. At least one-third of world population is affected by Zn deficiency due to low dietary intake of Zn (Hotz and Brown, 2004). Not surprisingly, many papers in this special issue are based on agronomic and molecular approaches to improve grain Zn concentrations. As shown for rice and wheat, foliar application of Zn fertilizers represents a short term and highly effective strategy to increase grain Zn concentration. Breeding for high grain Zn is also an important solution and discussed as a cost-effective and long-term solution. Over-expression of certain proteins and increasing amount of certain compounds such as nicotianamine have been also shown contributing both to accumulation and availability of Zn in grains. Quick and reliable essays are available used both in screening genotypes for grain Zn and localization and distribution of Zn within grain.

The organizers are most grateful to all participants and sponsors for their great support, and the journal "*Plant and Soil*" for devoting a part of this issue to selected papers from the 3rd International Zinc Symposium. The organizing committee of the 3rd International Zinc Symposium decided to hold the next (4th) International Zinc Symposium in Brazil in 2014.

References

Andreini C, Bertini I, Rosato A (2009) Metalloproteomes: a bioinformatic approach. Acc Chem Res 42:1471–1479

Broadley MR, White PJ, Hammond JP, Zelko I, Lux A (2007) Zinc in plants. New Phytol 173:677–702

Cakmak I (2000) Role of zinc in protecting plant cells from reactive oxygen species. New Phytol 146:185–205

Hotz C, Brown KH (2004) Assessment of the risk of zinc deficiency in populations and options for its control. Food Nutr Bull 25:94–204

Sillanpää M, Vlek PLG (1985) Micronutrients and the agro-ecology of tropical and Mediterranean regions. Fert Res 7:151–167