

Zinc Enrichment of Cereal Grain by Fertilization: Historical Perspective, Constraints and Prospects

Abdul Rashid

National Agricultural Research Center, Islamabad-45500, PAKISTAN
(dr.a.rashid@gmail.com)

SOIL ZINC DEFICIENCY AND HEALTH HAZARDS

Zinc deficiency in soils does not only reduce crop productivity, but it also leads to low-Zn feed and food causing animal and human malnutrition. The problem is global. However, it is more acute in arid to semi-arid regions of the world (Rashid and Ryan 2004). Livestock and humans fed on Zn-poor feed and food, particularly with high calcium levels, are liable to suffer from Zn malnutrition. While severe Zn deficiency is rarely observed in livestock, marginal Zn deficiency, characterized by suboptimal growth, reduced fertility and mild skin disorders, has been reported for sheep and cattle. However, widespread Zn deficiency has been observed in humans. In Pakistan, 40–50% of women and 36–38% of children (<5 years old) suffer from Zn deficiency (Anonymous 2004). The problem pertains to resource-poor rural populations that depend entirely on staple cereals (i.e., wheat and rice) for their diet. Unless addressed adequately, this nutritional problem ought to magnify over time.

HISTORICAL PERSPECTIVE AND POTENTIAL

Historically, grain-Zn composition was believed to remain unaffected by the Zn-fertility status of the soil (Jones 1972). Contradicting the myth, Rashid and Fox (1992) were the first to observe that Zn concentration in grains of numerous cereal and legume species can be enhanced with Zn fertilization (Table 1). Subsequent research around the globe has adequately established that Zn composition of grain depends on the plant genotype as well as the Zn supply to the plant. In moderately Zn-deficient soils, some cereals, like wheat, are generally less susceptible to yield reduction. Thus, yield increases with Zn fertilization may not be substantial. Even in such situations, grain Zn concentration can be more than doubled with Zn fertilization (Rafique et al. 2006). However, a slightly higher Zn dose, in excess of the rate required to maximize crop yield, is required to attain adequate Zn-enrichment of grain. As Zn toxicity *per se* is not a problem and a good dose of Zn remains effective for a number of subsequent crops, this option appears safe as well as cost-effective. Thus, loading of Zn into grain, by tailoring the soil to fit the plant, is a viable alternative to Zn bio-fortification for combating Zn deficiency-induced malnutrition in poor segments of the society, particularly in less developed countries of the world.

Table 1. Cereal grain Zn concentration as affected by Zn fertilization of deficient soils: some examples.

Species	Zn Concentration (mg kg ⁻¹)		Reference
	Control	+Zn	
Wheat	14	71	Rashid and Fox (1992)
Wheat	15	33	Rafique et al. (2006)
Rice	18	44	Rashid and Fox (1992)
Corn	12	45	Rashid and Fox (1992)
Sorghum	6	28	Rashid and Fox (1992)

CONSTRAINTS AND PROSPECTS

Soil-Zn deficiency can be managed by genetic manipulation of plants for high Zn efficiency, like molecular breeding, as well as by Zn fertilization. While field-scale adoption of the former approach is a time consuming task, the latter with an immediate desired impact and high cost-effectiveness is well proven. However, despite adequate recognition of Zn deficiency as a yield limiting factor, the actual use of Zn fertilizer by resource-poor farmers in arid to semi-arid regions of the world is dismally inadequate. With regards to other crop species, the actual use of Zn remains sporadic even in rice, the crop in which this micronutrient deficiency was initially identified in the late 1960s. Major constraints to the use of Zn fertilizer include inadequate availability of quality Zn sources and growers' inability for uniform field application of small quantities of Zn fertilizer. As an alternate, techniques that require low-fertilizer Zn, like Zn-enriched rice nursery, are being adopted to manage the deficiency. These techniques, though effective in curing the deficiency, fail to help enhancing the Zn content of grain or foliage. In this scenario, fertilizer industry must rise to the occasion of providing Zn-fortified fertilizers because fertilization gets more easily adopted by growers.

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