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Foreword

Mineral biofortification and metal/metalloid accumulation in food crops: recent research and trends (Part I)

Shahid Hussain

Department of Soil Science, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan, Pakistan. Email: shahid.hussain@bzu.edu.pk

Introduction

Human health is directly related to the quality of food consumed. Copper (Cu), iron (Fe), manganese (Mn), selenium (Se) and zinc (Zn) are micronutrients that are often deficient in diets consumed around the world (Ritchie and Roser 2017). Plants are the direct or indirect sources of these micronutrients for human consumption. The micronutrient concentrations in plant-based foods are, therefore, the indicators of the balanced and healthy diets of humans. With plant-based foods not providing sufficient micronutrients to meet the human needs, the agricultural sector needed to address this challenge. Micronutrient biofortification of food crops, especially of staple cereal grains, is a promising approach to mitigate the widespread micronutrient deficiencies in susceptible human populations in both developing and developed countries. Several agronomic and genetic approaches have been suggested to increase micronutrient density in edible plant parts. In the last two decades, the research on various aspects of micronutrient biofortification is one of the major foci of plant scientists around the world.

Contamination of natural resources and the resultant accumulation of toxic metal(loid)s such as arsenic (As) and cadmium (Cd) in food crops has increased dietary intake of these contaminants (Afonne and Ifediba 2020). Exposure to their high concentration may lead to both acute and chronic toxicities in human population, even when living far away from the contamination sources. This is quite an opposite challenge to the micronutrient deficiencies in human populations. In living cells, the potentially toxic metal(loid)s are absorbed via the transporters of essential minerals. This makes it very challenging for plant breeders to develop crop cultivars that can differentiate between the essential and toxic elements.

Given the prevailing scenario, it is urgent to develop the strategies for producing micronutrient-dense plant-based foods with the concentrations of heavy metal(loid)s below the maximum permissible levels. The special issue on *Mineral Biofortification and Metal/Metalloid Accumulation in Food Crops* was aimed at publishing the latest research on agronomic and genetic biofortification, and metal/metalloid accumulation in food crops. Following is a brief description of the articles included in part one of the special issue.

Agronomic biofortification

Accumulation of micronutrients in grain may be influenced by source, rate, time and method of fertiliser application. For common bean, soil application of 0.25 mg Se kg^{-1} contributed to water deficit tolerance and Se biofortification (Ravello *et al*. 2022). Comparing Fe application methods for rice, Zulfiqar *et al*. (2022) concluded that grain yield and benefit-to-cost ratio were the highest with Fe osmopriming. However, the largest increase in grain Fe concentration was recorded with foliar Fe application. Ning *et al*. (2022) reported that, as compared to the foliar spray of Zn sulfate alone, grain Zn bioavailability was at par or significantly increased in combined foliar sprays of Zn, insecticides and biostimulants. Micronutrients can also be sprayed on fruits and vegetables after harvest. The postharvest spraying of nano Zn increased Zn concentration and shelf life of tomato fruits (Sharifan *et al*. 2022).

Micronutrients interact with other agricultural inputs and such interactions may influence micronutrient biofortification. Zhang *et al*. (2022) reported that, compared with applying Zn only, the combined Zn and sucrose supply to detached ears of wheat increased grain content of Zn, Fe and proteins. Because of phosphorus (P)-Se interactions in soils, soil P application increased Se desorption from soils and its uptake by Mombaça grass (dos Santos *et al*. 2022).

Wild plant species with edible parts may also be used in human nutrition. Low electrical conductivity and moderate pH in fertigation were associated with optimal yield and micronutrient concentrations (Fe, Zn, Cu and Mn) in wild dune spinach (*Tetragonia decumbens*) (Nkcukankcuka *et al*. 2022).

Genetic biofortification

Genetic and molecular characterisation is important to identify the potentially useful germplasm/genes and to develop micronutrient-dense and/or low-antinutrient cultivars. Tahir *et al*. (2022) evaluated advanced breeding lines of wheat for genes related to Zn and Fe concentrations in grains. From a population of doubled haploid lines of wheat, Lephuthing *et al*. (2022) identified 15 lines (high in Fe, Zn and yield) for future research. Regarding selection of low-antinutrient genotypes, Ragi *et al*. (2022) identified several promising maize hybrids produced from inbred lines of wild-type and subtropically adapted low-phytate mutants (*lpa1–1*). In addition to the above genetic approaches, Ibrahim *et al*. (2022) argued that precise genome editing tools (such as CRISPR/Cas9) can deliver new micronutrient biofortified cultivars with no linkage-drag and biosafety issues.

Understanding expression of genes associated with the antioxidant system, micronutrient uptake and plant growth is fundamental for developing biofortified cultivars suitable for nutrient-poor conditions. Kenzhebayeva *et al*. (2022) studied the parents (cv. Almaken and cv. Zhenis) and their genetically-stable M5 mutant lines of wheat. The grain Fe accumulation under low Fe supply depended on the expression of several genes related to Fe uptake and transport in roots and shoots. In barrel medic, the tolerance to Fe deficiency was linked to the expression of genes coding for Cu chaperone, Fe-SOD and Cu/Zn-SOD, and the leaf accumulation of polyphenol compounds (Kallala *et al*. 2022).

Metal/metalloid accumulation

The studies on toxicity, tolerance and partitioning of heavy metal (loid)s in food crops are prerequisite for producing safe food. Khan *et al*. (2022) suggested that detoxification of both As and Cd in brown mustard occurs via a glutathione-dependent pathway, but the concentration of cysteine (the precursor of glutathione) is regulated differently under Cd versus As stress.

There are numerous reports on As being above the permissible levels in plant-based foods. Along with wise management of irrigation water, the effective agronomic approaches that could mitigate the problem include balanced fertilisation/treatment with essential and beneficial elements, use of metal nanoparticles and application of biochars (Srivastava *et al*. 2022). In zucchini grown under As contamination, chitosan-modified biochar decreased As uptake and increased plant growth (Mehmood *et al*. 2022). Islam *et al*. (2022) suggested seed microbial inoculation to increase plant tolerance to As and concurrently enable phytoremediation of As and other metal (loid)s. Developing new crop cultivars low in toxic metal(loid) accumulation, however, remains one of the fundamental approaches to mitigate the contamination problem.

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