MICRONUTRIENTS: THE BORDERLINE BETWEEN THEIR BENEFICIAL ROLE AND TOXICITY IN PLANTS

Tokhtasinova Yasemin Bakhramovna
SUE "TUPROQSIFATTAHLIL"
tuhtasinovaasemin@gmail.com

Abstract. Recent research focusing on crop micronutrient management revealed several mechanisms involved in micronutrients' uptake and translocation in plants, and their role in plant physiological processes. Moreover, several reports suggest specific strategies that could help toward the optimization of micronutrients application management in modern crop production.
Keywords: Plant, method, micronutrients, mechanism.

INTRODUCTION

Apart from their role in plant growth and development, micronutrients are also essential in plant tolerance against stressors and in plant innate immunity, by being involved in metabolic processes that control plant response and perception to stressors (Jan et al., 2022). However, despite the well-proven beneficial role of micronutrients, excessive applications of such nutrients may lead to plant toxicity, soil contamination and environmental problems, and detrimental health effects (Rehman et al., 2019). Moreover, considering that plant-derived micronutrients are essential for human health, another important aspect in crop nutrition is the biofortification of end-products with micronutrients that could help fighting against mineral deficiencies that plague a great part of world population (Di Gioia et al., 2019).

MAIN PART

Another important micronutrient is Fe whose deficiency can cause chlorosis in many crops. Li, Cao et al. studied Fe deficiency in *Areca catechu* (L.) seedlings and reported chloroplast degeneration and reduced chlorophyll synthesis in chlorotic leaves. Iron-deficient plants showed a down-regulation of nitrate reductase and glutamate synthase gene expression but accumulated more organic acids and flavonoids. In the case of Fe excess, peroxidase-related genes were upregulated as a defense strategy against Fe toxicity.

Manganese is an essential micronutrient for plant growth as it is involved in the structure of photosynthetic proteins and enzymes. However, Mn deficiency might be observed in dry, calcareous and sandy soils, resulting in crop yield reduction. Ijaz et al. studied Mn solubilization and the ability of *Bacillus* spp. strains to solubilize Mn. The Mn-solubilizing bacterial strains were isolated from the maize rhizosphere and could be used as potential bioinoculants to promote plant growth under Mn deficiency. On the other hand, Mn in excess can be toxic to plants as reported by Li, Dong et al., who suggested that metal tolerance proteins (MTPs) may play a critical role in Mn tolerance in plants, including soybean (*Glycine max*). In the same study, it was demonstrated that GmMTP8.1, an endoplasmic reticulum- localized Mn transporter, contributes to confer Mn tolerance by stimulating export of Mn out of leaf cells and increasing sequestration of Mn into intracellular compartments.

Boron is another key micronutrient required for plant growth and development, but causing severe symptoms of phytotoxicity when applied in excess. Khan et al. investigated different B levels in 19 *Aegilops* accessions and one bread wheat cultivar. The impact of B toxicity stress affected growth parameters, with more pronounced effects on shoots rather than roots. In this study, it was also proposed that some of the studied *Aegilops* accessions could potentially be used for developing introgression lines or as pre-breeding material to genetically improve B toxicity-tolerance traits. In another study, Rékási et al. reported that in tomato, green bean, potato, and cabbage irrigated with water containing

0.1 or 0.5 mg/L of B and grown in different soil types, the accumulation of B in plant tissue was influenced by plant species and soil type. Moreover, irrigation with 0.1 mg/L B accelerated tomato fruit ripening and doubled chlorophyll content while
0.5 mg/L B negatively affected green beans nutritional value. Additionally, Pereira et al. reported that when B is absorbed by the roots, it is preferably distributed to developing tissues, such as meristems and reproductive organs. This highlights the potential role of B in mediating plant development programs, by promoting the transition from the vegetative to reproductive phase, as well as enabling land plants to complete their life cycle. Indeed, understanding the mechanisms behind the accepted (and potential) functions of B may help to elucidate how and to what extent B is an important element for plants.
Agronomic biofortification is a new approach used to enhance mineral content in plant tissue and as such may prevent nutritional deficiencies and chronic diseases in humans. Examining the biofortification of several herbs with *selenium (Se)*, Newman et al. found that biofortification not only increased Se levels, but also enhanced total phenols and antioxidant capacity, turning crops tested into functional food. Rakoczy-Lelek et al. also reported on the effectiveness of foliar biofortification of carrots with Se and *iodine (I)* and found that levels of Se and I translocated from leaves to the storage roots were within ranges considered safe for consumption. However, no synergistic or antagonistic interaction between Se and I was observed in terms of biofortification effectiveness in roots, suggesting the possibility to biofortify carrots with multiple minerals. Additional work on I uptake, translocation and metabolism in lettuce was performed by Smoleń et al. by testing different sources of I whether or not combined with vanadium (V) fertilization. The study revealed that several genes (i.e., *per64-like*, *samdmt*, *msams5*, and *cipk6*) played a functional role. It was proposed that the protein encoded by *cipk6* may function as a triiodothyronine (T3) or thyroxine (T4) receptor, mainly in lettuce roots. Additionally, the *per64-like*, rather than the *per12-like* gene, may encode a V-dependent haloperoxidase (vHPO), an enzyme that participates in I uptake.
Among those, agronomic biofortification proposed as an effective strategy for enhancing the micronutrient profile of target crops, emerges in this Research Topic as a new area of research that advances our understanding of micronutrients metabolism in plants while contributing to address nutrition security issues. Finally, besides providing an update of the state of the art of micronutrient research, this Research Topic offers a perspective on future research needs and priorities. Emerging areas of research related to micronutrients include investigating (i) micronutrient roles and function in plant metabolism and their uptake and transport within the plant as a function of different genetic and environmental factors; (ii) novel fertilizer management strategies to address plant micronutrient deficiency or toxicity stress, (iii) the use of plant grafting and epigenetic technology to address micronutrients deficiency and/or toxicity stress; (iv) sustainable strategies for the development of functional food through agronomic biofortification techniques, including the use of biofertilizers, biostimulants, supplemental artificial lighting, and micronutrient nanoparticles.

REFERENCES

1. Ayoub, A. T. (1999). Fertilizers and the environment. *Nutr. Cycl. Agroecosyst.* 55, 117–121. doi: 10.1023/A:1009808118692
2. Baldantoni, D., Saviello, G., and Alfani, A. (2019). Nutrients and non- essential elements in edible crops following long-term mineral and compost fertilization of a Mediterranean agricultural soil. *Environ. Sci. Pollut. Res.* 26, 35353–35364. doi: 10.1007/s11356-018-3353-8
3. Di Gioia, F., Petropoulos, S. A., Ozores-Hampton, M., Morgan, K., and Rosskopf,

4. E. N. (2019). Zinc and iron agronomic biofortification of Brassicaceae microgreens. *Agronomy* 9, 110677. doi: 10.3390/agronomy9110677

5. Jan, A. U., Hadi, F., Ditta, A., Suleman, M., and Ullah, M. (2022). Zinc- induced anti-oxidative defense and osmotic adjustments to enhance drought stress tolerance in sunflower (*Helianthus annuus* L.). *Environ. Exp. Bot.* 193, 104682. doi: 10.1016/j.envexpbot.2021.104682