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

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Introduction

Widespread deficiencies of essential minerals in human populations require the agricultural sector to produce nutritious plant-based foods. For that, mineral biofortification of food crops is a promising approach (Stangoulis and Knez 2022). On the other hand, the contamination of soil resources and the resultant accumulation of heavy metal(loid)s in food crops have increased dietary exposure to these toxic elements (Anaman *et al.* 2022). In such a situation, developing strategies for producing mineral-dense plant-based foods having only the permissible levels of heavy metal(loid)s is urgent and highly challenging.

Considering the importance of the research area, a special issue of *Crop & Pasture Science* was called to publish the latest research on *Mineral Biofortification and Metal/Metalloid Accumulation in Food Crops*. In response to the call, 226 manuscripts were submitted to the journal from the six continents. Due to time and page limitations, we were able to publish only 52 manuscripts in the special issue. Thirty-three articles were included in the previous two parts of the special issue (Hussain 2022*a*, 2022*b*) and the remaining 19 are included in this last part.

Mineral biofortification

Many scientists are now working to develop effective and sustainable approaches to agronomic biofortification. Chugh *et al.* (2022) reviewed the current use of iron (Fe) nano-fertilisers for Fe biofortification; they also identified the challenges that must be addressed to optimise nano-fertilisation for sustainable agriculture. For wheat grown in acidic soil, Jalal *et al.* (2022*a*) compared foliar rates of ZnO nanoparticles for increasing grain zinc (Zn) concentration and grain yield. In oat, concentrations of selenium (Se) in grains from soil application of nano-elemental Se were 7- to 20-fold higher than the concentrations in those from bulk elemental Se, but 5- to 16-fold lower than the concentrations in those from sodium selenate (Zeinali *et al.* 2022). Grain yield of oat, however, was significantly higher with nano-elemental Se than the other sources tested in the study.

Macronutrients [e.g. nitrogen (N) and sulfur (S)] may influence soil and plant processes that control soil mobilisation, root uptake, shoot translocation and grain accumulation of micronutrients. Several studies on biofortification have reported positive effects of the combined applications of N and micronutrients (see Kaur and Singh 2022). Based on field experiments, Petković *et al.* (2022) recommended combining N applications with Zn and Se applications for increased fodder yield and improved mineral composition. In another study, both the soil application of Se-enriched urea and foliar spray of Se significantly increased Se contents in grains of common beans (Araújo *et al.* 2022). Integrated approaches to nutrient management may also influence mineral biofortification in crop plants. For example, summer green manuring and elemental S fertilisation of rice–wheat cropping system had significant effects (compared with respective controls) on increasing grain micronutrient concentrations (Zn, Fe, copper and manganese) and grain yields (Mandi *et al.* 2022). For wheat, a sustainable approach to Zn biofortification is combining soil Zn application with inoculation of diazotrophic bacteria on seeds (Jalal *et al.* 2022*b*).

Micronutrient fertilisers remain the key method of agronomic biofortification. In field-grown peas, the combined foliar applications of Zn and Se increased Zn and Se concentrations in grains by around 30% and 73%, respectively (Reynolds-Marzal *et al.* 2022). Comparing different soil Zn rates, Verma *et al.* (2022) recommended 10 kg Zn ha^{-1} for field-grown rice as the best treatment for grain yield, benefit-cost ratio, and grain Zn accumulation. Comparing selenite and selenate at two rates (5 and 10 mg Se kg^{-1}), Zafeiriou *et al.* (2022) found that a relatively high fraction of the soil-applied selenate was translocated to shoots of rocket plants, but the higher rate (i.e. 10 mg selenate kg^{-1}) was toxic for plant growth.

Metal/metalloid accumulation

Under the increasing soil pollution, it is becoming a challenge to produce plant-based foods that have only permissible levels of toxic metals. For mung beans grown in cadmium (Cd)-contaminated nutrient solution, the application of ZnO nanoparticles increased not only Zn but also Cd concentration in shoots (Rashid *et al.* 2022). Sohail *et al.* (2022) reviewed the agronomic and genetic approaches that are important for producing cereal grains high in Fe but low in toxic metal(loid)s [such as Cd, lead (Pb) and arsenic (As)]. Mamun *et al.* (2022) summarised the latest reports on the use of various organic amendments for soil immobilisation of metals contained in P fertilisers. In tomato plants, application of extract from *Halopteris filicina* (macro-alga) decreased Pb accumulation, with concurrent stabilisation of genomic DNA and stimulation of plant growth (Unal *et al.* 2022).

Mondal *et al.* (2022) provided a comprehensive review of current knowledge on proteomic, transcriptomic and genomic approaches to metal tolerance in plants along with an extensive discussion on the underlying physiological and molecular mechanisms. Evaluating 130 accessions of durum wheat, Alsaleh *et al.* (2022) identified low-Cd genotypes by employing phonotypic (i.e. grain Cd concentration) and genotypic (i.e. molecular markers) parameters. The genotypic differences in plants determine their tolerance to metal stresses. For example, fenugreek tolerated high Fe concentrations by multiple adaptive mechanisms (Mnafgui *et al.* 2022). By partitioning significantly more Pb in roots, fenugreek was relatively more tolerant to Pb than Cd stress (Melki *et al.* 2022).

References

Alsaleh A, Baloch FS, Sesiz U, Nadeem MA, Hatipoğlu R, Erbakan M, Özkan H (2022) Marker-assisted selection and validation of DNA markers associated with cadmium content in durum wheat germplasm. *Crop & Pasture Science* **73**, 943–956. doi:10.1071/CP21484

Anaman R, Peng C, Jiang Z, Liu X, Zhou Z, Guo Z, Xiao X (2022) Identifying sources and transport routes of heavy metals in soil with different land uses around a smelting site by GIS based PCA and PMF. *Science of the Total Environment* **823**, 153759. doi:10.1016/j.scitotenv.2022.153759

Araújo SNd, Raymundo JF, Costa FFR, Lessa JHdL, Guilherme LRG, Lopes G (2022) Selenium application methods and rates for biofortification of common bean and their residual effects on Mombaça grass. *Crop & Pasture Science* **73**, 792–803. doi:10.1071/CP21501

Chugh G, Siddique KHM, Solaiman ZM (2022) Iron fortification of food crops through nanofertilisation. *Crop & Pasture Science* **73**, 736–748. doi:10.1071/CP21436

Hussain S (2022*a*) Mineral biofortification and metal/metalloid accumulation in food crops: recent research and trends (Part I). *Crop & Pasture Science* **73**, 1–2. doi:10.1071/CPv73n2_FO

Hussain S (2022*b*) Mineral biofortification and metal/metalloid accumulation in food crops: recent research and trends (part II). *Crop & Pasture Science* **73**, 425–426. doi:10.1071/CP21123_FO

Jalal A, Galindo FS, Freitas LA, Oliveira CEdS, Lima BHd, Pereira ÍT, Ferraz GF, Souza JSd, Costa KNd, Nogueira TAR, Teixeira Filho MCM (2022*a*) Yield, zinc efficiencies and biofortification of wheat with zinc sulfate application in soil and foliar nanozinc fertilisation. *Crop & Pasture Science* **73**, 749–759. doi:10.1071/CP21458

Jalal A, Oliveira CEdS, Freitas LA, Galindo FS, Lima BH, Boleta EHM, da Silva EC, Nascimento Vd, Nogueira TAR, Buzetti S, Teixeira Filho MCM (2022*b*) Agronomic biofortification and productivity of wheat with soil zinc and diazotrophic bacteria in tropical savannah. *Crop & Pasture Science* **73**, 817–830. doi:10.1071/CP21457

Kaur A, Singh G (2022) Zinc and iron application in conjunction with nitrogen for agronomic biofortification of field crops – a review. *Crop & Pasture Science* **73**, 769–780. doi:10.1071/CP21487

Mamun SA, Saha S, Ferdush J, Tusher TR, Islam MS (2022) Organic amendments for crop production, phosphorus bioavailability and heavy metal immobilisation: a review. *Crop & Pasture Science* **73**, 896–916. doi:10.1071/CP21726

Mandi S, Shivay YS, Prasanna R, Kumar D, Purakayastha TJ, Pooniya V, Nayak S, Raihan O, Baral K, Pal M (2022) Improving micronutrient density in basmati rice and durum wheat through summer green manuring and elemental sulfur fertilisation. *Crop & Pasture Science* **73**, 804–816. doi:10.1071/CP21313

Melki F, Talbi Zribi O, Jeder S, Louati F, Nouairi I, Mhadhbi H, Zribi K (2022) Cadmium and lead excess differently affect growth, photosynthetic activity and nutritional status of *Trigonella foenum-graecum* L. *Crop & Pasture Science* **73**, 969–980. doi:10.1071/CP21583

Mnafgui W, Rizzo V, Muratore G, Hajlaoui H, Schinoff BdO, Mnafgui K, Elleuch A (2022) *Trigonella foenum-graecum* morphophysiological and phytochemical processes controlling iron uptake and translocation. *Crop & Pasture Science* **73**, 957–968. doi:10.1071/CP21419

Mondal R, Kumar A, Shabnam AA, Chaturvedi AK (2022) Elucidation of molecular and physiological mechanisms addressing integrated omic approaches for heavy metal stress tolerance in crops. *Crop & Pasture Science* **73**, 927–942. doi:10.1071/CP21467

Petković K, Manojlović M, Čabilovski R, Lončarić Z, Krstić Đ, Kovačević D, Ilić M (2022) Nitrogen fertilisation affected zinc and selenium biofortification in silage maize. *Crop & Pasture Science* **73**, 781–791. doi:10.1071/CP21735

Rashid MH, Rahman MM, Halim MA, Naidu R (2022) Growth, metal partitioning and antioxidant enzyme activities of mung beans as influenced by zinc oxide nanoparticles under cadmium stress. *Crop & Pasture Science* **73**, 862–876. doi:10.1071/CP21598

Reynolds-Marzal MD, Rivera-Martín AM, Pinheiro NM, Rodrigo SM, Santamaria O, Poblaciones MJ (2022) Combined zinc and selenium biofortification in field peas under Mediterranean conditions. *Crop & Pasture Science* **73**, 831–841. doi:10.1071/CP21711

Sohail MI, Zia ur Rehman M, Aziz T, Akmal F, Azhar M, Nadeem F, Aslam M, Siddiqui A, Khalid MA (2022) Iron bio-fortification and heavy metal/(loid)s contamination in cereals: successes, issues, and challenges. *Crop & Pasture Science* **73**, 877–895. doi:10.1071/CP21771

Stangoulis JCR, Knez M (2022) Biofortification of major crop plants with iron and zinc - achievements and future directions. *Plant and Soil* **474**, 57–76. doi:10.1007/s11104-022-05330-7

Unal D, Sevim G, Varis G, Tuney-Kizilkaya I, Turkyilmaz Unal B, Ozturk M (2022) Ameliorative effect of *Halopteris filicina* extracts on growth parameters and genomic DNA template stability of tomato (*Solanum lycopersicum*) under lead chloride stress. *Crop & Pasture Science* **73**, 917–926. doi:10.1071/CP21455

Verma G, Dhaliwal SS, Sharma V (2022) Yield and zinc accumulation response of basmati rice to incremental zinc fertilisation of a zinc-deficient soil. *Crop & Pasture Science* **73**, 842–849. doi:10.1071/CP21391

Zafeiriou I, Gasparatos D, Ioannou D, Massas I (2022) Selenium uptake by rocket plants (*Eruca sativa*) grown in a calcareous soil as affected by Se species, Se rate and a seaweed extract-based biostimulant application. *Crop & Pasture Science* **73**, 850–861. doi:10.1071/CP21529

Zeinali S, Yoon KS, Esselman E, Lin Z-Q (2022) Selenium bioconcentration in Canadian oat (*Avena sativa*) from soils treated with nanoscale elemental selenium. *Crop & Pasture Science* **73**, 760–768. doi:10.1071/CP21465

Conflicts of interest. The author declares no conflicts of interest.

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