Magnesium in crop production and food quality

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Received: 19 October 2020 / Accepted: 21 October 2020 / Published online: 25 October 2020
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After very successful International Symposia on Magnesium in Crop Production and Food Quality in Göttingen, Germany, in May 2012, and in São Paulo, Brazil, in November 2014, the 3rd International Symposium was held in Guangzhou, China, in November 2018. The main topics of this Symposium were the roles of magnesium (Mg) in plant physiology, the molecular biology of plant Mg nutrition, and the consequences of crop Mg nutrition for the nutrition of humans and their livestock.

The role of cereals, and their processing, for human Mg nutrition was an important topic of discussion at the Symposium. Cereal grains represent a major source of dietary Mg for human nutrition (White 2016). However, as discussed in this Special Issue by Rosanoff and Kumssa (2020), cereal grains are often subjected to intensive processing, which results in significant losses of Mg and consequently reduces potential Mg intakes from cereal grains by humans. Rosanoff and Kumssa (2020) also observed that the Mg nutritional status of

humans is affected by body weight which is, however, not considered by international organizations when estimating daily Mg requirements. Prevalence of overweight and obesity among adults is growing worldwide, which would, therefore, affect daily Mg requirements.

Adequate Mg nutrition is also necessary for the healthy growth of animals, and is a challenge especially for grazing livestock. Sufficient amounts of available Mg are needed in soils as well as in grass to meet the Mg demand of grazing animals and avoid Mg deficiency-related disorders, such as “grass tetany” (White and Broadley 2009), which is a potentially fatal metabolic disorder in animals. In this Mg Special Issue, Kumssa et al. (2020) present several experiments, conducted under both controlled environment and field conditions, examining the potential of Mg fertilization for the enrichment (i.e., biofortification) of Italian ryegrass with Mg. Their results show that the addition of Mg fertilizers is a highly effective strategy for biofortification of Italian ryegrass and, consequently, maintaining the Mg nutritional status of animals. They also observed that cultivars of Italian ryegrass differ greatly in their abilities to accumulate Mg. The cultivar Bb2067 had the largest leaf Mg concentration and it was also the most responsive cultivar to Mg fertilization. In a complementary paper, Penrose et al. (2020) show that Bb2067 consistently exhibits larger leaf Mg concentrations than other cultivars of Italian ryegrass grown across multiple locations and years. The large leaf Mg concentrations found in Bb2067 were not related to low yield. Bb2067 is a highly promising cultivar for reducing the risk of grass tetany in livestock and

Responsible Editor: Hans Lambers.

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Penrose et al. (2020) suggest its inclusion in future breeding programs.

Magnesium also helps protect crop plants against various environmental stresses, including heat (Mengutay et al. 2013), high light radiation (Cakmak and Marschner 1992) and soil acidity and aluminum (Al) toxicity (Rengel et al. 2015). Three papers in this Special Issue focus on the mitigation of abiotic stresses by Mg nutrition of plants. Boaretto et al. (2020) show that adequate Mg nutrition of young lemon trees has an important protective effect against simultaneous exposure to high air temperatures and sunlight, especially in combination with sufficiently high nitrogen (N) supply. Combined fertilization of lemon trees with Mg and N had positive effects on the utilization of absorbed light energy in photosynthesis and the activity of antioxidant enzymes, such as chloroplastic H₂O₂-scavenging enzymes, at high air temperatures and elevated irradiance.

Similarly, appropriate Mg nutrition mitigates the detrimental effects of Al toxicity in plants. In this Special Issue, Kong et al. (2020) show that an adequate Mg supply reduces Al uptake and improves the growth of maize plants exposed to high Al concentrations in the rhizosphere. Increasing Mg supply also increased the antioxidative capacity of maize plants and promoted the expression of genes encoding superoxide dismutase, catalase and peroxidase when plants were exposed to Al stress. The results presented by Li et al. (2020) indicate a role for nitric oxide (NO) in the Mg-mediated mitigation of root growth inhibition by Al in *Arabidopsis thaliana* and the development of Al resistance. These authors show that exposure of plants to increasing Al toxicity resulted in a significant increase in NO production with a simultaneous reduction in root elongation, especially when Mg supply was low. Supplying more Mg resulted in reduced enzyme activities and expression of genes involved in NO biosynthesis.

Magnesium nutritional status of plants also has large effects on the uptake of N by roots. In this Special Issue, Peng et al. (2020) describe studies exploring the effects of Mg nutrition on root N uptake in soybean plants. Adequate Mg nutrition increased root N uptake and shoot N accumulation when N was applied as nitrate, but not when N was supplied as ammonium. A transcriptomic study indicated that two genes encoding nitrate transporters (*NRT2.1* and *NRT2.2*) were strongly upregulated in plants supplied with adequate Mg. Peng et al. (2020) observed that the upregulation of nitrate

transporter genes with improved Mg nutrition is likely related to increased shoot-to-root translocation of sucrose.

More than 250 researchers attended the Symposium in 2018. It was organized by the International Magnesium Institute (IMI), Fujian Agriculture and Forestry University and China Agricultural University with support from the Vegetable Research Institute of Guangdong Academy of Agricultural Sciences, China, the Institute of Applied Plant Nutrition (IAPN) at Göttingen University, Germany, Sabanci University, Istanbul, Turkey, the Center for Magnesium Education and Research, Hawaii, USA, and Shenzhen K + S Trading Co., Ltd.

The organizers of the 3rd International Magnesium Symposium thank *Plant and Soil* for publishing this Special Issue on Magnesium.

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