

Fortification of micronutrients for efficient agronomic production: a review

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Abstract Micronutrients are essential mineral elements required for both plant and human development. However, micronutrients are often lacking in soils, crop, and food. Micronutrients are therefore used as fertilizer to increase crop productivity, especially when the application of conventional NPK fertilizers is not efficient. Here, we review the application of micronutrients in crop production. Reports show that micronutrients enhance crop nutritional quality, crop yield, biomass production, and resiliency to drought, pest, and diseases. These positive effects range from 10 to 70 %, dependent on the micronutrient, and occur with or without NPK fertilization. We discuss the uptake by plants of micronutrients as nanosize particulate materials, relative to conventional uptake of ionic nutrients. We also show that packaging of micronutrients as nanoparticles could have more profound effects on crop responses and fertilizer use efficiency, compared to conventional salts or bulk oxides.

Keywords Agronomic fortification · Micronutrients · Crop nutrition · Crop productivity · Innovative fertilizers · Nutrient packaging

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1 Introduction

The task of feeding the global human population estimated at 9.6 billion by 2050 (United Nations 2013), combined with dietary transitions accompanying the change in human socio-economic statuses, calls for the intensification of farming systems. Achieving this goal entails increasing the quantity and quality of crop production inputs such as water, seed, pesticide, and fertilizer (Tilman et al. 2011). As a crucial input in modern agriculture, fertilizers make an important contribution to the attainment of high crop yields (Erisman et al. 2008). Agricultural productivity increased in many of the regions that experienced the Green Revolution through the application of nitrogen, phosphorus, and potassium (NPK)-containing

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