Better Nitrogen Nutrition Results in Enhanced Uptake, Transport and Grain Deposition of Zinc in Wheat

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INTRODUCTION

Zinc (Zn) deficiency is a widespread nutritional problem, caused mainly by insufficient diversity in diet and low dietary intake. In countries, where Zn deficiency is documented as a major public health concern, cereal-based foods are the predominant source of calories. Among the staple food crops, wheat is the most important food crop in a number of developing countries with respect to its contribution to the daily calorie intake. Wheat is, however, inherently too poor in Zn and Fe to meet the demands of human beings for Zn.

Biofortification of wheat with Zn in order to alleviate the associated health problems is a global challenge. Based on the hypothesis that nitrogen (N) nutrition may affect the transporter proteins and other nitrogenous molecules which are involved in root uptake, root-to-shoot transport, remobilization and grain accumulation as well as grain localization of Zn, the potential of N fertilization in biofortification of wheat grain was investigated.

METHODS

Several greenhouse experiments were conducted in order to study the effects of soil and foliar applications of N and Zn on grain Zn accumulation and localization as well as Zn partitioning among shoot organs in wheat. *Triticum durum* cv. Balcali2000 was grown on Zn-deficient soil, which was fertilized with different amounts of N and Zn. Depending on experimental design, grains and/or other shoot parts were harvested, dried and weighed. Samples were acid-digested and analyzed for the concentrations of Zn and other relevant essential minerals by ICP-OES. For N determination, samples were analyzed by a LECO TruSpec C/N analyzer.

Radio-labeled Zn (^{65}Zn) was used in another set of experiments carried out either in solution culture under growth chamber conditions or in soil culture under greenhouse conditions. These focused specifically on the effects of N nutrition on the uptake or root-to-shoot translocation or remobilization of Zn. Radio-labeled Zn was applied to the roots or selected leaves of plants growing at different N levels. Radioactivity in harvested plant parts was determined by a gamma counter.

RESULTS AND DISCUSSION

When sufficient Zn was supplied to the plants via soil and/or foliar applications, increasing the soil N application had a significant positive effect on the grain Zn concentration (Fig. 1). However, under Zn-deficient conditions, N treatments were ineffective. Nitrogen and Zn appear to act synergistically in improving the grain Zn concentration when both minerals are supplied in sufficiently high amounts. The Zn concentration is enhanced not only in the whole grain but also the endosperm, which is inherently poor in Zn and yet the most widely consumed part of the grain.

Under high Zn availability, higher N supply increased the total Zn content of above-ground parts of mature plants by up to 300%, indicating a significant enhancement in root uptake. Higher N application also led to a 240% increase in Zn remobilization to grains. Studies with radio-labeled Zn revealed that both the root uptake and the root-to-shoot translocation rate of Zn were significantly improved by higher levels of N supply (Fig. 2). Moreover, a better N nutritional status was associated with an improved remobilization of leaf-applied ^{65}Zn out of treated leaves in young seedlings and to developing grains in maturing plants.

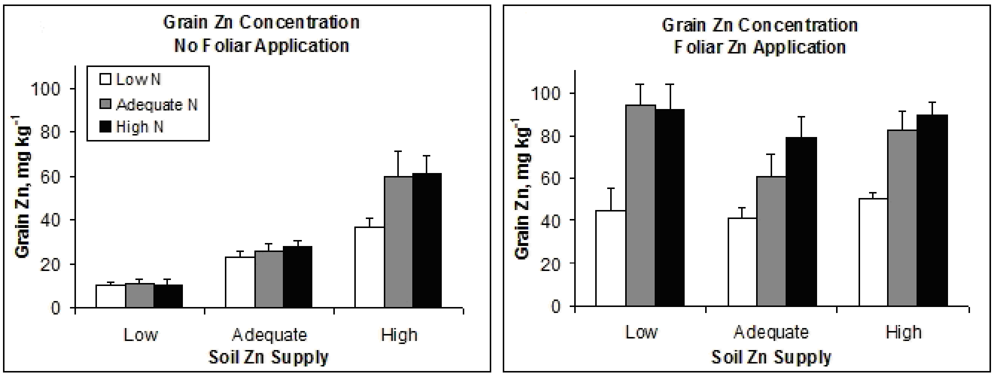

Fig. 1. Effect of N nutrition on grain Zn concentration, depending on soil and foliar Zn applications

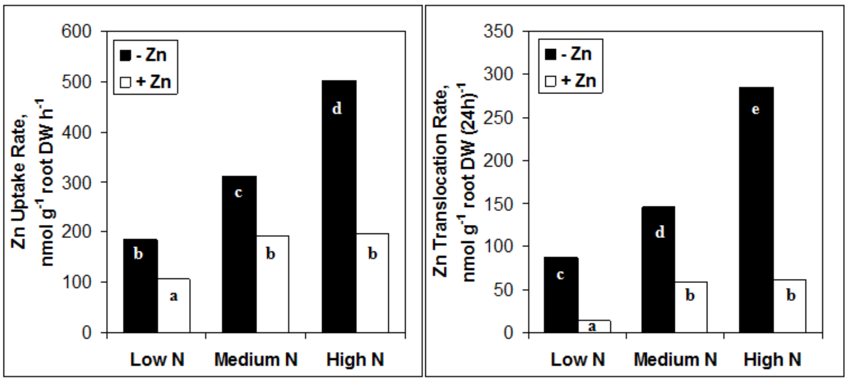

Fig. 2. Effect of N nutrition on ^{65}Zn uptake and translocation rates of Zn-deficient and Zn-sufficient wheat seedlings

CONCLUSIONS

On the way of Zn to wheat grain, all major processes, including uptake, translocation, remobilization and grain deposition, are under the influence of N nutritional status. Therefore, optimized nitrogen application to wheat, particularly in conjunction with foliar Zn treatment, appears to be a powerful tool for tackling Zn deficiency in societies whose diets are based on wheat products.

ACKNOWLEDGEMENTS

This study was financially supported by HarvestPlus Biofortification Challenge Program.

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