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A roadmap towards the development of Zn-biofortified rice for Madagascar

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Abstract

One-third of the human population consumes insufficient quantities of zinc (Zn) to sustain a healthy life. Increasing Zn concentrations in edible parts of food crops, an approach termed Zn-biofortification, is one cost-effective option to address this problem. Especially infants in countries like Madagascar are at risk of Zn deficiency because their dominant food source, rice, contains insufficient Zn. Breeding biofortified rice varieties with increased grain Zn concentrations would offer a solution and our objective is to explore the genotypic variation present among rice gene bank accessions compared to Zn-biofortified breeding lines and local varieties. A second objective was to investigate to what extent genotype, environment and their interactions contribute to variation in grain Zn concentrations.

Multi-environment trials conducted over four seasons in Madagascar revealed that local varieties had very low grain Zn concentrations in the range of 18–20 ppm Zn, which is far below the breeding target of 30 ppm Zn. Imported Zn-biofortified breeding lines reached 25–30 ppm Zn but lacked adaptation to local conditions and therefore do not offer a short-term solution. In gene-bank accessions grain Zn concentrations up to 40 ppm were detected, especially in accessions belonging to the aus subspecies of rice native to the Indian subcontinent. Across sites and seasons variation in grain Zn was attributed to 76–78 % by genotype (G) effects with much smaller contributions by the environment (E) and genotype by environment interactions (GEI). This rather high stability of grain Zn differences across sites and years contrasted with dominant E and GEI contributions to grain yield.

This has positive implications for Zn-biofortification breeding. Selection for Zn could be centralised at very few sites in earlier generations whereas selection for grain yield and general adaptation would have to rely on multi-environment testing in later generations. High-Zn gene-bank accessions and breeding lines identified here represent suitable donors and have been crossed to locally preferred varieties in an effort to develop healthier rice varieties that can alleviate Zn malnutrition in Madagascar and other countries relying predominantly on rice in daily diets.

Keywords: Genomic prediction, grain Zn concentrations, hidden hunger, rice breeding, Zn malnutrition

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