Distribution of Zinc in Barley Grain

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INTRODUCTION

Zinc (Zn) deficiency is a widespread problem that reduces yield and grain nutritive value in many cereal-growing regions in the world (Genc *et al.,* 2009). It has been estimated that 49% of the world population is at risk of suffering from Zn deficiency (Tauris *et al.,* 2009). One approach to increasing Zn concentration in seeds is fertilization of plants via soils or foliar sprays, but there is no direct economic motivation for farmers to improve the nutritional quality of seeds through fertilization (Cakmak *et al.,* 2000). Zinc-efficient genotypes have the capacity to grow and yield well on Zn-deficient soils (Pearson & Rengel, 1997), so an alternative approach to increase grain Zn concentration of staple food crops would be to exploit the genetic variation in concentrations of Zn in seeds. The underlying genetic basis of Zn-efficiency is not well understood yet, so this has hampered efforts to breed crops with enhanced Zn efficiency (Lonergan *et al.,* 2009). The aim of this study was to characterize differences between Zn-inefficient genotype Clipper and Zn-efficient genotype Sahara in Zn distribution in different grain parts during grain development.

METHODS

Two barley genotypes (Clipper and Sahara) were grown in plastic-bag-lined pots with deficient (0.3 mg Zn kg^{-1} soil) or sufficient (3.0 mg Zn kg^{-1} soil) Zn treatment. The experiment was set up in a completely randomized block design with three replicates.

Grain samples were collected between anthesis and full maturity and were hand-separated into embryo, seed coat and endosperm. The samples were oven dried for 72 hours at 70°C. Dried samples were digested with mixture of 70% (v/v) nitric acid (HNO_3) and concentrated perchloric acid ($HClO_4$). Zinc concentration was determined by inductively coupled plasma-mass spectrometry (ICP-MS). Statistical analyses were done with SAS software (SAS/STAT 9.1.3. Cary, N.C., USA, SAS Institute Inc.).

RESULTS AND DISCUSSION

Grain Zn concentration decreased during grain filling in both genotypes and Zn treatments. During grain filling, grain dry weight increased significantly, so decreases in grain Zn concentration during that period could have been due to a “dilution effect”. Total Zn content per grain increased during grain development in both genotypes and Zn treatments (Fig. 1).

Distribution of Zn within grain parts varied among harvests, and only Zn content in embryo increased consistently in both genotypes and Zn treatments during grain filling. At full maturity in the deficient-Zn treatment in genotype Clipper, the seed coat and embryo accounted for 72% of total grain Zn, whereas in the sufficient-Zn treatment, a major proportion of grain Zn was distributed between endosperm and the seed coat (81%). In both Zn treatments in genotype Sahara, the proportion of seed coat Zn to total grain Zn was high during grain development; at full maturity in the sufficient-Zn treatment, 52% of total grain Zn was stored in the seed coat.

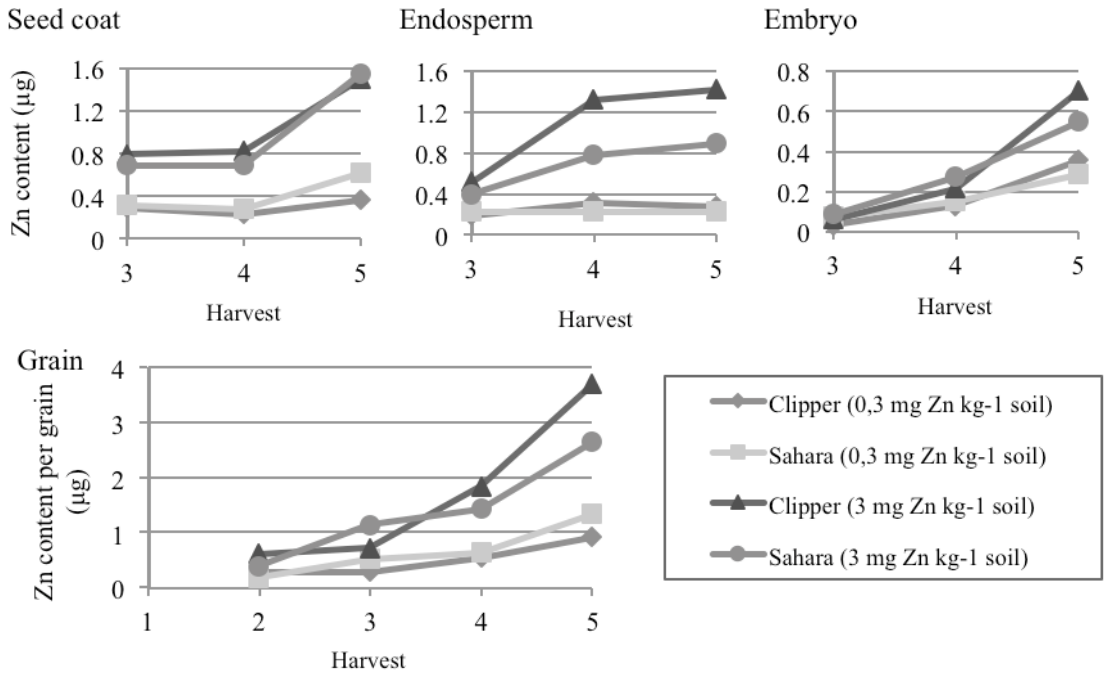

Fig. 1. Zn content in grain, endosperm, seed coat and embryo from anthesis (Harvest 1) to full maturity (Harvest 5).

CONCLUSIONS

The embryo had the highest Zn concentration among the analysed grain parts. The endosperm and embryo Zn concentration decreased while the Zn content increased during grain development, with substantially lower Zn contents for plants grown at deficient soil Zn. At full maturity, more than 50% of grain Zn was stored in the seed coat in Sahara, so the seed coat should be considered as a potentially valuble source of Zn in the human diet.

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