Concentrations of Bioavailable Zinc in Maize Grain Determined in a Vast Experiment

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INTRODUCTION

Maize breeding for higher Zn concentration in grain has been proposed as a sustainable strategy for reducing Zn deficiency in humans (Mason and D'Croz-Mason 2002, Welch and Graham 2002, Brkic et al. 2003). However, bioavailability of dietary Zn is affected by phytic acid, the predominant storage form (up to 90%) of P in maize grain. There are low-phytic acid strains in maize, but they express some less favorable agronomic features, e.g., reduction of seedling vigor (Banziger and Long 2000). Hence, identifying the relation between P and Zn concentrations in standard maize strains could be a way of increasing Zn bioavailability in maize grain during the breeding process.

The objectives of this study were to examine differences in Zn and P concentrations in grain among non-low-phytic acid maize genotypes determined in a vast experiment and to investigate the relationship between these concentrations, including the P:Zn ratio in grain as a quantitative trait of maize grain.

METHODS

Two elite dent inbred lines with contrasting Zn concentrations (Brkic et al. 2003) belonging to different heterotic pools were used as parents. Randomly chosen F_2 plants from the cross of the parents were selfed to produce 294 independently derived F_4 plants ($F_{3:4}$). The 294 F_4 families along with six checks, which included the parents and the subsequent F_1 generation, were grown in two replicates in 2005 in a soil of moderate fertility showing no nutrient deficiencies (eutric cambisol) at the Agricultural institute Osijek Experimental Station in Osijek, Croatia. Each replicate was randomized in a 30x10 alpha (0,1) design. The single-row plots were 6 m long with 0.75 m spacing between rows. Five random plants per row were selfed and harvested. For chemical analysis, grain samples were taken from a mix of the five selfed ears per plot.

The concentrations of P and Zn in kernels were determined by Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) after microwave digestion in the laboratory of the Research Institute for Soil Science and Agricultural Chemistry of Hungarian Academy of Science and Arts in Budapest, Hungary. Kernels were digested in 65% nitric acid (HNO_3) and 30% hydrogen-peroxide (H_2O_2) using a Milestone MLS 1200 microwave. The concentrations were measured using a Jobin-Yvon Ultrase 238 ICP-OES.

RESULTS AND DISCUSSION

The analysis of variance showed significant variation among 300 genotypes in P and Zn concentrations and in P:Zn ratios in grain (data not shown). The data of P:Zn ratios fitted a normal distribution according to the W-test charaterizing the ratio as a quantitative trait and corroborating herewith the findings of Vragolovic et al (2006).

The grain concentration ranges were 2736 – 3772 for P and 15.5 – 34.4 for Zn (both in mg kg^{-1} dry weight), as shown in Fig. 1. The range in Zn concentrations was somewhat wider

than the ranges obtained in previous evaluations, which included a large number of landraces, varieties and breeding germplasm (Welch and Graham 2002).

The association between P and Zn concentrations was weak (r = 0.30). This indicates that breeding non-low-phytic acid maize genotypes with a better P:Zn relation is possible. The P:Zn ratios varied from 91.5 to 182.6 indicating a considerable variation.

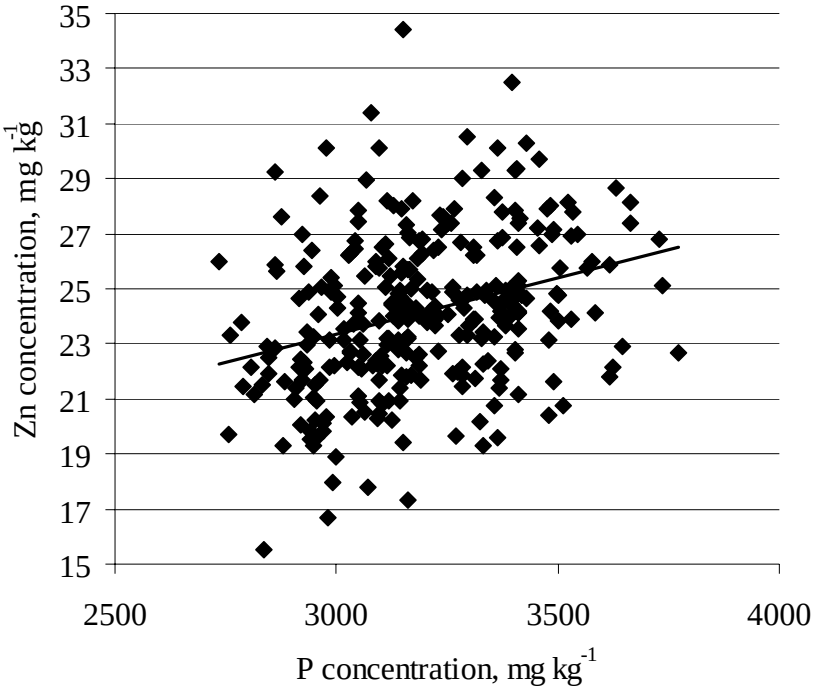

Fig. 1. Relationship between P and Zn concentrations in grain of 300 maize genotypes

CONCLUSIONS

Increasing the Zn bioavailability in grain of non-low-phytic acid maize genotypes seems possible due to a weak relationship between Zn and P concentrations. Although the breeding material used in this study is not completely relevant for areas where human micronutrient malnutrition occurs, our findings could be useful for regions with P-imbalanced soils found widely in the developing world, where low-phytic-acid maize production is not a good option.

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