Influence of agricultural practices on the nutritional quality of wheat: Zinc

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Marginal zinc deficiency and suboptimal zinc status have been recognised in many groups of the population in both less developed and industrialised countries. Although the cause of suboptimal zinc status in some cases may be inadequate dietary intake of zinc, inhibitors of zinc absorption are likely the most common causative factor. Many staple foods in developing countries, including cereals like wheat, are relatively good sources of zinc. Wheat flour and its products such as bread and pasta often occupies a large part of the diet and could therefore be a significant contributor to the zinc supply, especially of those individuals who do not consume meat on a regular basis. Agricultural practices, such as crop rotations and the application of phosphorus fertiliser can have a profound influence on the concentration of phosphorus in the soil and also in the grain. Because phosphorus is mainly incorporated into grains as phytic acid, and the presence of phytic acid is associated with a lower availability of zinc, we investigated the influence of those agricultural practices on the zinc concentration and availability in the wheat.

The objective was to compare the zinc, iron, calcium and phosphorus concentrations from grain of wheat grown in a field experiment with 4 pre-treatments (canola, linola, pasture and bare fallow), with or without phosphorus fertiliser. Among the pre-treatments, linola and pasture are known to stimulate levels of arbuscular mycorrhizal fungi (AMF) which is important for zinc uptake, while canola and fallow are known to suppress AMF. Phosphorus fertiliser is also known to suppress AMF. Total phenolics and phytates were measured on wheat following canola, linola and fallow only.

For concentrations of grain zinc, calcium and phosphorus, the main effects of preceding crop and fertiliser were highly significant ($P < 0.001$). The largest effect was a decrease in grain zinc concentration of 58%, from 26.1 ± 0.8 mg/kg for wheat following pastures receiving phosphorus fertiliser, to 11.2 ± 0.3 mg/kg for wheat following fallow with no phosphorus fertiliser. Grain zinc concentration was also positively associated with AMF colonisation, which was reduced by phosphorus application. Phosphorus fertiliser decreased grain calcium concentrations by approximately 16%. Furthermore, total phenolics and phytates were significantly ($P = 0.028$ and $P < 0.001$ respectively) more concentrated in wheat which received phosphorus fertiliser. The molar ratio of CaxPhytate/Zn, which is an indicator of dietary zinc availability, was also significantly affected by application of phosphorus fertiliser.

Table: Zinc concentration (mean ± SE) of wheat grain (mg/kg)

Preceding treatment	Canola	Fallow	Linola	Pasture
With P fertiliser	13.5 ± 1.7	11.2 ± 0.3	15.6 ± 0.9	17.5 ± 1.4
No P fertiliser	21.1 ± 0.5	18.4 ± 0.6	24.5 ± 1.1	26.1 ± 1.2

In conclusion, changes such as those found in the present study in the zinc and phytate ratios could have profound implications for human nutrition, especially where cereals are the staple diet. The agricultural practices of crop rotations and application of phosphorus fertiliser influence grain zinc concentration and possibly bioavailability. With further knowledge, farmers will be able to manipulate crop rotations, fertiliser rates and possibly other agronomic practices to improve the nutritional value of cereal grains. The challenge now is to develop both a marketplace where such changes are financially rewarded and agricultural systems which deliver favourable yields of produce with enhanced nutritional value.

Key words: zinc, wheat, availability