

Zinc and Cadmium in Soil and Wheat Grain: The Health Risks of the Population

Amir H. Khoshgoftarmanesh¹, Majid Afyuni¹ and Rainer Schulin²

¹ Isfahan University of Technology, College of Agriculture, Isfahan, IRAN
(amirhkhosh@cc.int.ac.ir)

² ETH Zurich, Institute of Terrestrial Ecosystems, SWITZERLAND

INTRODUCTION

Zinc nutritional deficiency is widely prevalent, and its morbidities are severe (Prasad 2003). On the other hand, Cd in food is a concern due to its toxicity if there is excessive uptake (Norvell et al. 2000). One reason for this appears to be that Cd can substitute for Zn in many chemical and physiological processes in plants and humans.

Increased Cd and decreased Zn concentrations have been reported for wheat grown in saline soils of central Iran (Khoshgoftarmanesh 2006). As there is very little information on the Zn and Cd concentrations and bioavailability in these soils, this study was carried out to investigate Zn and Cd transfer from soil into wheat, which serves as a main diet for Iranian people.

METHODS

Wheat and associated topsoil (0-25 cm) samples were taken from 60 different fields from all over the central Iranian province of Qom. The sites were chosen because they represented a wide range of Zn and Cd concentrations in grains. Soil samples included calcids and gypsid soils with a wide range of physical and chemical properties. We determined soil pH and EC_e, and clay, CaCO₃ and bicarbonate-P contents. Chelate-extractable Zn and Cd were determined using 0.005 M DTPA by atomic absorption spectrometry (AAS). After the harvest, concentrations of Zn and Cd in the grain and shoots were determined by AAS.

Furthermore, we investigated Zn and Cd concentrations in serum and hair samples of 220 women [150 non-pregnant women (age 17-30 years) and 70 students (age 7-15 years)], who were attending health centers in four different areas of Qom city and were asked at random to volunteer in this study.

RESULTS AND DISCUSSION

The sampled soils represent typical soils used for wheat production in Qom province. Most of the soils were heavily fertilized with phosphate fertilizers containing significant Cd impurities. The mean Cd level (0.07 mg kg⁻¹) found in this study is within the normal range for unpolluted soils though. Concentrations of DTPA-extractable Cd were highly correlated ($R^2=0.93$, $P<0.05$) with EC_e (not shown). The majority of the soils had DTPA-extractable Zn concentrations below 2 mg kg⁻¹, which is considered to be the critical level for Zn-deficiency (Fig. 1).

Grain-Cd concentrations from most soils were lower than the maximum permitted concentration (0.2 mg kg⁻¹). Grain-Zn concentrations were related to wheat genotype (Table 1). There was a negative association between grain-Zn and Cd concentrations (not shown).

The dietary record of women with low Zn levels in serum and hair showed a distinctive meal pattern that was based largely on wheat bread and some vegetables, but very little red meat and other sources of animal protein. Women with a more balanced diet generally showed no signs of deficiency in serum and hair Zn levels. This indicates the important role of Zn deficiency as a factor of human malnutrition in Iran.

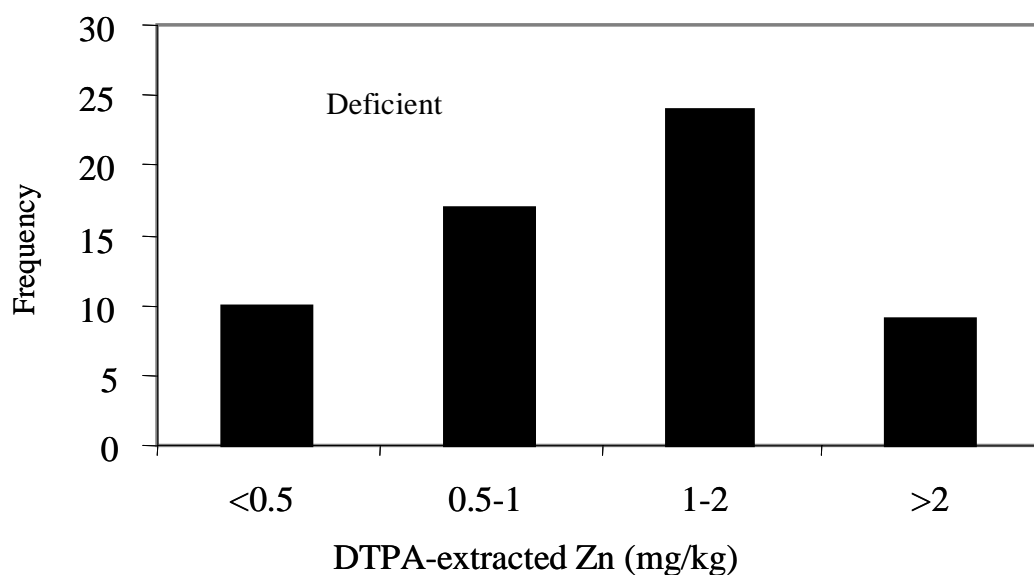


Fig. 1. Frequency distribution of Zn-deficient soils.

Table 1. Grain Cd and Zn concentrations (mg kg⁻¹) in different wheat genotypes*.

Genotype		Zn	Cd
Rushan	Range	12.0-17.5	<0.01-0.04
	Mean	14.3 ^b	0.02 ^b
Kavir	Range	8.0-10.0	<0.01-0.05
	Mean	8.9 ^c	0.04 ^a
Cross	Range	21.0-56.5	<0.01-0.02
	Mean	31.8 ^a	0.01 ^b
Falat	Range	11.1-14.2	<0.01-0.03
	Mean	13.8 ^b	0.01 ^b
Others	Range	9.9-15.2	<0.01-0.04
	Mean	11.3 ^b	0.02 ^b

CONCLUSIONS

The results show that Zn deficiency is a disorder common in the population of central Iran. It seems that low Zn and high Cd concentrations in wheat grains are major factors causing Zn deficiency and, thus, a poor nutrition of populations with a diet based on wheat.

REFERENCES

- Khoshgoftarmanesh, A.H., Shariatmadari, H., Karimian, N. and van der Zee, S.E.A.T.M. (2006) Cadmium and zinc in saline soil solutions and their concentrations in wheat. *Soil Sci. Soc. Am. J.* 70:582-588.
- Norvell, W.A., Wu, J., Hopkins, D.G. and Welch, R.M. (2000) Association of cadmium in durum wheat grain with soil chloride and chelate-extractable soil cadmium. *Soil Sci. Soc. Am. J.* 64:2162-2168.
- Prasad, A.S (2003) Zinc deficiency has been known for 40 years but ignored by global health organizations. *BMJ.* 10: 326-409.