Why Zinc Availability Does Not Comply with the Soil Organic Matter Content in Calcareous Soils?

A. Majidi and M.J. Malakouti

Department of Soil Science, College of Agriculture, Tarbiat Modarres University, P.O. Box:14115-336, Tehran, I.R, IRAN (A_Magidi@modares.ac.ir)

INTRODUCTION

Micronutrient deficiency is widespread in plants, animals, and humans in many Asian countries due to the calcareous nature of soils, high pH, low organic matter (OM), salt stress, continuous drought, high bicarbonates in the irrigation water and an imbalanced application of fertilizers. The pH of calcareous soils is controlled mainly by $CaCO_3$ levels.

METHODS

This experiment was conducted in four provinces of Iran to determine the factors that are limiting Zn availability, including soil $CaCO_3$, pH, and OM content. Altogether, 3,832 soil samples were collected in different provinces, including Qom, Tehran, Kermanshah, and Golestan. Soil samples were analyzed for $CaCO_3$, OM, and micronutrient (B, Cu Fe, Mn and Zn) contents. Soil data were categorized according to critical micronutrient levels (B < 1, Cu < 1 Fe < 5, Mn < 5, Zn < 1 mg kg^{-1}), and the relationships between deficient levels and soil $CaCO_3$, pH, and organic matter content were defined.

RESULTS AND DISCUSSION

Table 1 shows the occurrence of micronutrient-deficient soils in four provinces and soil $CaCO_3$ and organic matter content and pH.

Table 1. Characteristics and micronutrient deficiencies of soils from four provinces (Ali-Ehyaee 2001).

Provinces	No. of samples	pH	OM	TNV	Fe < 5	Mn < 5	Zn < 1	Cu < 1	B < 1
			%	%	mg kg^{-1} in %				
Qom			0.69		91	62	76	71	5
Tehran	71	7.7	1.03	17	65	30	63	28	30
Kermanshan	24	7.7	1.62	22	33	23	73	13	40
Golestan	52	8.0	2.29	15	22	9	72	9	10

A negative relationship was found between OM content and micronutrient deficiencies (Fig. 1). The mean values for OM in Qom, Tehran, Kermanshan and Golestan were 0.69, 1.03, 1.62 and 2.29 %, and the total numbers for micronutrient deficiencies were 300, 186, 142 and 112, respectively. The correlation coefficient between OM content and micronutrient deficiency was -0.81 (Fig. 2). Such a negative correlation was not found for Zn alone. In fact, the concentration of chelated DTPA-Zn in calcareous soils was dependent on soil pH (Lindsay 1979). This might be explained with the competition between DTPA and OM for metal ions which may affect the rate of attaining chemical equilibrium during the extraction. In most cases, Zn deficiency depends on soil chemical and physical properties such as high pH, level of $CaCO_3$ and bicarbonate in the irrigation water. These factors promote precipitation and adsorption of Zn and reduce transport of Zn to plant roots.

Zinc is mostly unavailable in calcareous soils due to sorption to clays and carbonates, co-precipitation with carbonates or formation of insoluble calcium zincate (Bradl 2004). Agbenin and Olojo (2004) found that the distribution coefficient K_D is five times greater for Cu than for Zn. It seems that reactions with OM and amorphous oxides control Cu, but Zn might be mostly sorbed to clay minerals. The metal binding sites in amorphous hydrous oxides and OM were more selective for Cu than for Zn. Similar results were obtained by others. A strong inverse relationship between soil OM and soluble Zn in rhizosphere was found in 18 soils from Colorado (Catlett et al. 2002).

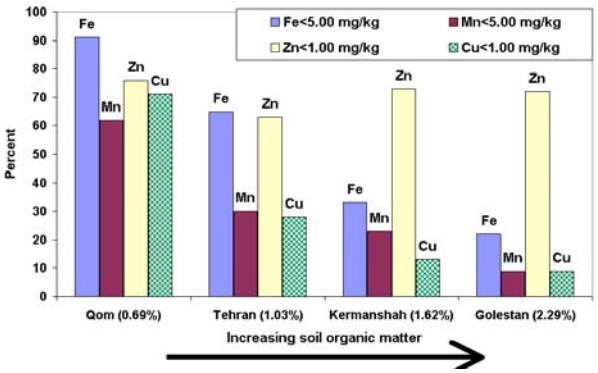

Fig. 1. Soil micronutrient deficiency percentages related to organic matter content in four provinces.

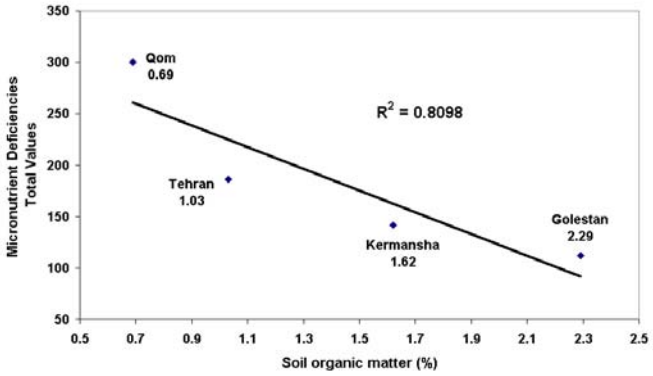

Fig. 2. Soil organic matter and total values of micronutrient deficiencies in four provinces.

CONCLUSIONS

Our soil data shows that there was a good correlation between the rate of deficiencies of Fe, Mn, Cu and soil OM, but this correlation was not found for Zn. This might be due to the facts that pH was relatively high in these calcareous soils which affects the solubility of micronutrients, and that complexes of Zn and OM are weaker than complexes of Fe, Mn, and Cu.

ACKNOWLEDGEMENT

The author wishes to thank the staff members of SWRI for all their scientific assistances.

REFERENCES

Agbenin, J.O. and Olojo, L.A. (2004) Competitive adsorption of copper and zinc by a Bt horizon of a savanna Alfisol as affected by pH and selective removal of hydrous oxides and organic matter, Geoderma 119: 85-95.

Ali-Ehyaee, M. (2001) Producing soil micronutrients distributions maps for 4 different provinces, Soil and Water Research Institute, Tehran, Iran.

Bradl, H.B. (2004) Adsorption of heavy metal ions on soils and soils constituents. Journal of Colloid and Interface Science 277: 1–18.

Catlett, K.M., Heil, D.M., Lindsay, W.L. and Ebinger, M.H. (2002) Soil chemical properties controlling zinc activity in 18 Colorado soils. Soil Sci. Soc.Am. J., 66:1182-1189.