Zinc and Cadmium in Soil and Wheat Grain on Swiss Farms: Comparison of Organic and Conventional Management

Steffen A. Schweizer [1]*, Susan Tandy [1], Benjamin Seitz [2,3], Marcel van der Heijden [2], Rainer Schulin [1]

1 Soil Protection, ITES, ETH Zürich (Switzerland), **2** Plant-Soil Interactions, Agroscope (Switzerland), **3** Environmental Geosciences, Universität Basel (Switzerland)

* Present address: schweizer@wzw.tum.de, Soil Science, Department of Ecology and Ecosystem Management, TU Munich (Germany)

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
Agroscope

Motivation

Increasing the zinc (Zn) concentration of edible plant parts is important to fight human Zn malnutrition. Factors enhancing Zn uptake may also increase the uptake of cadmium (Cd), a sister-element. How do farming systems influence Zn and Cd concentration in wheat grains? We analyzed soil and wheat grain samples from 28 farms around Zurich with different manure application, fertilization and livestock density representing three different farming systems: organic with compost (**COMP**, n=11), organic without compost (**ORG**, n=10), and conventional without compost (**CONV**, n=7) (Seitz et al. 2015).

Highlights

- **Total soil Zn and Cd** increased with **soil organic carbon** (SOC) concentration
- **Total soil Zn** higher in farms with livestock
- **Soil Cd** higher in **COMP** than in the two other systems
- **Grain Cd** higher in **COMP** than in the two other systems if compared among farms with livestock

Soil organic carbon (SOC) as key factor in soil Zn and Cd

- Stabilized soil organic carbon correlates with soil metals (Fig. 1 and 2)
- SOC as proxy for aggregate stability, clay content and soil microbial activity
- Higher SOC could increase both retention and mobilization of soil metals

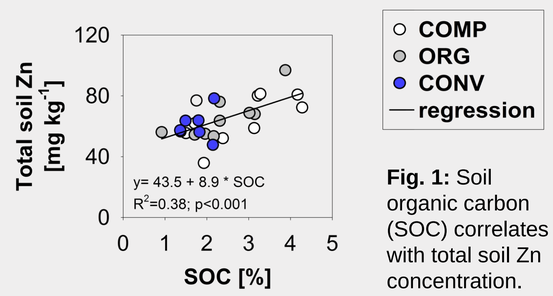


Fig. 1: Soil organic carbon (SOC) correlates with total soil Zn concentration.

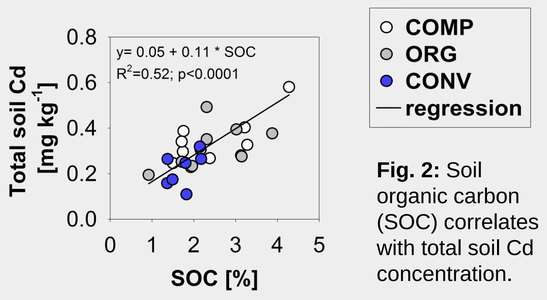
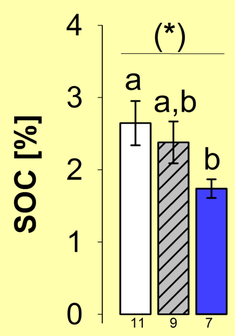


Fig. 2: Soil organic carbon (SOC) correlates with total soil Cd concentration.

Effect of organic management vs. livestock

- **COMP** higher SOC than **CONV** (Fig. 3), but not higher Zn due to additional effect of livestock management
- Soil Zn not different between farming systems but between farms with and without livestock (Fig. 4)



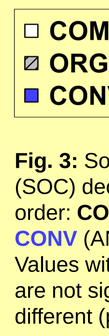
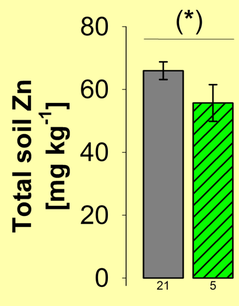


Fig. 3: Soil organic carbon (SOC) decreased in the order: **COMP**, **ORG** and **CONV** (ANOVA p=0.1). Values with the same letter are not significantly different (p<0.05)



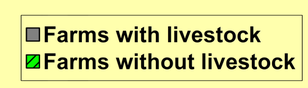


Fig. 4: Tendency towards higher total soil Zn in farms with livestock than in farms without livestock (ANOVA p=0.9).

Cadmium enrichment in COMP

- More total and phytoavailable Cd in **COMP** (Fig. 5 and 6)
- Grain Cd not significantly different between systems (Fig. 7)
- Tendency towards higher grain Cd in COMP on farms with livestock (Fig. 8)

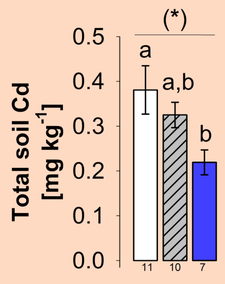


Fig. 5: Total soil Cd decreased in the order: **COMP**, **ORG** and **CONV** (ANOVA p=0.05).

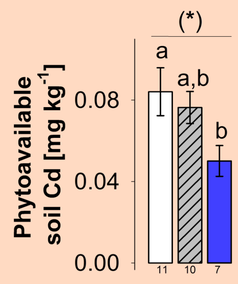


Fig. 6: Phytoavailable soil Cd decreased in the order: **COMP**, **ORG** and **CONV** (ANOVA p=0.08).

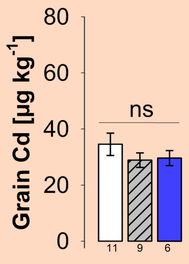


Fig. 7: Grain Cd not significantly different between farming systems.

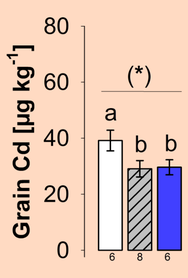


Fig. 8: Only farms with livestock: Grain Cd was higher in **COMP**, than in **ORG** and **CONV** (ANOVA p=0.07).

Methods

- Survey: Livestock, feeding and fertilization
- Sampling: July 2015, soil 0-20 cm, grain harvested on 1 m^2
- Elemental CN analyzer, TOC Analyzer
- Metal extraction from soil with aqua regia (total) and DTPA (available)
- Digestion of grains in microwave with HNO_3 + H_2O_2
- Metal analysis using ICP-OES and ICP-MS

References

Seitz, B. (2015): Kompostdüngung in der Schweizer Landwirtschaft. Auswirkungen auf Bodenqualität und Nährstoffeffizienz, Master thesis Universität Basel, Basel.

Acknowledgments

We thank the Mercator foundation and the World Food System Center for financial support for the ZOMM project of which this was part.

World Food System Center

Stiftung Mercator Schweiz

Further information: www.soilprot.ethz.ch/research/active-research-projects/zomm.html