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Effects of compost fertilization in organic farming on micronutrients and heavy metals in soil and crops

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For organic stockless and vegetable farms using biowaste compost is a way to sustain soil humus content. At the same time compost use in agriculture closes local nutrient cycles. Besides organic matter and main nutrients, biowaste compost also imports micronutrients and heavy metals in amounts determined by the compost input material. The aim of this work was to assess total and plant-available contents of micronutrients B, Ca, Cu, Fe, Mn, Mo, Ni, Zn, beneficial elements Co and Se and heavy metals Cd, Cr and Pb in the soil and in crops after 20 years of fertilization with compost produced from source-separated organic waste.

Topsoil and wheat grain samples were collected from the long-term field experiment 'STIKO' situated near Vienna on a Molli-gleyic Fluvisol. Between 1992 and 2012 the organic treatments C1, C2 and C3 had received 5, 10 and 14 t ha-1 yr-1 (wet wt.) biowaste compost on average. They were compared with the unfertilized organic control treatment and with three mineral fertilization treatments, which had received 20, 32 and 44 kg N ha-1 yr 1, respectively, plus 40 kg P and 68 kg K ha-1 yr-1 on average. Total soil element contents of B, Cd, Cr, Co, Cu, Fe, Mn, Mo, Ni, Pb, Se and Zn were measured in aqua regia digestion. Immediately water-soluble elements were analysed in soil saturation extract, elements in exchangeable form in LiCl extract following Husz (2001), and long-term available elements in 0.5 N HCl extract. Wheat grains were dehulled, milled and subjected to microwave digestion with HNO_3 and H_2O_2. Wheat was analyzed for Cd and Pb with ICP-MS. All other elements in wheat and all soil extracts were analyzed using ICP-AES.

Total soil concentrations of micronutrients, heavy metals and beneficial elements were in the range of usual soil contents and lower than the Austrian background values for arable land with comparable pH and carbonate concentration (Schwarz and Freudenschuss, 2004) in all treatments (all mg kg-1: B 14-19, Fe 16000-18000, Mn 397-445, Mo 0.7-1.0, Cu 15-17, Ni 21-22, Zn 45-52, Cr 26-28, Pb 13-17, Co 7.5-8.4). Total soil concentrations of Cd (0.37-0.46 mg kg-1) were the same as the background values. No significant differences were found between the treatments and the unfertilized control. Similarly, the plant available LiCl-fraction and the long-term available HCl-fraction did not show significant differences between the treatments.

In the soil saturation extracts, Cu content was 18-22 μg kg-1, B 172-187 μg kg-1, Fe 62-113 μg kg-1 and Ca 62-71 mg kg-1, all in the usual range of soil saturation extracts of agricultural fields without significant differences between treatments. The other elements were below the limit of determination.

In the wheat, contents of micronutrients, heavy metals and beneficial elements were in the same range as in other Austrian wheat samples (Spiegel and Sager, 2008) with the exception of Ca. Element contents were (all in mg kg-1): B 0.5-0.6, Ca 387-464, Cd 0.023-0.028, Co 0.006, Cr 0.10-0.17, Cu 4.7-5.3, Fe 36-50, Mn 30-33, Mo 0.31-0.35, Ni 0.11-0.15, Se 0.15-0.27 and Zn 28-31. Pb was below the limit of determination in the wheat grains. No significant differences were detected between the treatments.

After 20 years of compost fertilization with high quality biowaste compost at the above rates no increase in micronutrients and heavy metals was detected in total soil contents and in plant-available fractions nor in wheat grains.