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Nutrient uptake by agricultural crops from biochar-amended soils: results from two field experiments in Austria

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The use of biochar as soil amendment is considered as a promising agricultural soil management technique, combining carbon sequestration and soil fertility improvements. These expectations are largely founded on positive experiences with biochar applications to impoverished or degraded tropical soils. The validity of these results for soils in temperate climates needs confirmation from field experiments with typical soils representative for intensive agricultural production areas. Frequently biochar is mixed with other organic additives like compost. As these two materials interact with each other and each one may vary considerably in its basic characteristics, it is difficult to attribute the effects of the combined additive to one of its components and to a specific physico-chemical parameter. Therefore investigations of the amendment efficacy require the study of the pure components to characterize their specific behavior in soil. This is especially important for adsorption behavior of biochar for macro- and micronutrients because in soil there are multiple nutrient sinks that compete with plant roots for vital elements. Therefore this contribution presents results from a field amendment study with pure biochar that had the objective to characterize the macro- and microelement uptake of crops from different soils in two typical Austrian areas of agricultural production.

At two locations in North and South-East Austria, two identical field experiments on different soils (Chernozem and Cambisol) were installed in 2011 with varying biochar additions (0, 30 and 90 t/ha) and two nitrogen levels. The biochar was a product from slow pyrolysis of wood (SC Romchar SRL). During the installation of the experiments, the biochar fraction of <2 mm was mixed with surface soil to a depth of 15 cm in plots of 33 m2 each (n=4). Barley (at the Chernozem soil) and maize (at the Cambisol) were cultivated according to standard agricultural practices.

The highest crop yields at both study sites were observed after a biochar application rate of 90 t/ha and an abundant nitrogen supply (mineral N fertilizer rates: 120 kg/ha for barley, 150 kg/ha for corn). An omission of biochar addition at the same nitrogen addition rate resulted in a yield decrease of 10 % for barley although the total N uptake was 11 % higher but P and K uptake decreased by 14 and 6 %. This indicates that the higher yields with biochar were accompanied by increased availability of P and K but not N. The N deficiency treatment (with biochar amendment) resulted in yield decreases of 23 %, which were similar as the reductions of N uptake while reductions of P and K uptake were less pronounced. For corn, the omission of biochar caused only marginal yield effects (6%) and no significant changes in the N, P, and K uptake rates. Deficient N supply, however, resulted in severe yield reductions (46%) in spite of the high biochar application rate. The reductions of macronutrient uptake were in the same range for N (44%) but lower for P, K, Ca and Mg (19 to 33%). In summary, N and Cu were the elements that were least available for plant uptake at high biochar application rates.