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Can combined application of biochar and nitrogen promote microbial functions and root plasticity for plant growth in low-fertile soils?

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Biochar and nitrogen (N) fertilizers are frequently applied to improve soil properties and increase crop productivity. However, it remains unclear how root plasticity, soil enzyme activities, N and (phosphorus) P cycling in plant-soil system are changed after application of biochar, N or their combination. To address these questions, left and right parts of rhizoboxes were filled with silty-clay loam subsoil amended with biochar (15 g kg^{-1} soil, wheat straw, 300 °C), N (0.05 g KNO_3-N kg^{-1} soil) or a control (no amendments), resulting the following combinations (Cm): biochar/control (Cm1), N/control (Cm2) and biochar/N (Cm3). One seed of maize (Zea mays L.) was planted in the middle of each rhizobox, thus allowing roots to choose freely the growth direction. Root growth was quantified by a photographic approach constantly during the experiment (30 d), and soil enzyme activities, available N and P, root morphology and plant biomass were analyzed after plant harvest.

Maximum plant biomass was found for biochar/N application (0.91 g), whereas minimal values was for biochar/control (0.56 g). At the same time, decreased soil bulk density and increased availability of P in the biochar compartment (Cm1 and Cm3) stimulated root length by 1.4-1.8 times – an effect which was independent from the presence of N in the same rhizobox. Together with stimulated activities of ß-glucosidase and leucine aminopeptidase (by 33%-39%) in presence of biochar (Cm3) compared to N, this shows the coupling of C, N and P cycles in biochar/N treated soils. Application of N (Cm2) also increased ß-glucosidase activity compared to control soil, whereas root elongation stayed unaffected. Thus, combined application of biochar/N over-win benefits of biochar or N alone for plant growth, which is linked with i) the stimulation of microbial enzyme activity at the biochar locations to reduce C and N limitation for both plant and microorganisms, and ii) increasing of fine root proportion to improve N utilization efficiency in the N-treated compartment. Thus, strategy of combined biochar/N application can not only improve the above-ground biomass production, but also increase root-microorganism

interactions to overcome nutrient limitation in low fertile agricultural soils.