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Short-term effects of two wood-based biochars on nitrogen leaching and nitrous oxide emissions

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There is a need of proper nitrogen management in agricultural systems, which would enhance crop productivity, while reduce the negative consequences resulting from fertilization. Application of biochars is gaining popularity because of its potential to sequester carbon (C) in soil. Because of their high porosity and large surface area, biochars have been reported to be capable of adsorbing mineral N in their surfaces making it more available to plants, while reducing nitrogen (N) leaching and nitrous oxide (N_2O) emissions. However, its mechanism is not fully understood yet. To enhance the surface properties of biochar, various techniques of preparing biochars are being explored and one of the techniques is hot activation with nutrient enrichment. In the current study, our goal was to test the effectiveness of such hot-activated biochar in comparison with non-activated biochar in enhancing ryegrass growth while reducing N leaching and N_2O emission.

A ^{15}N-tracing pot experiment was conducted using two types of wood-based biochars: a commercially produced biochar (RPK Hilli Oy, BC1) and other produced with Kon-Tiki flame curtain pyrolysis of hardwood followed by activation with cattle slurry (BC2). The experiment consisted 11 treatments: control, 2 fertilized controls ($^{15}NH4^+$ and $^{15}NO_3{}^-$) and 8 biochar treatments [2 biochar types x 2 biochar application rates (1% and 5%) x 2 fertilization] with 5 replicates each. Ryegrass was sown in the pots and all the pots except control ones received N-fertilizer as either $^{15}NH_4NO_3$ or $NH_4^{15}NO_3$ corresponding to 110 kg N ha^{-1}. During the experiment, N leaching and N_2O emissions were measured weekly. At the end of the 33-day experiment, plant above ground and root biomass were measured. N_2O emissions were measured using gas chromatography. N-$NH4^+$ and N-$NO_3{}^-$ in leachate (after micro-diffusion) and ^{15}N content in plant biomass and soil were measured from isotope ratio mass spectrometer (Thermo Scientific, Bremen, Germany). Compared to fertilized control, 1% biochar treatment pots had no differences while 5% biochar treatments had significantly higher above ground biomass irrespective of biochar type. The volume of leachate and N leaching was significantly higher in fertilized control compared to all biochar treatments, and 5% biochar treatments were better in reducing leaching compared to 1% biochar treatments. In addition, the biochar treatments reduced N_2O emission by around 60% compared to fertilized control but among the biochar treatments, there was no difference. The results suggest that wood-based biochar application helps in minimizing N leaching and N_2O emission. Also, in our short-term test, irrespective of biochar type, amount of biochar applied had significant impact on ryegrass biomass yield.