Wood biochar as soil amendment material combined with organic or mineral fertilizers [Helsinki, Finland]

EXPERIMENT GOALS

To study the long-term potential of biochars in improving the nutrient use effiency and soil water retention capacity in boreal soils depending on the fertilizer type.

Umbrisol experiment started in 2011, ongoing at least to 2025

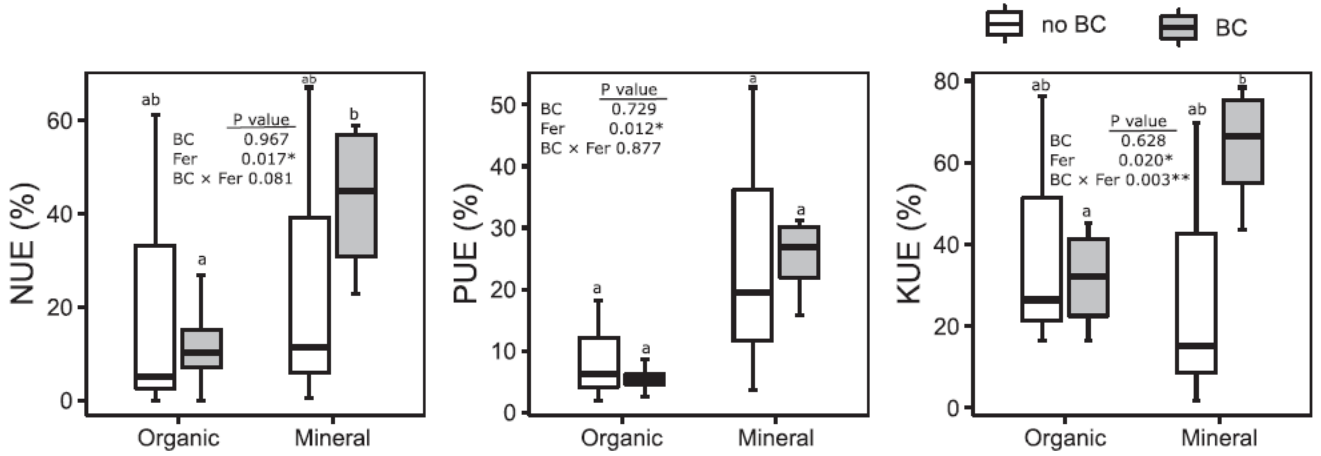

Fig. 3. Overall use efficiencies of N (NUE), P (PUE) and K (KUE) in the experimental treatments [organic fertilization or mineral fertilization (Fer), each without or with 30 Mg ha^{-1} added biochar (BC)] and statistical significance of experimental factors of the Umbrisol field. The information about the experimental treatments and the box and whiskers is same as in Fig. 1.

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SITE DESCRIPTION

Example: Boreal climate, nutrient deficient Umbrisol with a loamy sand texture at the Viikki Research Farm, University of Helsinki, Finland where spring wheat, barley, grasses and peas have been grown.. The long-term biochar experiment was started in 2011 with single-dose additions of softwood biochar. Prior to the biochar application, field was cropped with small grains and the soil was tilled with conventional annual moldboard ploughing up to a depth of 25 cm for the preceding five years. In the Umbrisol field, the experimental factor in the main-plot was the biochar application rate (0, 5, 10, 20 and 30 Mg DM ha 1) while that in the sub-plot was the fertilizer treatment with three different levels [unfertilized control, organic fertilizer (meat bone meal, MBM) and mineral (synthetic) fertilizer]. The organic and mineral fertilizers provided the same amounts of the most critical nutrients N and K on this high-P Umbrisol soil.

BIOCHAR AND ITS APPLICATION IN THE FIELD

Type of biochar and matrices used: Wood, slow pyrolysis
Biochar description (where it comes from, production technique, feedstock): debarked spruce, 550–600 ◦C. Air dried wood chips were fed into the reactor tube via an airtight system and subsequently moved by a screw conveyor through the hot region of the reactor tube in 10–15 min. Moistened.

Supply: Dosages ($tons_{dm}$ / ha), frequency of ap., single application applied 0, 5, 10, 20 and 30 t/ha.
Distribution method: Spread by sand spreader, uppermost 10 cm soil layer by two opposite passes with a rotary power harrow

MEASURED PARAMETERS

List here the parameters that you periodically measure in relation to the purpose of the experiment.

AIR

GHG emissions measured 2015, 2017, 2018

WATER

Biochar interaction with water: leaching measured in 2018 with resin bags

SOIL

Soil analysis and interactions with biochar: soil pH and available nutrients, total C and N at T0, then measured again in annually in autumns 2011-2013, 2015-2019, Water retention measured in 2010-2012 annually, 2015, 2017 and 2018. Soil moisture content measured all years from most extreme plots (years 2010-2022).
Plant-soil dynamics and interactions: carbon and nitrogen soil-plant dynamics, microbiological and –omics measured all years 2010-2018. Earthworm community studies in 2011 and 2015.

OTHER

Field conditions: rainfall / meteorological data
Production data: nutritional status of the plant 2011-2018, yield formation

KEY FINDINGS

Improved K status and use efficiency in soils, n.s. Effects on yields (most promising trends after legumes), improved soil moisture content and WRC.

PLANNED ACTIVITIES OR POTENTIAL EXPERIMENTAL ACTIVITIES

New nutrient-enriched biochars addition to 5 and 20 t/ha plots in 2023, intense measuring campaign afterwards.

PRESENTATION OF THE WORKING GROUP

AgriChar research group of University of Helsinki ise led by Adj. Prof. Priit Tammeorg. Regarding this experiment, main people active have been Dr. Subin Kalu (nutrient cycles) and doctoral student Jure Zrim (soil biota). Funding from Finnish national funding bodies, more information on website.

Website: http://biochar-hy.blogspot.com

Publications:

• Tammeorg, P., Simojoki, A., Mäkelä, P., Stoddard, F. L., Alakukku, L., & Helenius, J. (2014). Short-term effects of biochar on soil properties and wheat yield formation with meat bone meal and inorganic fertiliser on a boreal loamy sand. *Agriculture, Ecosystems & Environment*, 191, 108–116. doi: http://dx.doi.org/10.1016/j.agee.2014.01.007.

•Tammeorg, P., Parviainen, T., Nuutinen, V., Simojoki, A., Vaara, E., & Helenius, J. (2014). Effects of biochar on earthworms in arable soil: avoidance test and field trial in boreal loamy sand. *Agriculture, Ecosystems & Environment*, 191, 150–157. doi: http://dx.doi.org/10.1016/j.agee.2014.02.023.

•Tammeorg, P. (2014). Softwood biochar as a soil amendment material for boreal agriculture. Doctoral thesis. University of Helsinki.

•Kalu, S., Simojoki, A., Karhu, K., & Tammeorg, P. (2021). Long-term effects of softwood biochar on soil physicalproperties, greenhouse gas emissions and crop nutrient uptake in twocontrasting boreal soils. *Agriculture, Ecosystems & Environment*. 316: 107454.

•Kalu, S., Kulmala, L., Zrim, J., Peltokangas, K., Tammeorg, P., Rasa, K., ... & Karhu, K. (2022). Potential of biochar to reduce greenhouse gas emissions and increase nitrogen use efficiency in boreal arable soils in the long-term. *Frontiers in Environmental Science*. https://doi.org/10.3389/fenvs.2022.914766

•Kalu, S. (2022). Long-term effects of biochars as a soil amendment in boreal agricultural soils. Doctoral thesis. University of Helsinki.

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