Microchar an organic biowaste used to remediate agricultural drought soil and increase biomass growth.

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Agricultural drought is a widely experienced challenge linked to climate change, Europe experienced the most extreme hush temperature conditions within the 21st century, the conditions lasted from 2014 – 2018 and are still being realised (Hanel, Rakovec et al. 2018), affecting its hydrological cycle. One of the key factors affecting agriculture are the hydraulic properties of soil. In addition, arable soil is prone to erosion and this condition may be exacerbated by drought conditions (Verheijen, Jeffery et al. 2010). Soil erosion significantly reduces the long-term sustainability of modern agriculture as it leads to a decline of the productive function of the soil. Further, nutrient leakage from the soil represents both economic and ecological short-term loss (Tramblay, Koutroulis et al. 2020).

Biochar addition to the soil improves soil water retention capacity, optimal distribution of nutrients, increases crop production, leads to higher soil stability, and enhances microbial activity (Kammann, Linsel et al. 2011). This research project will aim to make use of these effects to minimise the effect of agricultural drought on crop production. Further, biochar improves the capacity of the soil to absorb contaminants and the utilisation of biowaste to produce biochar reduces CO2 emissions. This research will address agricultural challenges relevant at the global scale, an issue with profound importance to farmers and the wider society (Akhtar, Li et al. 2014, Alghamdi 2018, El-Naggar, Lee et al. 2019, Guo, Huang et al. 2020, Guo, Liu et al. 2020)

Agricultural soil called regosol from a drought prone location Zvěřínek,, the area experienced depletion of water resulting in low organic matter and forest soil from Jevany SLP also a drought prone region was used for this experiment. Biochar used was a commercial registered soil additive (Central Institute for Supervising and Testing in Agricuture, CZE) produced by gasification from dry raw wooden chips, high moisture (40-60% wt. on a wet basis). Microchar (table 1.) used in this experiment although its full treatment traits are not disclosed as yet is made from a commercial biochar and vermitea a liquid extract from vermicompost with high biological activity and organic carbon. A standard Hoagland solution was added to the pot experiment.

Table 1. Biochar Microchar chemical composition.

Character	Measured Mass
Apparent density [g / cm3]	0.21
Porosity [%]	/
pH [-]	9.1
Conductivity [/S / cm]	/
Corg [g / kg]	778
Ntotal [g / kg]	22.7
C / N	34.3
Ptotal [g / kg]	1.15
K [g / kg]	9.65
Ca [g / kg]	20.4
Mg [g / kg]	2.34

A short-term incubation experiment that included four treatments were compared: (1) Regosol soil only (control); (2) Regosol soil + 2% microchar; (3) forest soil only (Control); (4) forest soil + 2% microchar. The experiment was completed by using a total of 20 x 15ml containers, 5 replications per treatment. The microchar plus soil was homogeneously mixed to 61.2g with dry soil per container, previously sieved at 2mm (treatments were applied individually per container). A total of 18 leaching tests were conducted throughout the duration of the experiment.

A pot experiment was setup in an air-conditioned greenhouse, the selected crop was peas due to its sensitivity. Five treatments were tested: control (C – Regosol soil without additives), the soil mixed with different amendments (Biochar - B, Hoagland – H, Microchar – FB and Microchar + Hoagland spiked – FB (H-S)) at different doses B – 2%, H – 0.05%, FB – 2%, FB(H-S) – 2.01% respectively. The mixtures were put into 0.5ml pots, each in five replicates. The experiment was performed using a randomized design. Inside of each pot, two germinated pea plants were placed. Leaching tests with rhizons once a week. An FDR 5TM moisture sensor (Decagon, USA) to monitor soil moisture. An experiment of 80 days, with irrigation system set at optimal conditions of 25 pots and stress conditions of 25 pots.

Leaching test were conducted throughout the experiment, testing the pH and the electrical conductivity (EC) of the water. The sub-sample soils and microchar were analysed for TOC and TN with an elemental analyser. Water-soluble C and N including ICP-OES and IC anions on all essential elements. The dry samples were acid digested with a microwave oven. Chlorophyl tests were conducted using PAM-2500 machine at the initial stage and end of experiment. Extra germinated pea plants were weighed including measing the root length, shoot length and number of shoots, these were dried at 80°c overnight and weighed immediately. Peas at the end of the experiment were weighed, with root length, shoot length and number of fruit (peas) produced and weighed after drying. Weekly biomass growth was recorded.

The incubation soil treatments were only watered on days leaching tests were conducted Macronutrient and micronutrient regarded as essential elements were determined. Total DOC content was assessed and showed a decline throughout the assessment. Essential elements, N, P, K, Mg, B, S, Ca, Cu, Fe, Mn, Ni, Zn, F, Cl-, NO3-, Br and SO_4^{2-} showed a substantial amount of nutrient throughout the 18-week analysis, with a gradual decline indicating the prolonged lasting availability of essential nutrients within low organic matter at an average pH of 4.5. in each treatment. Treatments with regosol and microchar had shown to be more nutrient rich compared to forest soil and other treatment.

Pot experiment with selected soil regosol was based on its highest nutrient compared to other treatments conducted in the incubation experiment. Microchar showed low potassium and nitrate, the treatment was then spiked with a general Hoagland solution to increase key low macro elements. Incubation of pot experiment was conducted for two weeks before pea plants were repotted, nutrition soil with FB and FB(H-S) showed continuous availability of micronutrients, and pea health better than other treatments.

The application of microchar in soil reduces nitrogen (N) significantly in soil and indues stability within the soil parameters.

Agricultural soil with a low/loss of organic matter retained a healthy amount of phosphorous (P) and potassium (K) throughout an incubation experiment.

In all treatments, the concentration of nutrients and carbon declined with time, after having peaked immediately after the establishment of the experiment. While regosol leached more nutrients than the forest soil, the addition of biochar microchar reduced nutrient leaching, as well as Dissolved Organic Carbon loss from both soils. Microchar also positively improved the soil properties. The application of biochar microchar thus appears a viable method for reducing nutrient and carbon losses from managed soils.

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