HOW CAN BIOCHAR PROTECT AGRICULTURAL LAND FOR AGROUTOURISM FROM DROUGHT CAUSED BY CLIMATE CHANGE?

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Abstract
Due to climate change pursue, the necessity of building resilient farms becomes even more apparent. Farmers are more often dealing with intensive rainfall, floods and droughts. Many innovative soil water conservation methods have emerged and are being practiced all over the globe — some have been practiced for centuries and others are much newer. Most of these methods provide additional benefits as well, including soil conservation and improvement, enhanced biodiversity, and increased yields. Biochar is one of the materials to improve soil retention properties, water retention in land and landscape protection. The results of our research confirmed increased available soil water content in silt loam soil after biochar application.

Key words: biochar, climate change, soil water retention, tourism

Introduction
Soil moisture limitations in agroecosystems will be aggravated by climate change-driven increases in drought frequency. Increased climate variability will further destabilize dryland crop production and drive an overall spatial expansion of dryland agriculture (IPCC, 2014; Huang et al., 2016). Soil drought is an increasingly pressing issue deleteriously impacting soil organic matter contents (SOM) and soil fertility, with consequent implications to crop productivity and therefore food security (Lei et al., 2020). Maintaining and enhancing SOM can build physical, biological and chemical resilience to drought in soils (Magdoff and Weil, 2004). Water-limited agricultural systems are not only vulnerable to reduced crop yields but are often characterized by low concentrations of SOM and soil organic carbon (SOC) (Robertson et al., 2017). Since SOC is a proximate control on soil moisture, soil water retention may thus be further reduced, exacerbating an already water-limited system (Franzluebbers, 2002). Soil water retention can often be enhanced through the maintenance of crop residues and the addition of amendments including manure, compost, biochar, or engineered gels (Głąb et al., 2018). The positive effects of amendments on soil moisture are driven partly by subsequent increases in SOC, altering soil structure (e.g., promoting aggregation, modifying pore size), and because of SOC's own water adsorbing capacity (Franzluebbers, 2002). At higher moisture levels, water movement is capillary, driven by pore size and distribution (Or and Tuller, 1999). Soil water is attracted in the soil by forces that are smaller than those that the roots attract. Values of soil water content, which characterize the state and availability of soil water to plants are called "hydrolimits" (Novák and Hlaváčiková, 2019). Hydrolimits are possible to estimate from a soil water retention curve (SWRC). The SWRC describes the functional relationship between the soil–water content, and soil matric potential in unsaturated soils that is characteristic for different types of soil. The SWRC is affected by soil physical and chemical characteristics; e.g., soil texture, structure, amount and degree of aggregates, amount of colloids, type of clay mineral, and amount of soluble salts (Taylor and Ashcroft 1972). Available soil water content (ASWC) for plants is possible to estimate from the SWRC as difference between hydrolimits field capacity and wilting point (Novák and Hlaváčiková, 2019).
We focused on comparison between ASWC at variants with different amount of biochar and variant without biochar, in this laboratory study.

Materials and methods
In laboratory conditions were prepared soil-biochar mixtures and pure soil samples, which were used to measure SWRC on pressure plate apparatus.

Soil-biochar mixtures

In this research was used Haplic Luvisol soil with particles diameter ≤ 2 mm. The content of sand was 15.2 %, silt 59.9 % and clay 24.9 %, it was classified as silt loam soil (Simansky and Klimaj, 2017). The used biochar was obtained from wooden parts of grapevine (*Vitis*) in reactor by pyrolysis at 520 °C. The size of biochar pieces was 0 – 10 mm. Elemental composition of the biochar characteristics is listed in Table 1.

Tab. 1: Basic chemical characteristics of biochar (C – carbon, H – hydrogen, N – nitrogen)

C	H	N
%	%	%
81.4	2.4	1.09

The biochar was mixed with the soil at a ratio of 20, 40 and 80 t/ha (in dry weight basis). Measurements were provided on samples with volume of 100 cm^3 (Kopecky cylinders). Four different variants were established: a soil without biochar (soil), soil amended with biochar of 20 t/ha (G20), soil amended with biochar of 40 t/ha (G40) and soil amended with biochar of 80 t/ha (G80). Each variant had 3 replicates.

Soil water retention curves estimation

All mixed samples were saturated with water and moved to the pressure plate apparatus. The 5 Bar Ceramic Plate Extractor 1600 (Soil moisture, USA) at pressure heads from −20 to −4800 hPa was applied using the standard method (Soilmoisture, 2008) for 9 months. ASWC for plants is divided into easily available water content (EAWC) for plants, which is defined as a difference between field capacity and point of limited availability hydrolimits, and limited available water content (LAWC), which is difference between point of limited availability and wilting point hydrolimits. These hydrolimits are different for different types of soils. Šútor and Rehák (1999) determined the field capacity (FC) hydrolimit at pF 2.5 and the point of limited availability (LA) at pF 3.3 for this type of soil. The hydrolimit wilting point (WP) is standardly determined at pF 4.18.

Statistical analysis

Differences between the group means of retention parameters estimated for different variants were evaluated using single factor ANOVA with Tukey's Honest Significant Difference (HSD) post-hoc test. The Tukey-Kramer method (also known as Tukey's HSD method) uses the Studentized Range distribution to compute the adjustment to the critical value. The Tukey-Kramer method achieves the exact alpha level (and simultaneous confidence level $(1 - \alpha)$) if the group sample sizes are equal and is conservative if the sample sizes are unequal. The statistical significance in the analysis was defined at $P < 0.05$.

Results

Fig. 1 shows that the highest differences between soil water content in pure soil and in variants with biochar are at saturation and at near pressure heads (pF 0.1 – 2). The soil water retained in very large soil pores is not available for plants but is still present in soil (land). With increasing of biochar amount increases also the value of soil water in these pores. We found the statistically significant increase in the amount of ASWC (difference between FC and WP) in biochar variants compared to pure soil (Fig. 2). Increase in ASWC in biochar variants was 14% (G20), 15% (G40) and 20% (G80), respectively. We found also significant increase in EAWC value in biochar variants compared to soil. Increase in EAWC was 1.1% (G20), 2% (G40) and 1.4% (G80), respectively.

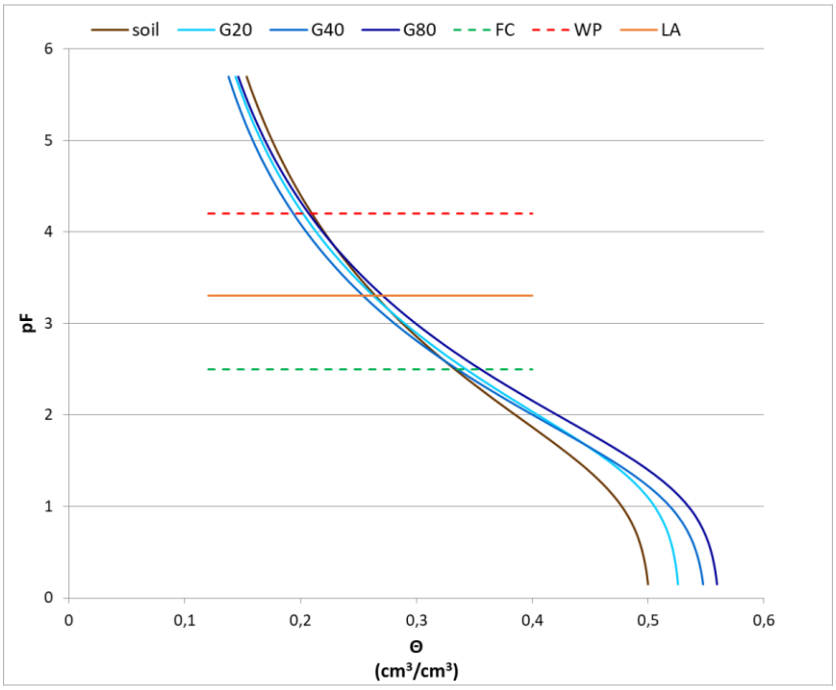

Fig. 1: SWRC of pure soil (soil), soil-biochar mixture of 20t/ha (G20), soil-biochar mixture of 40t/ha (G40) and soil-biochar mixture of 80t/ha (G80) in comparison to hydrolimits FC, LA and WP

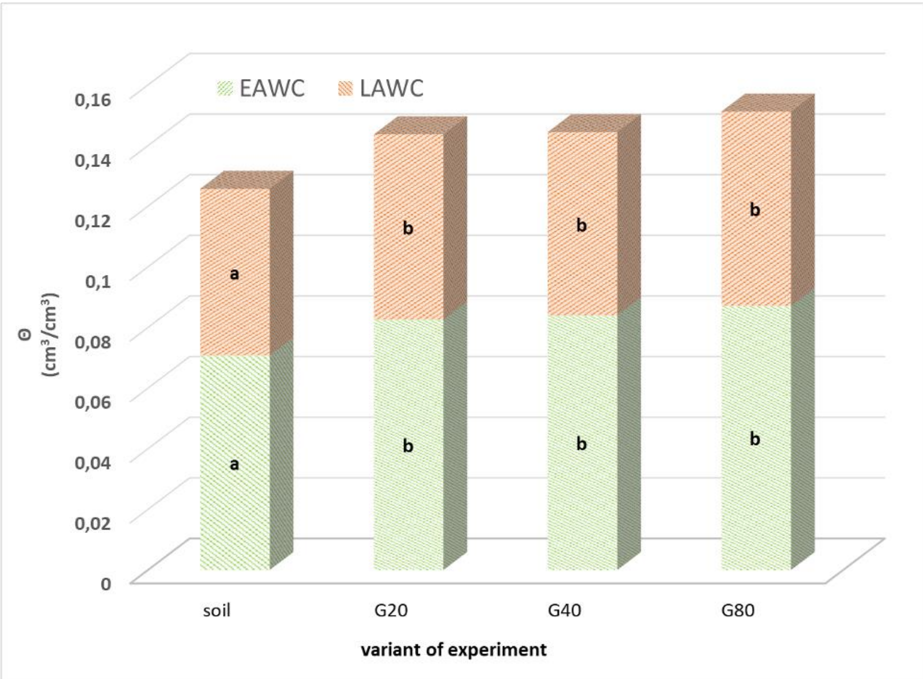

Fig. 2: Statistical analysis of differences between the easily available water content (EAWC) and water content with limited availability (LAWC) in pure soil (soil), soil-biochar mix of 20 t/ha (G20), soil-biochar mix of 40 t/ha (G40) and soil-biochar mix of 80 t/ha (G80). Arithmetic means with the same letter are not significantly different from each other (Tukey's HSD test, $P < 0.05$)

Conclusion and discussion

Many people use agro tourism as one of the forms of recreation, especially with their children. For people providing such types of services is necessary to reduce impact of climate change on crop quality and quantity and protect their agricultural land. The soil's ability to retain water is determined by many factors and soil structure is one of them. Water enters to the soil in the form of precipitation or irrigation and drought, that causes stress to crops, is very often phenomena in last years. Soil structure could be improved by the addition of biochar. Measures (for increasing the water retention capacity of soil) of longer retention of water in land are very needed due to frequent periodicity of nonprecipitation periods, especially in summer season. In our study was confirmed that the application of biochar to the soil can increase the retention of water in the land. A part of retained water is not available for plants, but it is still present in the soil. It has been shown that this type of biochar can retain more water in the agricultural land - the amount of ASWC for plant was higher compared to pure soil without biochar. Our results also showed that the application of this biochar is sufficient in the amount of 20 t/ha or 40 t/ha, respectively because the G80 variant did not show a statistically higher positive effect on soil water retention. By applying biochar to the soil, it is possible to improve its structure and water-air regime, which results to longer soil water retention in soil (land) and its availability to the roots of cultivated plants. Biochar has properties which can retain more water in soil during drought times, improve soil structure and thus ensure the satisfaction of agro businessmen and vacationers.

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Souhrn

Mnoho lidí využívá agroturistiku jako jednu z forem rekreace, zejména se svými dětmi. Pro lidi poskytující tyto typy služby je nutné snížit dopady změny klimatu na kvalitu a kvantitu plodin a chránit zemědělskou půdu. Schopnost půdy zadržovat vodu je dána mnoha faktory a struktura půdy je jedním z nich. Voda se do půdy dostává ve formě srážek nebo zavlažování a sucho, které způsobuje stres plodinám, je velmi častým jevem posledních let. Struktura půdy se může zlepšit přidáním biouhlí. Opatření na delší zadržování vody v krajině jsou velmi potřebná z důvodu časté periodicity bez srážkových období, zejména v letní sezóně. V naší studii se potvrdilo, že aplikace biouhlí do půdy dokáže zadržovat vodu v krajině. Část vody není k dispozici pro rostliny, ale stále je zadržována v půdě. Ukázalo se, že tento typ biouhlí dokáže zadržet více vody v zemědělské krajině – množství dostupné půdní vody pro rostliny bylo vyšší v porovnání s čistou půdou bez biouhlí. Naše výsledky také ukázaly, že aplikace tohoto biouhlí je dostatečná v množství 20 t/ha, respektive 40 t/ha, protože varianta G80 neprokázala vyšší pozitivní vliv na strukturu půdy. Aplikací biouhlí do půdy lze zlepšit její

strukturu a vodně-vzduchový režim, což má za následek delší zadržování půdní vody v krajině a její dostupnost pro kořeny pěstovaných rostlin. Biouhlí má vlastnosti, které dokážou zadržet více vody v půdě v období sucha, zlepšit strukturu půdy a zajistit tak spokojenost agropodnikatelů i rekreantů.

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