Statistical analysis of soil water content differences after biochar application and its repeated application during 2020 growing season

Justína VITKOVÁ*, Peter ŠURDA, Peter RONČÁK, Natália BOTKOVÁ, Anton ZVALA

Soil water content is an important factor influencing crop yield quantity and quality. Extreme meteorological events are more frequent in our geographical conditions in last years and they affect soil water storage. Biochar is an organic material and one of its properties is soil water holding for a longer time. This is one of great benefits during non-precipitation days. Our study is focused on soil water content changes with biochar amendment in comparison to soil without biochar. In addition, we analyzed biochar repeated application as well. It means addition another biochar dose into the soil where the biochar had been applied previously. Our results confirmed positive effect of biochar application and repeated application on soil water content. The soil water regime with biochar repeated application was the most stable in 2020 in comparison to other variants of experiment.

KEY WORDS: biochar, repeated application, soil moisture, statistical analysis

Introduction

In current times of increasing weather extremes and climate change, is difficult to ensure good-quality and safe agricultural products. It is challenge not only for big farmers, but also for individual persons who tried to grow their own vegetables in good (bio) quality. Soil fertilization is one of possibilities how to improve soil physical and chemical properties and increase an agricultural production. To improve soil properties are used various organic materials, and biochar is one of them. Biochar is carbon-rich porous material produced from biomass by pyrolysis process, what means thermochemical decomposition of organic material at temperatures from 300°C to 1000°C with reduced access of oxygen. The interest of researchers began to focus on applications of burned organic waste into soil in the 80's of the 20th century. They were inspired by Amazon area (Lehmann and Joseph; 2015) where the soils called Terra Preta were made by massive input of wood burnt (similar to biochar). These soils have a high content of organic material and retain a higher production potential than the surrounding soils (Glaser et al., 2003). The soils throughout the world contain specific amounts of biochar as a result of natural events such as natural fires, paleo fires (Kuzyakov et al., 2018) and land use history – deforestation, pre-industrial charcoal kilns and anthropogenic oven mounds (Kuzyakov et al., 2018; Hardy et al., 2017). Biochar may alter the physical properties of the soil, including increasing aeration and water holding capacity of certain soils (Sohi, 2010). High amounts of biochar added to soil affected soil wettability that influenced soil water retention (Ojeda et al., 2015). Biochar addition has been shown to improve plant growth (Graber et al., 2010), but also stimulate soil microbial activity (Smith et al., 2010). The agronomic value of biochar mainly resides in its value as a fertilizer and its ability to improve soil properties and increase crop production (Subedi et al., 2017; Yu et al., 2019).

In Slovakia, we started with biochar experiment in field condition in March of the 2014 and in the 2018 was the same biochar repeatedly applied. The aim of this paper was to evaluate the impact of the biochar application and its repeated application on soil water content of silt loam soil in surface layer during the monitoring time period of the year 2020.

Material and methods

Our measurements were conducted at the experimental area at Malanta site (Fig. 1). This area belongs to the Slovak University of Agriculture in Nitra, Slovakia. The research site is located 5 km north-east of Nitra city in the Nitra river basin where there is a deficit of soil water available to plants due to dry years (Tarnik and Letimanova, 2017). The locality is 175 MASL and the soil is classified as a silt loam with content of sand 13.2%, silt 59.9% and clay 24.9% (Simansky and Klimaj, 2017). Our measurements began in March 2014 when certificated biochar was applied to the 0–15 cm soil
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Table 1. Biochar characteristics

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>N</th>
<th>H</th>
<th>O</th>
<th>pH_{(\text{CaCl}_2)}</th>
<th>Ash</th>
<th>SSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochar</td>
<td>53.1</td>
<td>1.4</td>
<td>1.84</td>
<td>5.3</td>
<td>8.8</td>
<td>38.3</td>
<td>21.7</td>
</tr>
</tbody>
</table>

(C – carbon, N – nitrogen, H – hydrogen, O – oxygen, pH determined by CaCl₂, SSA – specific surface area)

Fig. 2. Courses of measured soil moisture values at plots with old biochar, new biochar and without biochar (Control) during monitoring period.

the wet days were these values the highest. Opposite situation was measured at B20 new variant, where during days without precipitation were measured the highest values of soil water content. Based on these results it can be seen, that soil water content at B20 new variant was the most stable during the monitoring period. For plants (globally, but also for pea grown in 2020) it is not important higher amount of soil moisture during wet days, but higher amount of soil moisture during days without precipitations. Soil water content was higher at plots with biochar during dry days of monitoring period, so we can conclude that biochar application had a positive effect on soil water content. Aydin et al. (2020) observed the positive effect of biochar on the alternation of crop yields in the third and fourth year after biochar application into Haplic Luvisol soil, but it also depended significantly on the climatic conditions in the individual year. Higher positive effect of biochar repeated application (B20 new) on crop yield could be also observed during our monitoring period, but our study was not focused on it. According to values of \( \theta \) at B20 old, B20 new and Control variants of experiment measured during the whole monitoring period, we can state that both minimal (0.101) and maximal (0.427) value of \( \theta \) were measured at Control plot. As a positive effect of the biochar application we can indicate that at B20 old, resp. B20 new the value of \( \theta_{\text{min}} \) did not decrease below 0.124 resp. 0.153. Group means of \( \theta \) for whole monitoring period increased in order Control < B20 old < B20 new (Fig. 3a) with statistically significant differences between all variants of experiment (Table 2). During dry period, we found statistically significant differences between all variants of experiment (Table 2) and group means of \( \theta \) increased in the same order as during the whole monitoring period (Fig. 3b). During the wet period we did not found significant difference between the Control and B20 old variant (Fig. 3c); significantly different were B20 new and the remaining two variants. Slightly higher mean value of \( \theta \) was measured on B20 new variant, than on the B20 old and Control.
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Fig. 3. Box plots with measured values of $\theta$ during a) whole monitoring period, b) dry period and c) wet period at Control, B20 old and B20 new variants.
Table 2. Measured values of volumetric soil water content, $\theta_{\text{min}}$. – minimal value of $\theta$, $\theta_{\text{max}}$. – maximal value of $\theta$, $\theta_{\text{mean}}$ (± their standard deviation) – arithmetic mean of $\theta$ values measured during monitoring period, $\theta_{\text{dry}}$ (± their standard deviation) arithmetic mean of $\theta$ values measured during dry period 4.7.2020–10.7.2020 and during wet period 5.6.2020–11.6.2020 ($\theta_{\text{wet}}$); Arithmetic means with the same letter are not significantly different from each other (Tukey’s HSD test, $P < 0.05$).

<table>
<thead>
<tr>
<th>Plot</th>
<th>$\theta_{\text{min}}$ [–] (N=24023)</th>
<th>$\theta_{\text{max}}$ [–] (N=24023)</th>
<th>$\theta_{\text{mean}}$ [–] (N=24023)</th>
<th>$\theta_{\text{dry}}$ [–] (N=2016)</th>
<th>$\theta_{\text{wet}}$ [–] (N=2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.101</td>
<td>0.427</td>
<td>0.161 ± 0.0519$^a$</td>
<td>0.149 ± 0.0070$^a$</td>
<td>0.216 ± 0.0354$^a$</td>
</tr>
<tr>
<td>B20 old</td>
<td>0.124</td>
<td>0.400</td>
<td>0.180 ± 0.0398$^b$</td>
<td>0.166 ± 0.0090$^b$</td>
<td>0.217 ± 0.0206$^a$</td>
</tr>
<tr>
<td>B20 new</td>
<td>0.153</td>
<td>0.342</td>
<td>0.195 ± 0.0297$^c$</td>
<td>0.187 ± 0.0060$^c$</td>
<td>0.230 ± 0.0183$^b$</td>
</tr>
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Conclusion

The application of organic material into the soil has been used for several centuries. In last decades, the interest of scientists has been focused on biochar. Its application into soil can improve its structure and quality thereby also having a positive effect on the crop quantity and quality. Statistically significant differences between all variants of experiment were measured especially during dry period. Repeated application of biochar (B20 new) increased the soil water content at 4% vol. in comparison to Control variant. During the wet period was the different between B20 new and Control variants only 1% vol. It was statistically confirmed that soil water regime was the most stable at B20 new variant (range of values 18.9% vol.) in comparison to B20 old (range of values 27.6% vol.) or Control (range of values 32.6% vol.), respectively. The results of our research at field conditions show that the application of biochar in the soil is very important, especially during dry days.

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References


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