Impact of Biochar on Soil Temperature

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Abstract. The aim of this paper was to investigate the relation of temperature of the soil surface to a biochar dose used in the field cultivation. Material from observations in a vegetation season of 2018 was used in the studies. Based on the research that was carried out it was reported that the strongest relations of the temperature of air with the temperature of soil occurred for all biochar doses. In summer, relations of biochar to the soil temperature were stable and statistically significant.

1. Introduction

Knowledge of thermal conditions of the soil surface is significant for the proper cultivation process. The temperature of soil has a significant impact on the dates when biological processes in environment begin and end. It decides on the intensity of respiration processes and biochemical changes that are particularly material in the vegetation period. Water content of soil depends on the soil temperature, which decides inter alia, on the speed of germination and health of plants. M. Molga made a thorough analysis of thermal and moisture conditions of soil [1-3]. He carried out, inter alia, a detailed characteristic of thermal properties of soil as well as factors that influence distribution of temperature including specificity of the ground layer of air.

Current research proved that the key role in shaping thermal conditions of soil plays a balance of solar radiation and field exposure. The soil temperature, especially, its ground layer, in a daily course is characterised by great changes. These changes are the most often concurrent with air temperature shifts and radiation balance [4-6]. Z. Olecki [7] investigated thermal relations of soil in an annual course in Pogórze Wielickie [Wieliczka Foothills] (Raba River Valley). The author described regularities in the annual course of the temperature of soil. He paid attention to, inter alia, a considerable decrease of temperature on the soil surface after the summer maximum and occurrence of isotherm in the soil profile. In the following publication Z. Olecki [8] analysed the impact of the cloudiness on shaping a daily course of the temperature of soil. T. Orlik [9] presented differences in
the course of temperature of soil in relation to the sculpture of land. Measurements of the temperature of soil were carried out near Lublin in four characteristic points: on the northern, southern slope, on the top part of the upland and in the bottom of the valley.

The objective of the article is to determine the relation of the temperature course in the superficial layer of soil in relation to the applied biochar dose.

2. Material and methods
The studies presented in this article were made on the experimental field that belongs to the University of Agriculture in Kraków. Soil used for research is brown soil made of Jurassic limestone. 11 experimental fields with dimensions of 1.2x1.2 m were distributed on an experimental field. They were fertilised with biochar in the amount of 0, 1, 5, 10, 20, 30, 40, 50, 60, 80 and 100 Mg∙ha⁻¹. Before measurements were initiated, probes were conditioned in an incubator. Read outs on experimental fields were made every 24 hours from May to September 2018. The analysis of variance in the scheme of repeated measurements that constituted extension of the analysis of the t-Student test for dependent tests were used for statistical assessment of the results of measurements. In the t-Student test we can compare only two measurements and in the analysis of variance we may compare two or more measurements of the same group of fields depending on the biochar dose.

3. Results and discussions
Analysis of the temperature of soil in relation to the biochar dose and time of application showed that in all investigated periods, temperature was similar (fig. 1, 2). One may notice a trend that at the highest doses, the temperature of fields is lower than for objects with smaller doses of biochar in three final periods of research. Such an observed trend most probably results from a bigger sorption surface of soil, even in a longer period after application of biochar to soil. The univariate analysis of variance for the temperature of soil in relation to biochar doses proved that there are significant differences between the doses from 0 to 30 Mg∙ha⁻¹ and doses from 40 to 100 Mg∙ha⁻¹. Within doses from 40 to 100 Mg∙ha⁻¹ no statistical differences in the temperature of soil were reported. The same relation was observed for doses from 0 to 30 Mg∙ha⁻¹ of biochar. The temperature of soil was rising along with the biochar dose for a dose of 100 Mg∙ha⁻¹ and the temperature was lower than for doses of 60 and 80 Mg∙ha⁻¹.

Statistical analysis showed that an average dose of biochar from group 1, 2 and 3 should be accepted for further research in order to limit the amount of biochar dose in further research (table 1).

Table 1. Determination of significant differences between doses of biochar and temperature on fields.
Figure 1. Average value of temperature in relation to biochar dose and month (Miesiąc) of measurement.

Figure 2. Average value of temperature in relation to biochar dose (Dawka poletko).
4. Conclusions
A relation between a biochar dose and the temperature of soil was reported. It was concluded that with field doses of 5-8 and 100 Mg·ha\(^{-1}\), temperature was at a similar level. In other cases, it was reported that the increase of the biochar dose by 10 Mg·ha\(^{-1}\) causes the increase of the temperature of soil by average 0.5-1.0°C.

Analysis of the data used in the paper confirmed the regularity that the scope of daily changes of superficial layers of soil is higher than the range of air temperature changes [10]. It is important, however, to include the temperature of soil delay in relation to the air temperature which is emphasised by *inter alia* [11,12].

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References
[1] M. Molga, “O klimacie gleby,” *Gazeta Obserwatora PIHM*, vol. 4, pp. 9–13, 1953.
[2] M. Molga, “Meteorologia rolnicza,” *PWRiL*, Warszawa, 1958.
[3] M. Molga, “Siła ssąca gleby,” *Gazeta Obserwatora PIHM*, vol. 12, pp. 3–6, 1959.
[4] M. Angiel, and M. Cisowska, “Stosunki klimatyczne progu Pogórza Karpackiego między Rabą i Uszwicą,” *Wyd. Uniw. Jagiell.*, Kraków, 1995.
[5] J. Kossowski, “O relacji między strumieniem ciepła w glebie a promieniowaniem słonecznym,” *Acta Agrophys.* vol. 151, pp. 121–135, 2007.
[6] E. Bednorz, and L. Kolendowicz, “Daily course of the soil temperature in summer in chosen ecosystems of Śląski National Park, northern Poland,” *Quaestiones Geographicae*, vol. 29, pp. 5–12, 2010.
[7] Z. Olecki, “Przebieg roczny temperatury gleby w pogórskim odcinku doliny Raby,” *Zeszyty Naukowe UJ, Prace Geograficzne*, vol. 18, pp. 71–85, 1968.
[8] Z. Olecki, “Wpływ zachmurzenia na przebieg dobowy temperatury gleby w okresie letnim w piętrze pogórskim Karpat,” *Zeszyty Naukowe UJ, Prace Geograficzne*, vol. 25, pp. 99–116, 1969.
[9] T. Orlik, “Wstępne badania temperatury gleby w kilku elementach rzeźby terenu,” *Zeszyty problemowe Postępów Nauk Rolniczych*, vol. 222, pp. 59–75, 1979.
[10] J. Kossowski, “Związek amplitud dobowych temperatury gleby w warstwie przypowierzchniowej z amplitudami temperatury powietrza i innymi elementami meteorologicznymi,” *Acta Agrophys.*, vol. 5, pp. 657–667, 2005.
[11] B. Michalska, and J. Nidzgorska-Lencewicz, “Dobowa zmienność temperatury w profilu gleby porośniętej w stacji meteorologicznej w Ostoi,” *Folia Pomer. Univ. Technol. Agric.*, vol. 279, pp. 63–72, 2010.
[12] D. Ciaranek, “Wpływ warunków pogodowych na przebieg temperatury gleby w ogrodzie botanicznym Uniwersytetu Jagiellońskiego w Krakowie,” *Zeszyty Naukowe UJ, Prace Geograficzne*, vol. 133, pp. 77–99, 2013.