Impact of Biochar on Soil Water Content and Electrical Conductivity

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Abstract. The article presents the possibilities of using time-domain reflectometry (TDR) to determine the water content and electrical conductivity of mineral soil with biochar addition. The TDR method consists in measuring the time of electromagnetic pulse transmission and reflection from the obstacle back to the source point. The impulse is a step signal of voltage. The reflected signal contains information on the dielectric properties of the material being tested. Therefore, qualitative, and quantitative properties of the material can be detected. The tests were carried out using a mobile reflectometric device as an electronic humidity and conductive meter. Based on the obtained results, the usefulness of reflectometric methods in the study of the water content and electrical conductivity of mineral soil was determined.

1. Introduction

Most physico-chemical properties of soil which are indicators of its quality from the point of view of the production value and purity of environment depend on its water content. Water is not only an element that is indispensable for biological transformations that precondition fauna and flora development, it also constitutes a transport mean for nutrients and thermal energy in soil [1-5].

Water contained in soil influences fundamentally the size of agricultural production but also weather and climate. Knowledge of physico-chemical parameters such as water content, salinity and temperature enable to carry out analysis of water resources, content of plant nutrients and their shift in the soil profile as well as assessment of thermal capacity of soil. Adjustment of soil parameters to plant needs of big agricultural areas known as precise farming requires optimal selection of the above parameters. Thanks to suitable dosing of fertilisers, economic effects are obtained but also environment is protected since excess of fertilisers, that would have permitted to ground water and as a result contaminate water reservoirs and rivers, is prevented. Control of the water content in soil has recently become a significant issue in the light of reduction of water resources. In the presence of increasing weather anomalies related to water excess or its long-term lack, the control of its content in...
the surface layers of soil and in the soil profile has started to play a decisive role which enables modelling and verification of model and provides information necessary to interpret satellite imagery [6-8].

Biochar is produced in the process of pyrolysis. It is an endothermal process in which at relatively high temperatures and anaerobic atmosphere the following products are generated: oil - mixture of liquid carbohydrates, synthesis gas - mixture of gas carbohydrates and biochar [9]. It is a complex process in the course of which the following reactions overlap: dehydration, isomerisation, aromatisation, carbonization, oxidation, and others [10]. Both the amount and quality of particular substances depend on the conditions of the process and thus on the distribution of temperatures, time of keeping in the chamber, temperature and pressure [10] and the quality of substrates [11].

The aim of this paper is to use time-domain reflectometry (TDR) method to measure soil humidity and electrical conductivity. The purpose of the present paper is to validate and to clarify the limits of TDR method for long-term moisture and electrical conductivity measurements in field conditions.

2. Material and methods
The studies presented in this article were performed on the experimental field that belongs to the University of Agriculture in Kraków. Soil used in the study is a brown soil from Jurassic limestone. 11 experimental fields with dimensions of 1.2x1.2 m were distributed on the 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 probe measurements were started, TDR was conditioned in an incubator in 0.1 n solution of KCl and temperature of 30°C. 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 t-Student test for dependent tests was 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 discussion
The water content in soil was at a similar level for all investigated doses of biochar (fig. 1). In the second month, some trend could have been observed. The higher was the biochar dose the higher was the water content. In subsequent months we see a clear relation - the higher is the biochar dose the higher is the water content of soil. The accepted doses of biochar from 0 to 30 Mg∙ha⁻¹ show similar values of the average water content of soil in relation to the application time. Such a course of the analysed phenomenon indicates clearly the increase of water capacity of soil in relation to the biochar dose.

The analysis of soil electrical conductivity showed no significant differences in relation to the amount of biochar dosage and time from the moment of application (fig. 2). The analyses that were carried out show that the amount of biochar influences the electrical conductivity of soil. The biggest differences in the investigated variable were obtained for dose 10 Mg∙ha⁻¹ of biochar per one hectare. In the first period of measurements, the highest values of electrical conductivity of soil were reported on the field with the dose of 40 and 100 Mg∙ha⁻¹ of biochar per hectare; in the second period the highest values were reported for dosage 80 and 100 Mg∙ha⁻¹ per hectare. For a dosage of 100 Mg∙ha⁻¹ per one hectare of biochar also in the last period of research the highest values of the investigated variable were reported.

Analysis of soil moisture in relation to the biochar dose showed that there are no significant differences between the average values of doses from 0 to 20 tonnes of biochar per hectare. The same value was obtained for doses 30-50 tonnes of biochar per hectare, the last group with similar average
values was obtained for doses from 60-100 tonnes of biochar per hectare. The level of water content considerably differed in relation to biochar doses. The higher were the doses the higher was the water content of soil. It undoubtedly proves the impact of the amount of biochar on the water content of soil.

**Figure 1.** Average value of water content in relation to biochar dose and month of measurement

**Figure 2.** Average value of electrical conductivity in relation to biochar dose and month of measurement
4. Conclusions

A relation between biochar dose and water content of soil was observed. It was concluded that with fields, doses of 5-10 Mg·ha⁻¹, the water content maintained at a similar level. The second group with similar parameters of the water content consisted of fields with the dose of 30-50 Mg·ha⁻¹, and the third group were fields with the dose of 60-100 Mg·ha⁻¹. For group 1, average water content was 8.52% for group 2 - 9.68% and for group 3 - 11.96%. 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 (tables 1, 2).

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