Biochar impact on tensile strength of *Dystric Cambisol* aggregates – a model study

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Introduction

Intensive agriculture and significant environmental pollution contribute to the continuous deterioration of soil conditions. Soil structure is often destroyed and, consequently, the water and air properties of soil become unfavorable for plant growth. In order to limit such negative phenomena, various soil additives are often used. Biochar is one of such substances that can prevent negative changes and improve soil condition due to its specific properties. This organic material is obtained in the pyrolysis process from biomass (e.g., wood, leaves, rhizomes, wastes) and is usually characterized by a high specific surface area and numerous surface functional groups [1-3] .

In response to the discrepancies in literature reports about the effect of biochar on soil aggregate tensile strength, this paper focused on the tensile strength of *Dystric Cambisol* cylinders with and without biochar obtained from wood waste and sunflower husks. The examined soil cylinders were artificially remolded from the unfractionated soil or its selected fractions (1–0.25, 0.25–0.1, 0.1–0.05 and below 0.05 mm) in the laboratory. Two biochar doses (0.1% and 5%) and different sample moistures (air-dry and wetted samples) were under study.

Dystric Cambisol

- silty soil,
- Rogóźno (Lublin province, Poland, 50°46′N, 23°38′E),
- taken from a 0–20 cm depth.

Biochars

- BC1 - produced from wood waste by FLUID S.A. (Poland),
- BC2 - prepared from sunflower husks by NEW TECHNOLOGY TRADE (Poland),
- two types of biochar were obtained by pyrolysis process at 650°C.

Methods

- Soil fractions of 1–0.25 mm, 0.25–0.1 mm, 0.1–0.05 mm, and below 0.05 mm were obtained using the sieves with the following mesh sizes: 1 mm, 0.25 mm, 0.1 mm, and 0.05 mm,
- 10 g of the air-dry unfractionated soil or its fraction was wetted by 2 ml of demineralized water. Then, the wetted material was placed in a closed chamber for 48 hours. After this time, the aggregates were formed using a special plastic syringe. A single artificial aggregate had the following dimensions: d (diameter) = 10 mm, h (height) = 7 mm,
- Total porosity and pore size distribution (PSD) of the pure biochars, *Dystric Cambisol*, and prepared cylinders were determined using the autopore IV 9500 (Micrometrics INC, USA) mercury porosimeter,
- The measurements of cylinder tensile strength (*Q*, MPa) were carried out using the strength testing device (*Zwick/Roell*).

Tab. 1. Soil and biochar characteristics

Parameter		Soil	BC1	BC2
Specific surface area [m^2/g]		15.2 ± 0.7	69.9 ± 2.2	80.9 ± 2.1
pH_{H20}		6.3 ± 0.1	8.2 ± 0.1	9.7 ± 0.2
pH_{KCl}		6.1 ± 0.1	7.6 ± 0.1	9.2 ± 0.2
Density [g/cm^3]		2.6 ± 0.1	1.5 ± 0.1	1.4 ± 0.1
Ash content [w%]		97.0 ± 1.5	43.7 ± 1.8	35.4 ± 1.1
Organic carbon content [%]		1.2 ± 0.1	12.3 ± 0.2	22.5 ± 0.2
Texture [%]	Sand (2-0.05 mm)	16 ± 1.2	-	-
	Silt (0.05-0.002 mm)	75 ± 1.5	-	-
	Clay (<0.002 mm)	9 ± 0.8	-	-

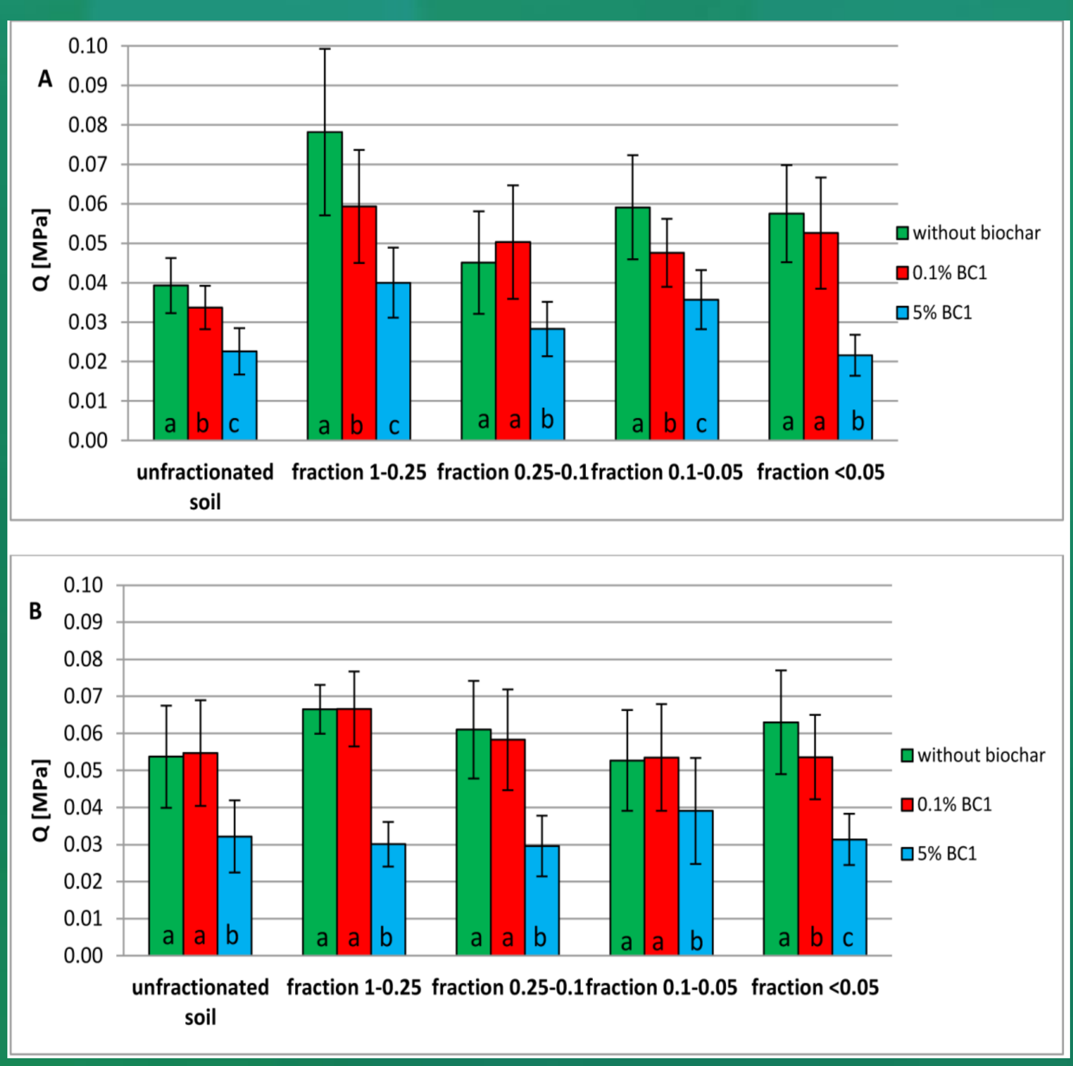

Fig. 1. Wood waste biochar (BC1) effect on tensile strength of air-dry (A) and wetted (B) cylinders formed from the unfractionated soil and its selected fractions

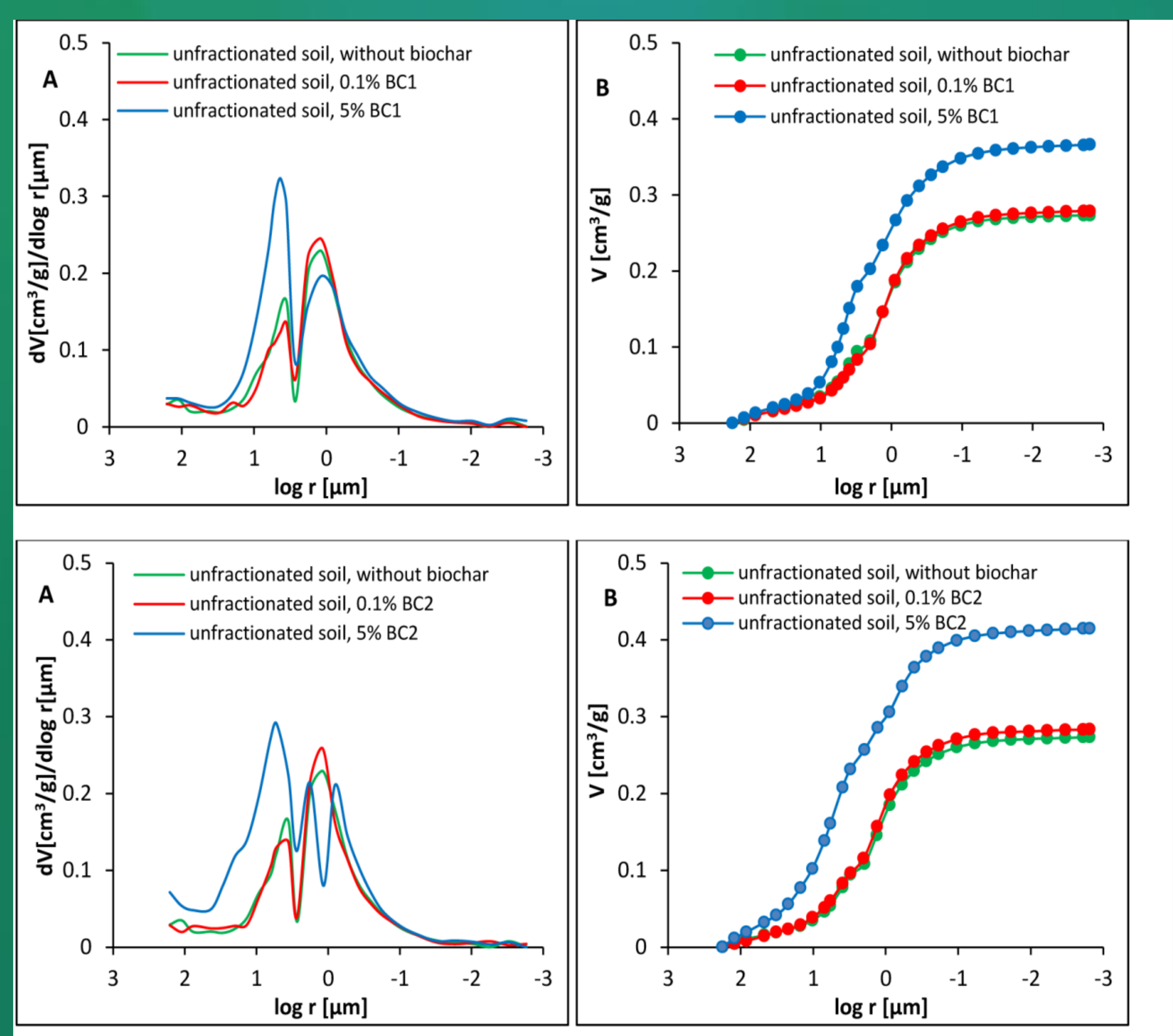

Fig. 2. Differential (A) and cumulative (B) curves of pore volume vs. equivalent pore radius of cylinders remoulded using unfractionated soil with and without wood waste (BC1) and sunflower husks (BC2) biochars

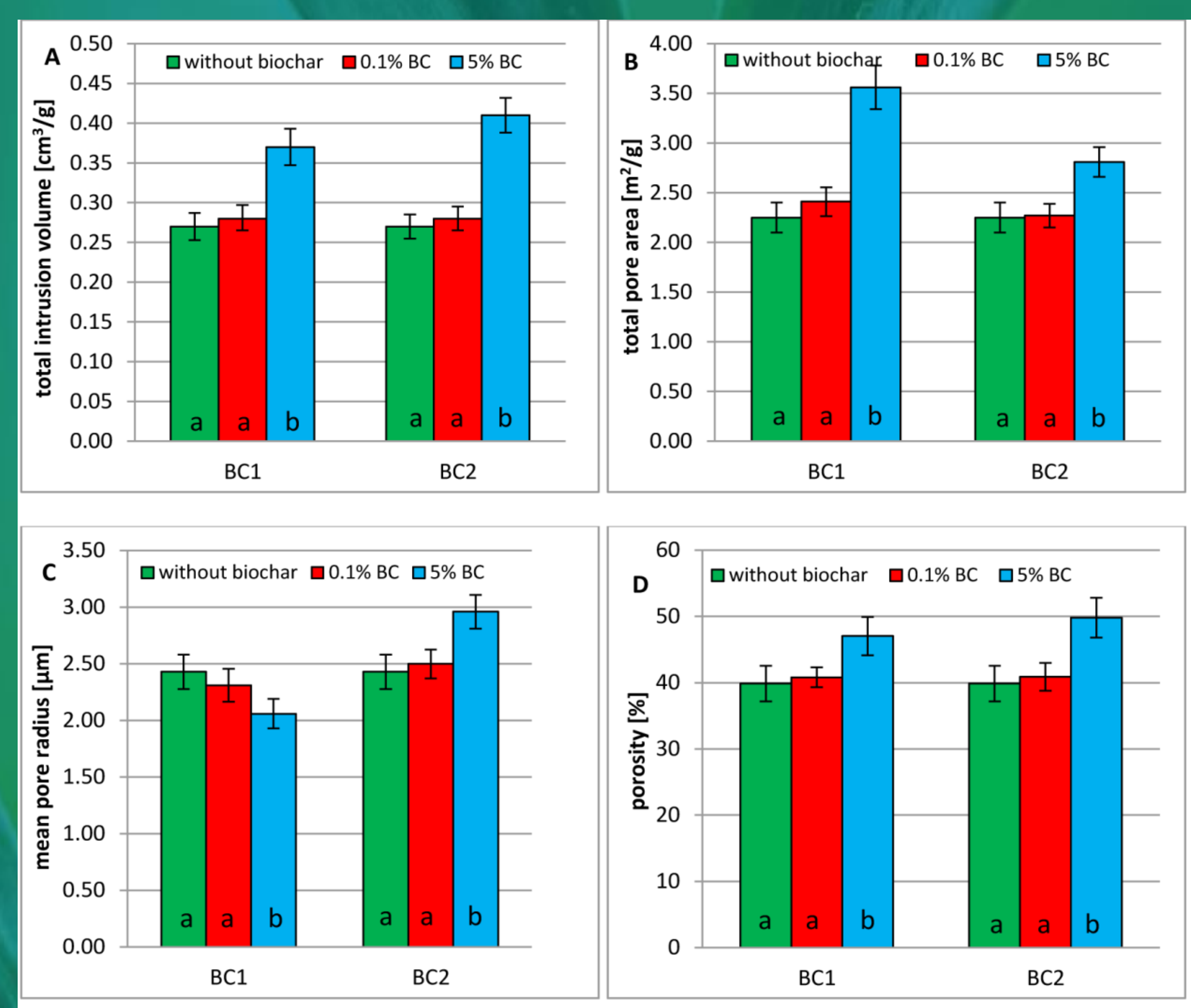

Fig. 3. Porosity characteristics of the unfractionated soil cylinders with and without wood waste (BC1) and sunflower husks (BC2) biochars: A) total intrusion volume, B) total pore area, C) average pore radius, D) porosity

Conclusions

1. The cylinders with biochar were characterized by macropores of larger radii than those without the carbon-rich additive. These phenomena were more significant in samples with a higher dose of biochar (5%). For example, the cylinders remolded from unfractionated soil without biochar contained two groups of macropores of 1.58 µm and 4.77 µm. In turn, the cylinders formed using the same material with sunflower husks with a 5% biochar dose were characterized by macropores of 5.78 µm.
2. The increase in macropore size in artificial aggregates after the biochar addition contributed to the reduction in tensile strength. The largest reduction (by 0.048 MPa) was observed in the case of the sunflower husks with a 5% biochar dose in the wetted 1–0.25 mm fraction.
3. The highest tensile strength of the cylinders was observed for the fraction of the largest particle sizes (1–0.25 mm); this is probably related to the high silica content in this fraction.

See more: Zofia Sokołowska et al., *Agronomy* 10(2) (2020) 244

References: [1] L. Beesley et al., *Environ. Pollut.* 186 (2014) 195, [2] D. Yang et al., *Pedosphere* 27(4) (2017) 645, [3] G. Shrestha et al., *Sustainability* 2 (2010) 294.

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