Effect of Biochar on Soil Physical Characteristics: Water Retention and Gas Transport in a Sandy Loam

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Introduction

Biochar, as a soil amendment, has received much attention. However, little is known about its effect on soil structure

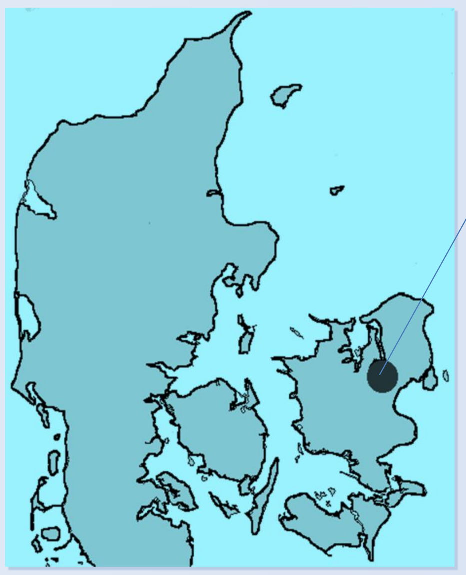
Objectives

- To observe variations in soil water retention after biochar application
- To investigate gas transport characteristics under a series of matric potentials

Methods

Field

4 control (C) plots, 4 biochar (BC) treated plots (6×8 m)



Biochar

Birch
pyrolysis at 400℃
Dose = 20 t ha^{-1}

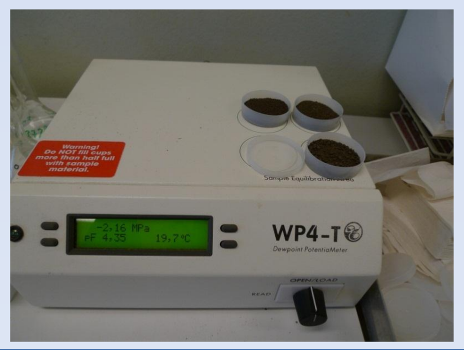
Sampling

5 soil cores(100 cm^3) per plot

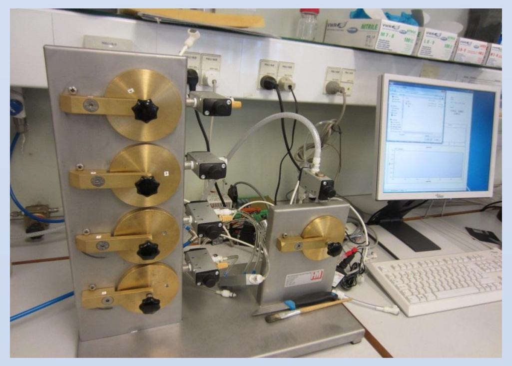
Water retention

- **Wet region**
  Soil cores: sand box + ceramic plate apparatus
  Matric potentials, ψ (pF 1.0 – 3.0)
  pF = log (-ψ, cm H_2O)

- **Dry region**
  Bulk soil: WP4-T
  High pF values (4.0 – 6.8)

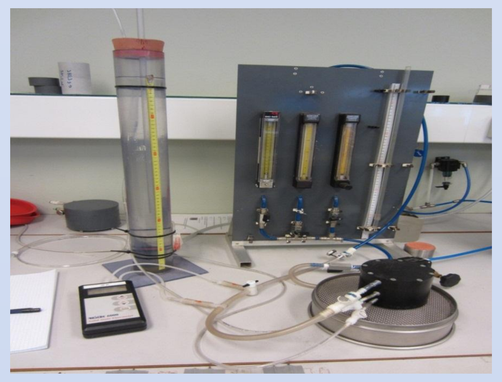


Gas parameters



Air-filled porosity, ε

Gas diffusivity, D_p/D_o



Air permeability, k_a

Matric potentials pF 2.0 – 3.0

Soil structure parameters

Pore connectivity-tortuosity factor, X = $\log(D_p/D_o)/\log(\varepsilon)$

Pore structure parameter, P = $k_a/(D_p/D_o)$, μm^2(Kawamoto et al., 2006)

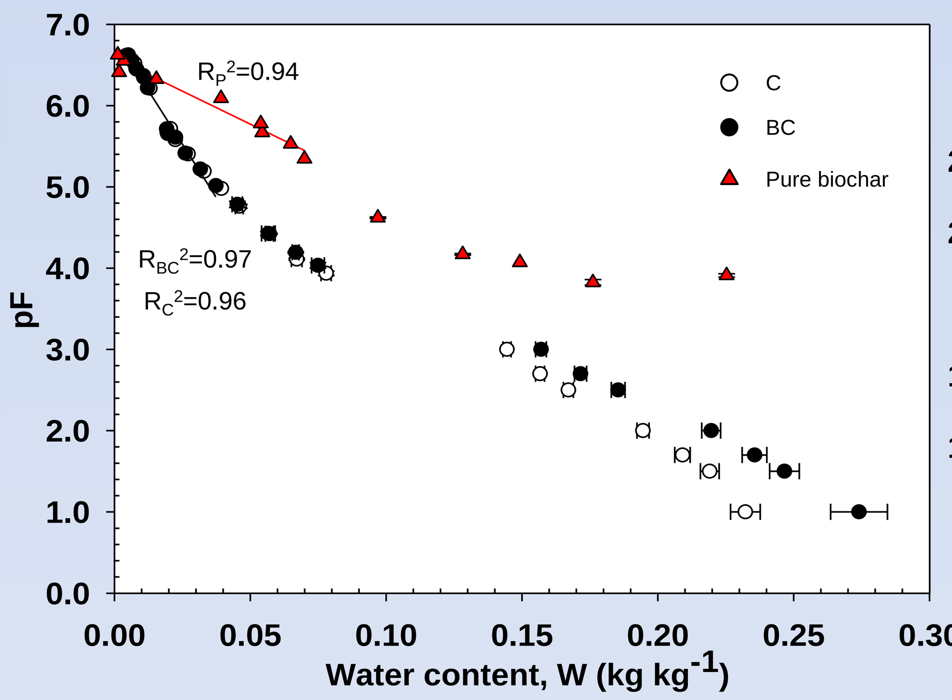
Results

Basic properties of soil and pure biochar

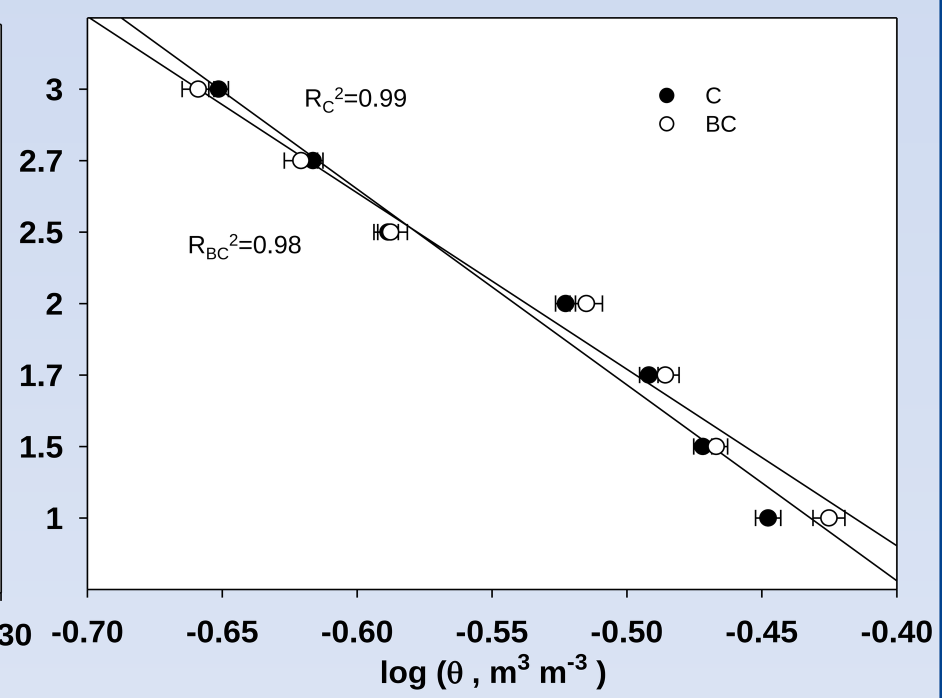
	Bulk density g cm^{-3}	Total porosity m^3 m^{-3}	*Water content kg kg^{-1}	Surface area m^2 g^{-1}	A_dry	Campbell b	H	ep m^3 m^{-3}
Control	1.54	0.42	0.16	40.8	-43.8	9.1	0.30	0.057
BC	1.40	0.47	0.18	38.6	-43.9	8.2	0.32	0.055
Pure biochar	–	–	–	321.8	-20.3	–	–	–

—: not determined; A_dry: the slope of linear regression for water retention curves (6.8≥pF≥5.0); H, ep: coefficient of Millington Model $Dp/Do=H*(\varepsilon-ep)^{1.333}$;*: field soil-water content at sampling time

Water retention curves and modelling

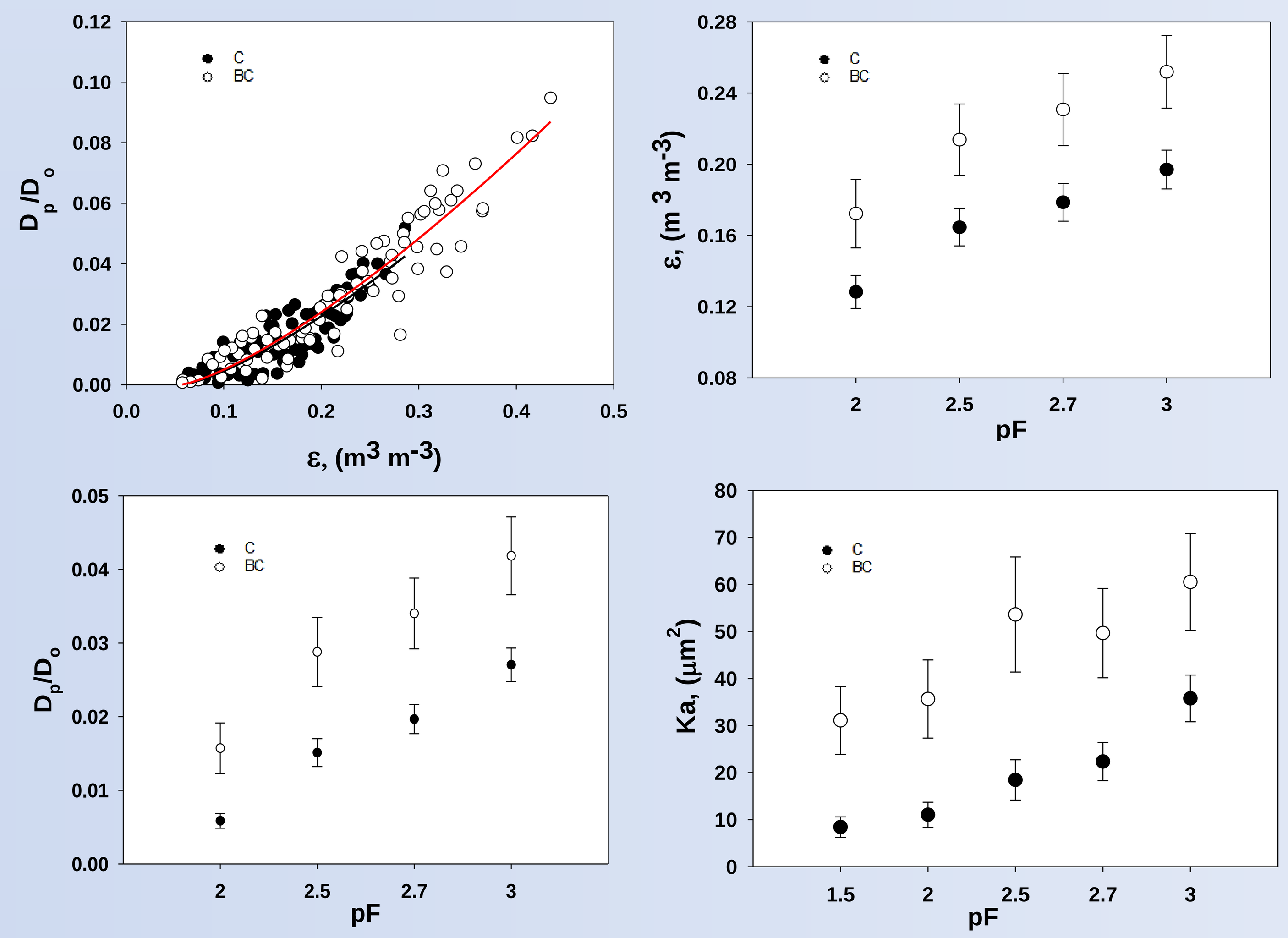


Complete water retention curves from wet to hyper-dry

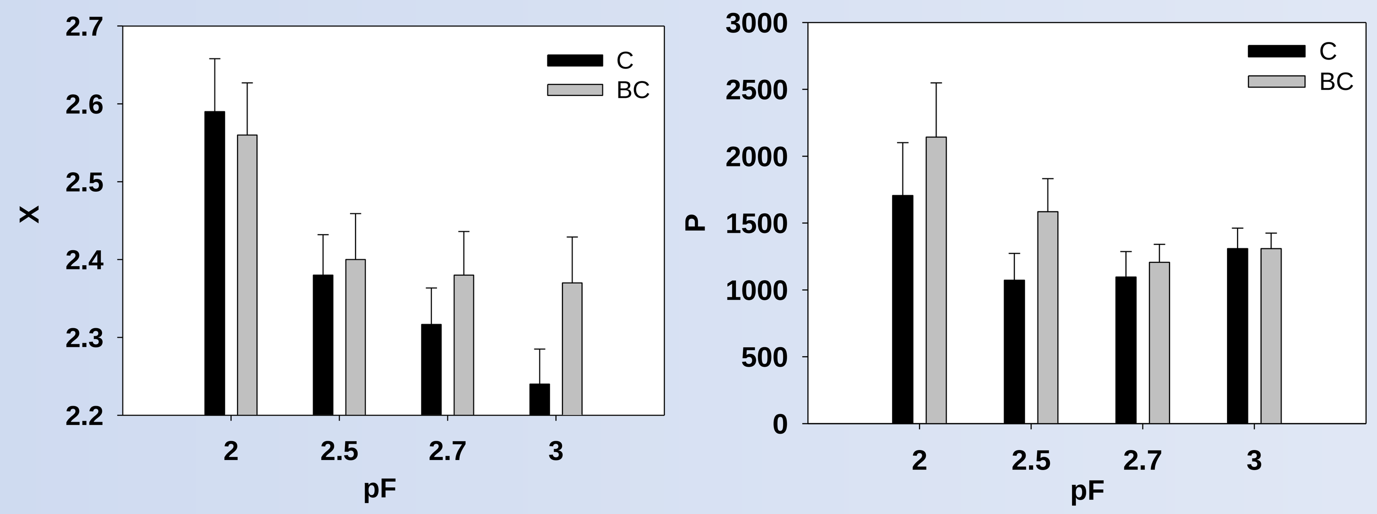


Campbell model fitted to the wetter part data with x-axis based on volumetric water content(θ)

Gas phase transport



Pore structure indexes



Conclusions

- Biochar increased soil water retention.
- Biochar at the same time markedly enhanced air-filled porosity and gas transport parameters and likely also changed/improved pore network structure as inferred from the X and P indexes.

Acknowledgements

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References

Kawamoto, K., P. Moldrup, P. Schjønning, B.V. Iversen, T. Komatsu, and D.E. Rolston. 2006. Gas transport parameters in the vadose zone: Development and tests of power-law models for air permeability. Vadose Zone J. 5:1205-1215

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