SOIL WATER RELATIONS IN A SOIL TREATED WITH BIOCHAR

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Introduction

Biochar and its applications have known a growing interest in these last years, due to the carbon sequestration capacity and the generally positive impact on soil and agricultural productivity. Next to the numerous studies assessing the positive effect of biochar on crop yield [1, 6], little researches have been published elucidating the mechanisms responsible for the reported benefits of biochar on crop growth, production and soil characteristics [1,2,3,5]. Few studies cited soil moisture as the key factor attributing the increased yield to the higher soil water availability.

Research Objectives

Aim of this study is to investigate the effect of a biochar, produced from horticulture waste by pyrolysis, on the physical properties of a North-Italy agricultural soil.
In particular, soil water content, bulk density, electrical conductivity, soil water retention and soil temperature are measured, in field and/or in laboratory.

Materials and Methods

The trial was conducted in the experimental farm of the University of Bologna in Cadriano (BO, 44° 33' N, 11° 24' E, 33 m a.s.l.). The climate is continental, with mean annual rainfall amount of 740 mm (all climatological information in [4]).

The soil has a loam texture, with a subalcaline pH. Biochar derives from fruit trees pruning residues, with pH = 9.8 and total C = 57.8 mg kg^{-1}.

A preliminary experiment was held in 2009 to first explore the biochar influence on soil moisture, in six 1x1 m^2 plots. Biochar was applied at two rates (Q1 = 10 t/ha, Q2 = 30 t/ha). It was tested in a fully randomised experimental design, with two replications and a control (Q0). Plots were tilled after the biochar distribution to incorporate it into the soil, at a depth of about 20 cm.

The water content probes (EC-5 Decagon Device) were inserted at 10 and 30 cm. Each probe was calibrated by means of thermogravimetric data.

Results from this trial showed no significative differences between control and treated plots. This could be due to the fact that the probes were not totally dipped into the biochar soil layer, and also to the low amount of char in soil. In 2010 we replicated the experiment changing probe depths and biochar rates to 5 and 10 cm and to T1 = 30 t/ha and T2 = 60 t/ha, respectively.

The experiment was set in May 2010, the data were evaluated from May the 31st to September the 3rd, 2010. Two irrigations were applied to have good calibration equations.

Bulk density, electrical conductivity, and soil temperature were measured in field, soil and soil plus biochar samples were collected to measure soil water retention in laboratory using Richards pressure chambers. They were crushed and sieved at 2mm, water retention was measured on disturbed soil.

Conclusions

- Biochar addition in soil significantly reduces bulk density in field and increases water retention for low potentials, measured in disturbed samples in laboratory.
- No effects are detected on soil moisture measured in field on bare soil, with both gravimetric and electronic methods.
- Soil temperature results higher in treated soil than in the control, but only when measured on the surface, probably due to differences of albedo.

Results

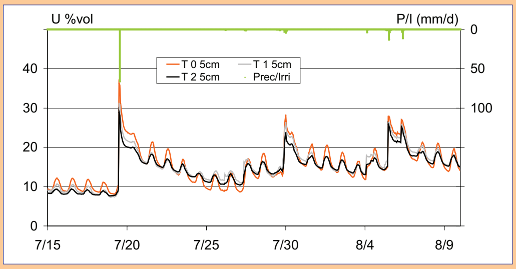
Treatment	Biochar amount (t/ha)	pH		EC (μS)		Bulk density (g/cm³) 5 cm		Bulk density (g/cm³) 10 cm	
T0	0	6.65	a	498.5	a	1.20	a	1.23	a
T1	30	6.95	a	500.0	b	1.06	b	1.15	b
T2	60	7.10	a	504.0	c	0.98	c	1.09	b

Soil characteristics

A biochar effect on pH was not found, while electrical conductivity showed significative differences.

There are significative differences between bulk density of the control and the two rates of biochar in the first 5 cm. At major depths, the difference between control and treated plots is still evident, but it is impossible to distinguish the rate effect. This could be explained considering that biochar in soil is not homogenously distributed and the border between the two soil layers (with and without biochar) is not well defined. The control plot has the highest bulk density.

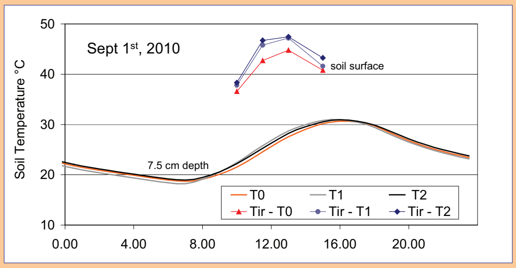
Soil moisture

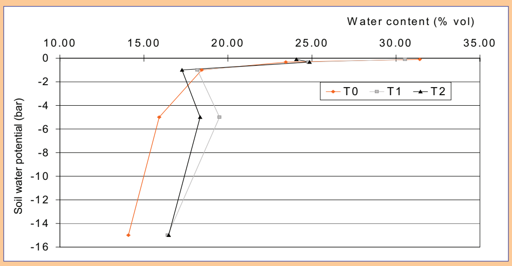


No differences are found in volumetric soil moisture, with both measurement techniques, thermogravimetric and capacitive. This is true for the whole range of soil moisture, between 7% and 30%vol. The same result is verified in soil water content (in mm for 10 cm layer). The only significant difference (***) is found after the irrigation (66 mm) with θ ~ 35%vol. After a few hours, with the drying of the soil surface, the effect disappears. In this case soil moisture decreases with increasing biochar concentrations. The graph shows only a little part of the soil moisture continuous monitoring, that was in the field for about four months.

Soil temperature

No effect of biochar on soil temperature is detected.
The appearance of the surface is quite different between treated and not treated soil, being darker for increasing amounts of biochar. In fact, soil temperature measured by the IR thermometer results to be affected by biochar application, with significative differences among plots in all cases. This is probably due to the diverse soil surface albedo.





Potential

Soil water potential in disturbed soil is affected by biochar amount only for low potential (-5 bar, -15 bar). In these cases there is a greater water retention, while no effect of biochar amount is detected for higher potentials.

References

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