Effects of biochar on water retention in the Interreg Biochar: climate saving soils field trials

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Investing in the future by working together for a sustainable and competitive region

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1. Introduction

Improvement of water availability is one of the claims of application in agricultural soils. Biochar is generally considered to have similar properties as soil organic matter (SOM) and since it is generally accepted that SOM positively affects crop moisture availability in agriculture, a similar affect is often assumed (and reported) for biochar.

In the Interreg project Biochar Climate saving Soils, biochar has been applied to agricultural soils (arable fields) in seven countries surrounding the North Sea: Belgium (Flanders), Netherlands, Germany, Denmark, Sweden, Norway and the UK. The locations are indicated in Figure 1 (Blue marks). Soil types included sandy soils, loam soils and clay soils.

Figure 1. Locations of the Interreg Biochar Climate saving soils field trials (blue marks, sites at the pink marks are from another project and obtained a different type of biochar).

2. Experimental method

Each of the field obtained the same type of biochar, which was applied at a rate of 20 tons per ha and mixed with the upper 20-30 cm of soils. Undisturbed Soil samples were taken in Spring 2013, 1-2 years after biochar application (application date varied per location) using the following scheme:

Instruction for Soil sampling for pF curves in the Interreg project

1. Sites to be sampled:
   a. Each biochar plot and
   b. each control plot without biochar
   c. plus preferentially if available each plot with an alternative for biochar, e.g. compost
2. Sampling depth: In the centre of the layer with biochar. If this layer is 20 cm or 30 cm, sampling depth is 7.5-12.5 cm and 12.5-17.5 cm, respectively
3. Preparation of sampling sites: Follow the general rules in the Technical Document (Stolte et al, 1997[1])
4. Try and find a stone-free area.
5. If one has the full equipment for soil sampling, please use that. If not:
   a. place a ring on the soil surface. Place a wooden block on top of it and push it into the soil, if needed use a (rubber) hammer. Take care not to introduce cracks or any other disturbance of the soil inside the sample ring. The ring must be completely full with soil, but may not be filled up by hand with loose material. This step is essential and must be performed with great care.
   b. Carefully remove the ring from the soil by removing the surrounding soil, until you reach the end of the ring, Take care that no soil is lost from the ring. Please leave a bit of soil on top and at the bottom, do not cut it off. If there are stones inside the ring, please repeat the procedure until a stone-free sample has been obtained
   c. Carefully cover the rings with kitchen foil. Do not compact the soil, but the foil may be attached pretty tightly.
   d. Extra packing of the rings into aluminium foil is not really necessary, but it may be an extra care ?)
   e. Mark the rings with a number if not already present and write down the sampling location and depth on a sheet of paper
6. Place the rings into a box in such a way that they remain fixed during transport and are prevented from being subjected to heavy mechanical shocks

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[1] Stolte, J, Veerman, G.J. & Wopereis M.C.S (1997) Taking Soil samples in the field for laboratory analysis. Technical Document 37, 1997, 11-15

7. After sampling all samples have been sealed and sent to Wageningen where the water retention curves were produced.

Water retention curves

Standard procedures have been applied to obtain the water retention curves (see for instance http://www.astm.org/Standards/D6836.htm) using a combination of a sand box, evaporation method and the pressure plate extractor for low, medium and high pressure, respectively.

After full saturation of the undisturbed ring samples with water, the amount of water freely moving from the column was determined. Next , a certain step-wise increased amount of vacuum pressure was put on the soil column (pF values at 0.70; 1.00; 1.48; 1.70; 1.85; 2.00; 2.30 2.85; 3.48 and 4.2, respectively), and after an equilibration period the weight of the rings was measured in order to determine the amount of water left in the soil. The entire procedure takes several weeks to obtain equilibrium at each pressure regime.

Next to the water retention curves of the field soils, also a retention curve of biochar mixed in different concentrations (0, 10, 20, 50 and 100% biochar) with pure sand have been made and compared with retention curves from perlite-sand mixtures. Perlite is used as a soil amendment in potteries in order to improve the water holding properties of such soils.

3. Results

General explanation of a retention curve

A general explanation of the water retention curve is given using the results of Flanders (Fig 2).

The curve shows the amount of water (volume of water per volume of soil) at different pressures (pF = log hecto-Pascal). Water below the lower red line freely moves from the soil column by gravity. Water between the red lines can be removed by plants using evapotranspiration and equals the amount of plant available water. Water above the upper red line is stored in extreme small pores (below 0.2 micrometer in diameter), that evapotranspiration pressures are too small to remove water. On average soils in Flanders with biochar have a little more water than controls without biochar (blue line is mostly right from the green line). However the variation within the three replicates is too large to make the differences statistically significant. This means that the results are similar for biochar and the controls.

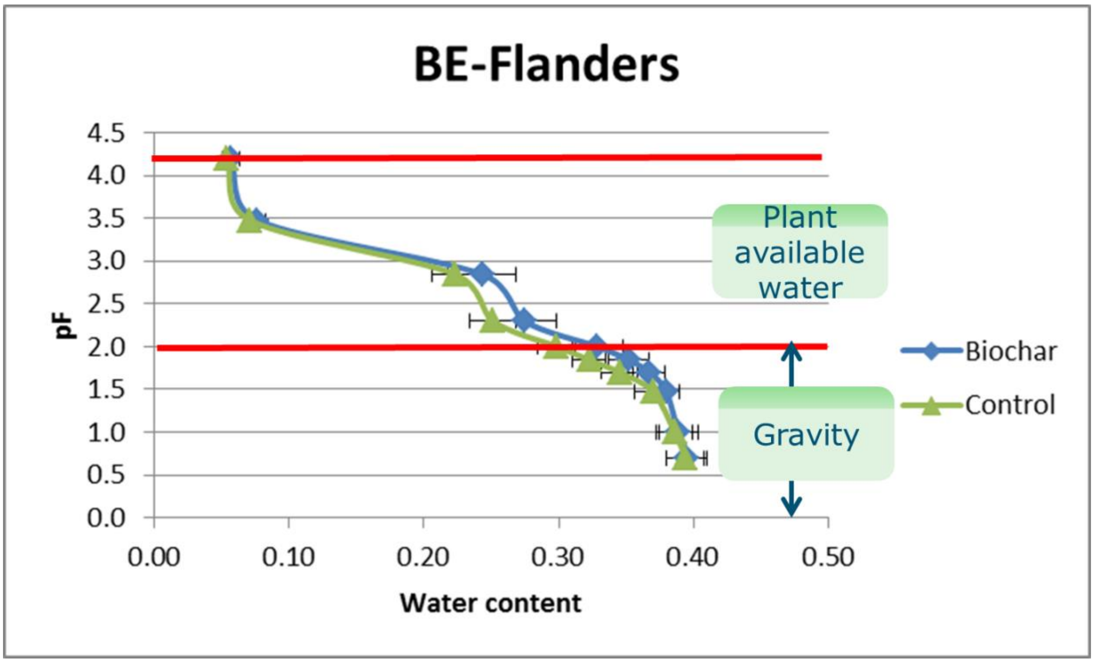
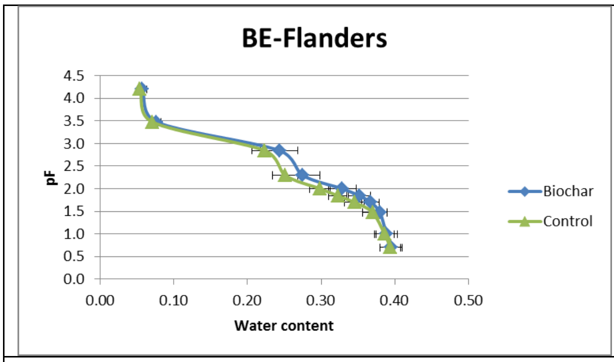


Figure 2. General explanation of the water retention curve.

Water retention curves of the Interreg field trials

The water retention curves of soils from the Interreg region (all sites except Germany from which no soil samples were received) is shown in Fig.3 It is clear that there is no difference between the treatments with biochar and the control which was in all fields chemical fertilizer. The plots in the Netherlands which had received compost showed, surprisingly, a lower water availability than the control and the biochar treatment.



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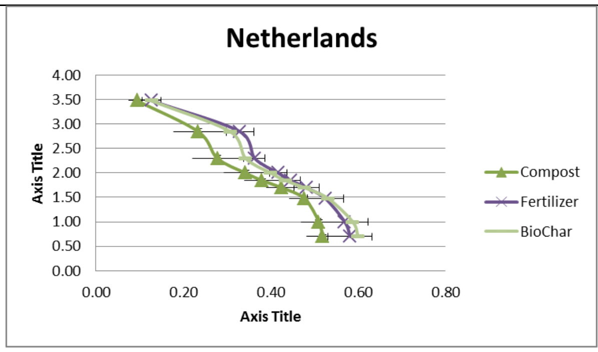

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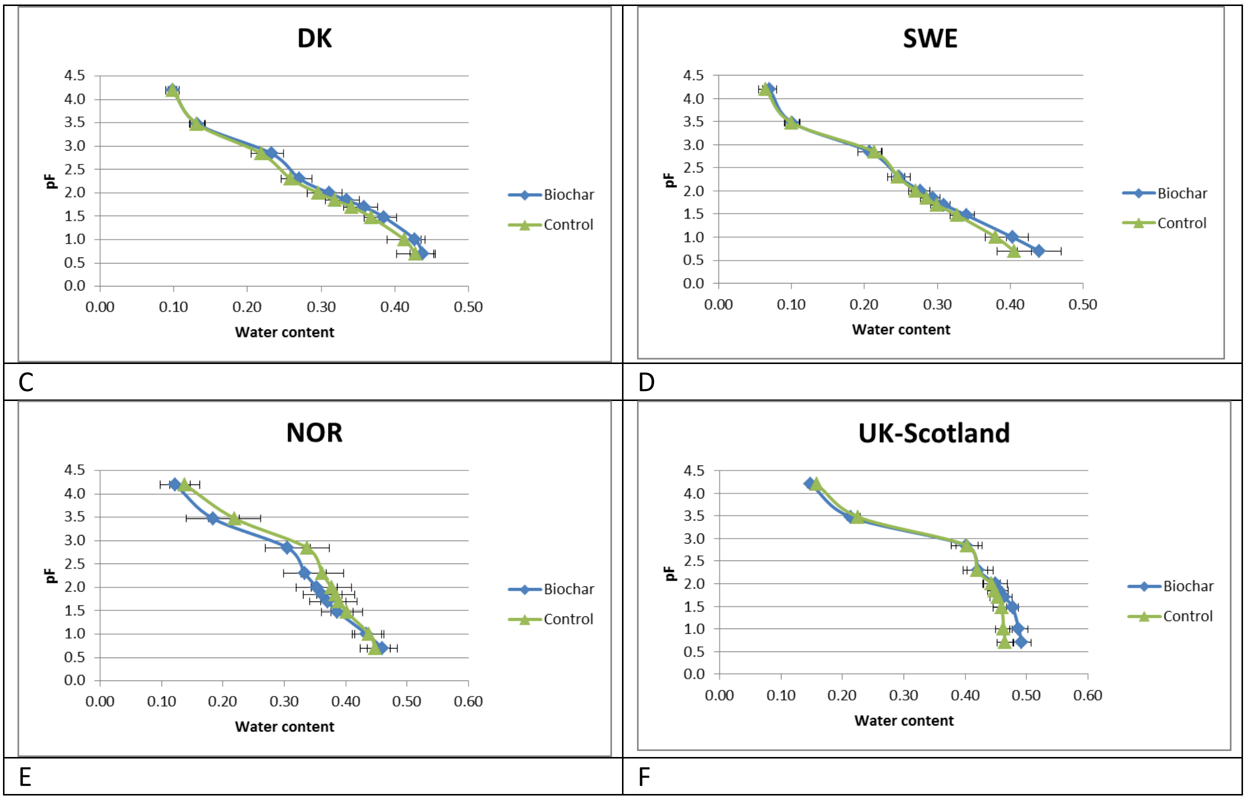

Figure 3. Water retention curves in the Interreg North Sea Region Field trials. (pF= pressure expressed as log hPa. BE, Belgium. DK, Denmark; SWE, Sweden; NOR, Norway).

It is clear that there is no difference between the treatments with biochar and the control which was in all fields chemical fertilizer. The plots in the Netherlands which had received compost showed, surprisingly, a lower water availability than the control and the biochar treatment.

Biochar sand mixtures

The water retention curves of biochar mixtures and pure sand are shown in Figure 4. It is clear that biochar has superior water retention properties than pure sand. It is also clear that at least 10% biochar is needed to obtain a result with positive practical implications. At lower concentrations only a very small positive effect of biochar may be expected.

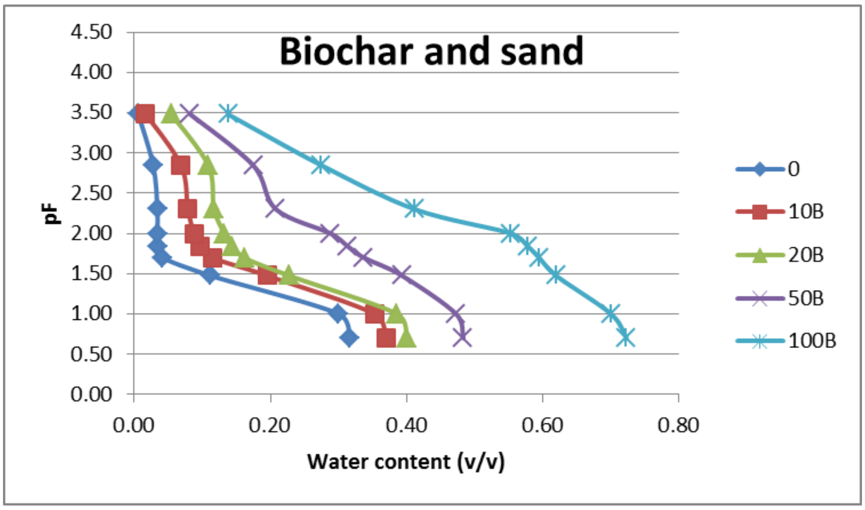

Figure 4. Water retention curves of biochar- sand mixtures (0-100B = 0% - 100% biochar)

Biochar is rather rigid in nature. In contrast to for instance peat fibres, biochar will probably not take up a large amount of water by swelling. In that respect biochar properties are more comparable to the inorganic compound perlite than to organic fibres; the latter being able to take up several times their own weight of water.

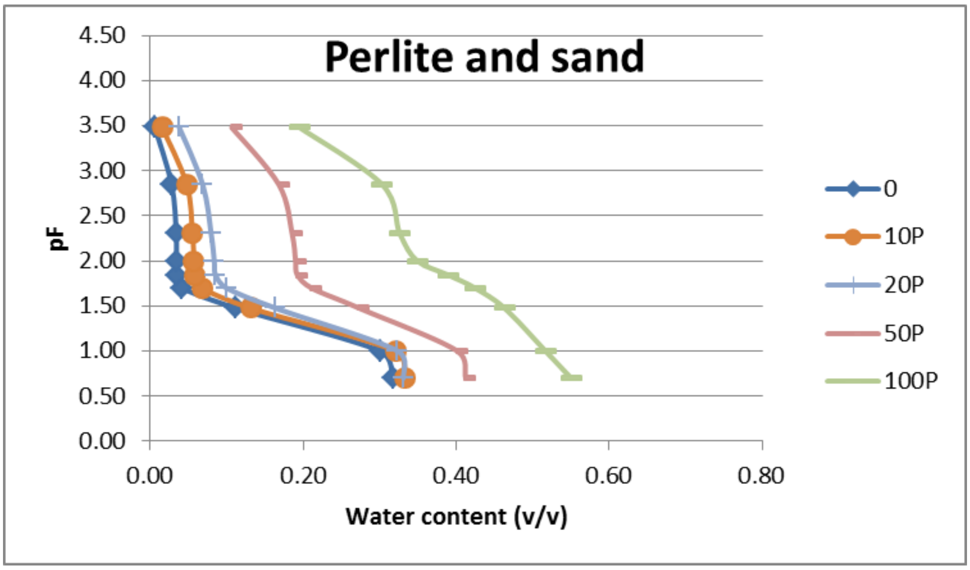

Figure 4. Water retention curves of perlite- sand mixtures (0-100P = 0% - 100% perlite)

pF	Biochar	Perlite	Biochar/Perlite
0.7	0.72	0.55	1.3
1.0	0.70	0.52	1.4
1.5	0.62	0.46	1.3
1.7	0.59	0.42	1.4
1.8	0.58	0.39	1.5
2.0	0.55	0.35	1.6
2.3	0.41	0.33	1.3
2.8	0.28	0.30	0.9
3.5	0.14	0.20	0.7

Table 1. Water content of 100% biochar and perlite at different pressures and the content in biochar relative to perlite

Comparing the water retention characteristics of mixtures of sand with biochar and perlite confirmed this hypothesis (Fig 5 and Table 1). Between pF 0.7 and 2.3 100% biochar could take up 1.3 – 1.6 times more water than 100% perlite, above pF 2.3 perlite was more effective than biochar.

4. Conclusions

Application of biochar at a rate of 20 tons per ha (equivalent to 0.5% soil organic matter) had no effect on the crop availability of water. Biochar application to pure sand will improve the water retention characteristics of the sand, but only if substantial amounts of biochar have been applied. Biochar properties regarding water retention are comparable to those of perlite.

BIO CHAR

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