How Does Biochar Affect the Pore Size Distribution, S-Index and Saturated Hydraulic Conductivity of a Sandy Soil?

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Objectives

The main objective of this study is to evaluate the effects of hardwood fast pyrolysis biochar on the hydraulic and physical properties of a sandy soil. This evaluation was done, by assessing changes in:

1. Pore Size Distribution (PSD)
2. Most frequent pore size
3. S-Index
4. Saturated Hydraulic conductivity

Introduction

- Crop growth can be highly dependent on soil physical properties, directly and indirectly through their effects on:
  1. Water, aeration,
  2. Temperature,
  3. Penetration resistance.

- Biochar has been shown to improve some soil physical properties such as Bulk density, porosity and water holding capacity.

Materials & Methods

![Image](90 days Deep banded Top soil mixing 68.2% sand 25.1% silt 6.7% clay)

- Van-Genuchten function was used to estimate parameters of the water retention curves.

\[
\theta(\Psi) = \theta_s - \frac{(\theta_s - \theta_r)}{[1 + (\alpha |\Psi|)^n]^{1-1/n}} \quad (1)
\]

- The pore size distribution was estimated from the soil water characteristic curve according to the Young Laplace equation.

- Peak of the pore size distribution shows the highest change in soil water content for a specific unit of suction head which corresponds to the most frequent pore size diameter.

- The S-index also was calculated using the following equation (Dexter 2004):

\[
S = -n(\theta_s - \theta_r)\left[\frac{2n-1}{n-1}\right]^{1/2} \quad (2)
\]

- The hydraulic conductivity was also estimated by using the following model (Aschonitis and Antonopoulos (2013)):

\[
K_s = 1632.5|S|[3.9(\alpha\phi_s)]^{30.9(\alpha\phi_s)} \quad (3)
\]

Results

Change in Soil water retention curve

- All biochar treatments have higher \(\theta_s\) and steeper slope than the control (Fig. 1).

- As a result of having steeper slope, it is expected to have a higher s-index than control.

- This increases in water content was higher particularly at lower tensions suggesting a significant change in soil structure, proportion and distribution of macropores.

- Both method and application rate increases the soil quality index.

- Analysis of Ks showed that only for DBR3 treatment had lower Ks, compared to control.

- Our results suggests that DBR method had lower Ks in comparison to the UTM method.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>(\theta_s)</th>
<th>(\theta_r)</th>
<th>(\alpha)</th>
<th>D</th>
<th>S</th>
<th>Ks</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
<td>-</td>
<td>0.09</td>
<td>0.43</td>
<td>0.031</td>
<td>201</td>
<td>0.081</td>
<td>237</td>
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<td>UTM 3%</td>
<td>1.51</td>
<td>0.11</td>
<td>0.47</td>
<td>0.021</td>
<td>125</td>
<td>0.092</td>
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<tr>
<td>UTM 6%</td>
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<td>0.10</td>
<td>0.50</td>
<td>0.032</td>
<td>217</td>
<td>0.088</td>
<td>258</td>
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<td>DBR 3%</td>
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<td>0.45</td>
<td>0.017</td>
<td>99</td>
<td>0.092</td>
<td>203</td>
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<tr>
<td>DBR 6%</td>
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<td>0.11</td>
<td>0.46</td>
<td>0.021</td>
<td>133</td>
<td>0.087</td>
<td>218</td>
</tr>
</tbody>
</table>

Change in Pore Size Distribution Curve

- An increase was seen in soil quality index for all biochar treatments compared to control, except for DBR treatment with 6% biochar application.

Change in saturated hydraulic conductivity and S-index

- An increase was seen in soil water retention curve for different treatments

- All biochar treatments shift to the left with smaller pore size compared to the control treatment except for UTM6.

- This phenomenon is being considered as major reason for an increase in water content near saturation and field capacity.

- Both method and application rate decreases the soil quality index.

- Analysis of Ks showed that only for DBR3 treatment had lower Ks, compared to control.

- Our results suggests that DBR method had lower Ks in comparison to the UTM method.

REFERENCES


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