Biochar Effects on Water Consumption by Soybean on A Claypan Soil in Central Missouri

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Hello Planet Earth! I am up...
Ouch...! Too hot, dry and inhospitable up here folks...


Yunnan Drought

Drought in California

Palmer index dropping <-4

Source: http://www.zengardner.com/california-governor-received-evidence-proving-drought-geoengineered/
US Drought Area (August 2, 2016)

Mauna Loa Monthly Mean CO$_2$ Concentration 1958-2015

Source: https://en.wikipedia.org/wiki/Climate_change
The Interaction of Soil Texture, Bulk Density/Pore Space, and Aggregation Affect Water-Holding Capacity
Water Content and Water Potential at Saturation, Field Capacity and Permanent Wilting Point

Source: http://www.nature.com/scitable/knowledge/library/soil-water-dynamics-59718900
Soil water holding capacity is affected largely by factors such as:

- Pore size/volume distribution
- Soil texture
- Aggregation
- Bulk density
- Organic matter
SEM Images of Torrefied (a, b) and Pyrolyzed (c, d) Switchgrass
Claypan Material Mixed with Miscanthus Biochar
Effect of Switchgrass Biochar on Soil Structure

This biochar promoted aggregation

Before Biochar Application  
60 Days after Application
Claypan Soil has a Low Hydraulic Conductivity
5% Switchgrass Biochar Treatment Increased the Hydraulic Conductivity of Claypan Soil
Apparently, Switchgrass Biochar has Affected the Expansion/Contraction of Smectitic Claypan
No Biochar - Soybean Plant Growing in Claypan Soil – Smectitic Clay Cracks as Soil Dries
2% Biochar - Soybean Plant Growing in Claypan Soil – Minimal Cracking of Soil
Biochars Influence Soybean Growth at Significantly Different Rates
Effect of Biochars on Soybean Growth
Biochar was Generated from a Variety of Feedstocks Using Slow Pyrolysis
Thermographs of Biomass Pyrolysis through Slow Pyrolysis

Biomass: Corn Stover

Biomass: Switchgrass

Biomass: Willow
Water Loss through Evaporation and Evapotranspiration from Untreated Pots

![Graph showing water loss over different dates for control no plant and control plant.](image-url)
Water Loss through Evaporation and Evapotranspiration from Untreated and 2% Corn Stover Biochar Treated Pots

![Graph showing water added over time with dates and categories: Control No Plant, Control Plant, 2% Corn Stover.](image-url)
Water Loss through Evaporation and Evapotranspiration from Untreated and 2% Miscanthus Biochar Treated Pots

**Graph:**
- **Control_No_Plant**
- **Control_Plant**
- **2% Giant Miscanthus**

**Axes:**
- **Water Added**
- **Date**

**Dates:**
- 9/3
- 9/23
- 10/13
- 11/2
- 11/22
Water Loss through Evaporation and Evapotranspiration from Untreated and 2% Pine Biochar Treated Pots

Date

9/3 9/23 10/13 11/2 11/22

Water Added

900 800 700 600 500 400 300 200 100 0

Control_No_Plant
Control_Plant
2% Pine
Water Loss through Evaporation and Evapotranspiration from Untreated and 2% Switchgrass Biochar Treated Pots

[Graph showing water added (ml) over dates from 9/3 to 11/12, with three lines representing Control_No_Plant, Control_Plant, and 2% Switchgrass.]
<table>
<thead>
<tr>
<th>Date</th>
<th>Control_No_Plant</th>
<th>Control_Plant</th>
<th>2% Willow</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Water Loss through Evaporation and Evapotranspiration from Untreated and 2% Willow Biochar Treated Pots
2% Biochar Application - Total Water Used per Soybean Plant (ml) through evapotranspiration

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Water Used (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control_No_Plant</td>
<td>b</td>
</tr>
<tr>
<td>Control_Plant</td>
<td>a</td>
</tr>
<tr>
<td>2% Corn Stover</td>
<td>a</td>
</tr>
<tr>
<td>2% Giant Miscanthus</td>
<td>a</td>
</tr>
<tr>
<td>2% Pine</td>
<td>a</td>
</tr>
<tr>
<td>2% Switchgrass</td>
<td>a</td>
</tr>
<tr>
<td>2% Willow</td>
<td>a</td>
</tr>
</tbody>
</table>
Water Loss through Evaporation and Evapotranspiration from Untreated Pots

![Graph showing water added over time with dates and water added in milliliters.]

**Water Added (ml)**
- **Control_No_Plant**
- **Control_Plant**

**Dates:**
- 9/3
- 9/13
- 9/23
- 10/3
- 10/13
- 10/23
- 11/2
- 11/12

**Legend:**
- Blue diamonds: Control_No_Plant
- Brown squares: Control_Plant
Water Loss through Evaporation and Evapotranspiration from Untreated and 5% Corn Stover Biochar Treated Pots

Control_No_Plant
Control_Plant
Corn Stover

Date
Water Added (ml)
9/3 9/13 9/23 10/3 10/13 10/23 11/2 11/12
Water Loss through Evaporation and Evapotranspiration from Untreated and 5% Miscanthus Treated Pots

![Graph showing water loss](image-url)
Water Loss through Evaporation and Evapotranspiration from Untreated and 5% Pine Biochar Treated Pots

![Graph showing water added over time for different treatments.](image-url)
Water Loss through Evaporation and Evapotranspiration from Untreated and 5% Switchgrass Biochar Treated Pots

Water Added (ml) vs Date:
- **Control_No_Plant**
- **Control_Plant**
- **Switchgrass Biochar**

Dates: 9/3, 9/13, 9/23, 10/3, 10/13, 10/23, 11/2, 11/12
Water Loss through Evaporation and Evapotranspiration from Untreated and 5% Willow Biochar Treated Pots

Water Added (ml)

Date

Control_No_Plant
Control_Plant
Willow
5% Biochar Application - Total Water Used per Soybean Plant (ml) through Evapotranspiration

- Control_No_Plan: c
- Control_Plan: a
- 5% Corn Stover: a
- 5% Giant Miscanthus: b
- 5% Pine: b
- 5% Switchgrass: b
- 5% Willow: b

Water Used (mL)
Water Used (mL) by a Soybean Plant (mL) Compared to Plant-No Biochar

- 5% Willow
- 5% Switchgrass
- 5% Pine
- 5% Giant Miscanthus
- 5% Corn Stover

Control Plant

Water Used (mL) Relative to Control
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Water Used Compared to Control per Plant</th>
<th>Water Use Compared to Control (Hectare - 250000 Plant)</th>
<th>Water Saved per Hectare (US gal)</th>
<th>Water Saved per Acre (US gal)</th>
<th>Water Saved in Terms of Rain (1 in rain/acre = 27154 gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control-No Biochar-Planted</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5% Corn Stover</td>
<td>305.7</td>
<td>+76425L (76m³)</td>
<td>+20189</td>
<td>8170</td>
<td>0.30</td>
</tr>
<tr>
<td>5% Giant Miscanthus</td>
<td>-714</td>
<td>-178500L (18m³)</td>
<td>-47155</td>
<td>19083</td>
<td>0.70</td>
</tr>
<tr>
<td>5% Pine</td>
<td>-684.1</td>
<td>-171025L (17m³)</td>
<td>-45180</td>
<td>18284</td>
<td>0.67</td>
</tr>
<tr>
<td>5% Switchgrass</td>
<td>-1169</td>
<td>-292250L (29m³)</td>
<td>-77204</td>
<td>31244</td>
<td>1.15</td>
</tr>
<tr>
<td>5% Willow</td>
<td>-705.7</td>
<td>-176425L (18m³)</td>
<td>-46607</td>
<td>18861</td>
<td>0.69</td>
</tr>
</tbody>
</table>
Biochar Effect on Soybean Leaf Area

- **Total Leaf Area (cm²)**

- **Treatment**
  - Control
  - 2% Corn Stover
  - 5% Corn Stover
  - 2% Miscanthus
  - 5% Miscanthus
  - 2% Switchgrass
  - 5% Switchgrass
  - 2% Pine
  - 5% Pine
  - 2% Willow
  - 5% Willow

The graph shows the comparison of total leaf area for different treatments with biochar application.
Conclusion

1. Biochars affect water consumption by soybeans on claypan soils but the effects are varied.

2. At 2% application rate, all studied biochars significantly increased leaf area without significantly affecting water use by soybean plants.

3. At 5% application rate, miscanthus and willow biochars significantly reduced water use but did not affect leaf area.

4. At 5% application rate, switchgrass biochar significantly reduced both water use and leaf area.

5. At 5% application rate, pine biochar increased the leaf area and reduced water use.

6. More study is needed to further investigate effects of biochars on soil water holding capacity and plant growth particularly in claypan soils.
THANK YOU...