Comparison of Biochar Source on the Vegetative Development of Cotton Seedlings

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RESEARCH PROBLEM

In cotton (Gossypium hirsutum L.) production, the amount of fertilizer input along with plant demand for nutrients can be substantial throughout the growing season. Although conventional fertilization has been instrumental in improving cotton yields, there are drawbacks that accompany their use such as nutrient groundwater leaching and surface runoff, substantial amounts of fossil fuel consumption used in their creation and the ever increasing expense associated with these fertilizers (Barrow, 2012). Therefore, the use of sustainable fertilization strategies could be considered beneficial to maintaining ideal yields while promoting environmental awareness.

BACKGROUND INFORMATION

Biochar is an end product of the low-oxygen combustion of biomass in a process called pyrolysis. Biomass sources used to generate biochar are varied and diverse. Agronomic benefits involving the use of biochars are heavily dependent on what type of biomass source is used in biochar production. Biochars originating from wood typically possess elevated levels of carbon (C) while having lower concentrations of essential plant nutrients such as nitrogen (N) and potassium (K) (Atkinson et al., 2010). Conversely, biochars originating from poultry litter have been proclaimed to possess higher values of N than biochars derived from plant-based sources (Chan et al., 2008). Although evaluations of the effect of biochar source on crops such as corn (Kimetu et al., 2008) have been documented worldwide, the influence of biochar source on the vegetative development of cotton is less understood.

RESEARCH DESCRIPTION

A greenhouse experiment was conducted in Fayetteville at the University of Arkansas System Division of Agriculture, Arkansas Agricultural Research and

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Extension Center in 2011. Cotton cultivar ST4288B2RF was planted in a complete randomized design with 9 treatments and 6 replications. A total of 108 1.5 liter pots (54 per biochar source) were each filled with 1.8 kilograms (kg) of a Memphis silt loam soil (Typic hapludalf) selected from the Lon Mann Cotton Research Station in Marianna, Ark. A fine mixed-hardwood based biochar (EE) and a coarse-textured poultry litter based biochar (BES) were used as biochar sources. Both biochar types were added at three equivalent rates: no biochar (control) (C); 5,000 kg/ha (1B); and 10,000 kg/ha (2B) while fertilizer was also added to pots at three equivalent rates: no fertilizer (control); 31-23-49 kg/ha (N-P-K); and 62-46-98 kg/ha (N-P-K). The plants were grown for 7 weeks and then harvested. Data collected at harvest included plant height, chlorophyll concentrations, leaf area and number of main-stem nodes along with plant dry matter. Statistical analysis was performed using JMP Pro 11 (SAS Institute, Inc., Cary, N.C.) software to determine if the main effect of biochar source had any significant influence on the vegetative development of cotton seedlings. Statistical outliers greater than 2 standard deviations from the overall mean were excluded from individual response variable analyses.

RESULTS AND DISCUSSION

Statistical analysis demonstrated that both types of biochars (EE and BES) positively impacted various characteristics of cotton vegetative development. The EE biochar significantly increased plant height and leaf area (Table 1) along with all dry matter measurements (Table 2). Additionally, the BES biochar significantly enhanced plant height (Table 3) as well as all dry matter measurements (Table 4). Although there were differences in the textural compositions of each respective biochar, these results indicate that the developing root network of these young cotton seedlings were able to access the nutrients contained by these biochars and effectively partition them to areas of active vegetative growth throughout the plant.

PRACTICAL APPLICATIONS

Investigation into analyses of specific biochar rates displayed enhancements in numerous vegetative growth parameters of young cotton seedlings. However in comparison, the mixed-hardwood based biochar significantly increased leaf area, whereas the poultry litter based biochar did not; therefore improving the potential for increased light interception and subsequent assimilate production by cotton leaves. Nevertheless, this experiment has potentially opened up other avenues related to biochar research in cotton. Additional focus is warranted on the rate of nutrient release from these multi-source biochars to the developing plant as well as biochar’s potential influence on other sectors of agricultural production.
ACKNOWLEDGMENTS

EE biochar was provided by Enginuity, Mechanicsburg, Pennsylvania and BES biochar was provided by BioEnergy Systems LLC, Springdale, Akansas.

LITERATURE CITED


Table 1. Node number, plant height, leaf area, and chlorophyll (Chl.) means for mixed hardwoods (EE) biochar.

<table>
<thead>
<tr>
<th>Biochar Treatment</th>
<th>Node number</th>
<th>Plant height (cm)</th>
<th>Leaf Area (cm²)</th>
<th>Chlorophyl (SPAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>5.72 a†</td>
<td>18.45 c</td>
<td>233.77 b</td>
<td>51.61 a</td>
</tr>
<tr>
<td>1B</td>
<td>5.94 a</td>
<td>19.97 b</td>
<td>264.13 a</td>
<td>52.04 a</td>
</tr>
<tr>
<td>2B</td>
<td>6.00 a</td>
<td>21.15 a</td>
<td>254.30 a</td>
<td>53.66 a</td>
</tr>
</tbody>
</table>

†Columns not sharing a common letter are significantly different (P ≤ 0.05).

Table 2. Stem, leaf, and total plant dry matter (DM) means for mixed hardwoods (EE) biochar.

<table>
<thead>
<tr>
<th>Biochar Treatment</th>
<th>Stem DM (g)</th>
<th>Leaf DM (g)</th>
<th>Total DM (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.95 c†</td>
<td>1.62 b</td>
<td>2.60 b</td>
</tr>
<tr>
<td>1B</td>
<td>1.16 b</td>
<td>1.81 ab</td>
<td>3.01 a</td>
</tr>
<tr>
<td>2B</td>
<td>1.37 a</td>
<td>1.92 a</td>
<td>3.30 a</td>
</tr>
</tbody>
</table>

†Columns not sharing a common letter are significantly different (P ≤ 0.05).
Table 3. Node number, plant height, leaf area, and chlorophyll (Chl.) means for poultry litter (BES) biochar.

<table>
<thead>
<tr>
<th>Biochar Treatment</th>
<th>Node Number</th>
<th>Plant Height (cm)</th>
<th>Leaf Area (cm²)</th>
<th>Chlorophyl (SPAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>6.00 a†</td>
<td>18.93 b</td>
<td>236.36 a</td>
<td>49.29 a</td>
</tr>
<tr>
<td>1B</td>
<td>5.72 b</td>
<td>20.68 a</td>
<td>234.35 a</td>
<td>50.81 a</td>
</tr>
<tr>
<td>2B</td>
<td>6.00 a</td>
<td>21.20 a</td>
<td>251.94 a</td>
<td>51.26 a</td>
</tr>
</tbody>
</table>

†Columns not sharing a common letter are significantly different ($P \leq 0.05$).

Table 4. Stem, leaf, and total plant dry matter (DM) means for poultry litter (BES) biochar.

<table>
<thead>
<tr>
<th>Biochar Treatment</th>
<th>Stem DM (g)</th>
<th>Leaf DM (g)</th>
<th>Total DM (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.12 b†</td>
<td>1.73 b</td>
<td>2.85 b</td>
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<tr>
<td>1B</td>
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<td>2.97 b</td>
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<td>2B</td>
<td>1.37 a</td>
<td>2.04 a</td>
<td>3.42 a</td>
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†Columns not sharing a common letter are significantly different ($P \leq 0.05$).