Influence of Multiple Source Biochar on Cotton Seedling Growth and Development

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OBJECTIVE

The objective of this study is to determine the effects of biochar originating from different sources on various aspects of cotton seedling growth and development. The results of this study will be used to help determine the feasibility of full-scale biochar production concerning cotton production.

INTRODUCTION

Biochar is the carbon rich product resulting from the pyrolysis of biomass materials (Renner, 2007). Biochars can be derived from biomass sources such as hardwood trees, crop residues and poultry litter (Baldock and Smernik, 2002). Biochar has been proposed as a beneficial amendment concerning various agricultural and environmental aspects such as increasing soil fertility, retaining water in the soil and enhancing plant growth and yield (Zimmerman, 2010). Even though various forms of biochar remediation have been practiced in some parts of the world for many years (Tenenbaum, 2009), it is still a relatively new concept for much of the developed world. Studies and experiments have been undertaken to observe the agricultural, environmental and economical benefits that biochar has been proposed to possess. However, many of these trials have either been localized or produced on a small-scale, giving biochar scarce recognition.

Plate 1: Mixed-hardwood based biochar

Plate 2: Pelletized poultry litter based biochar

HYPOTHESIS

It was hypothesized that biochar originating from either mixed-hardwood or poultry litter sources could have a beneficial effect concerning many aspects of cotton growth and development such as node count, plant height, leaf area, chlorophyll content and fruit production.

MATERIALS AND METHODS

Growth chamber experiments were conducted in Fayetteville, AR in the fall of 2010 and 2012. Cotton (*Gossypium hirsutum* L.) cultivar ST 4288 B2F was planted in a complete randomized design with 2 treatments and 6 replications. A total of 54 1.5 liter pots were each filled with 1.8 kilograms (kg) of a Captina silt loam soil. A fine mixed-hardwood based biochar (EE) and a pelletized poultry litter based biochar (BES) were used as biochar sources in 2010 and 2012 respectively.

Treatments consisted of three rates of biochar:

1. No biochar (Control) (C)
2. Biochar rate equivalent to 5,000 kg/hectare (ha) (B1)
3. Biochar rate equivalent to 10,000 kg/ha (B2)

Measurements conducted at harvest (8 weeks after planting) included:

1. Plant height and height to node ratio
2. Number of nodes and fruits
3. Leaf area
4. Chlorophyll content
5. Plant dry matter (Stems, leaves, fruits and total dry matter)

For plant dry weight data, the leaves, fruits and stems were collected from each plant and dried in an oven at 55ºC for 1 week prior to weighing. Statistical analysis was performed using JMP software versions 9.1 and 9.3 to determine if the sole interaction of biochar had any significant effect on cotton growth and development.

Plate 3: Randomized design in walk-in growth chamber.

RESULTS

Mixed-Hardwood Based (EE) and Poultry Litter Based (BES) Biochar Effects on Cotton Growth and Development

Uppercase letters denote significant differences in EE biochar and lowercase letters denote significant differences in BES biochar. Bars not sharing a common letter are significantly different (P≤0.05).

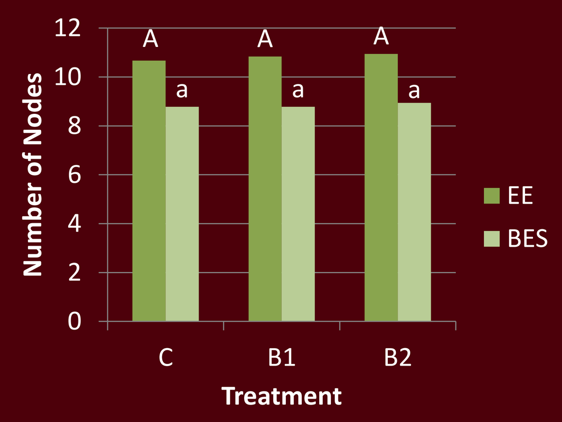

Fig. 1: Effect of EE and BES biochar on number of nodes (P≤0.05).

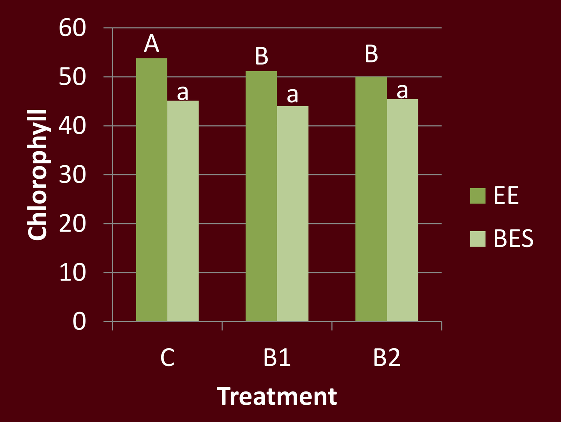

Fig. 2: Effect of EE and BES biochar on chlorophyll levels (P≤0.05).

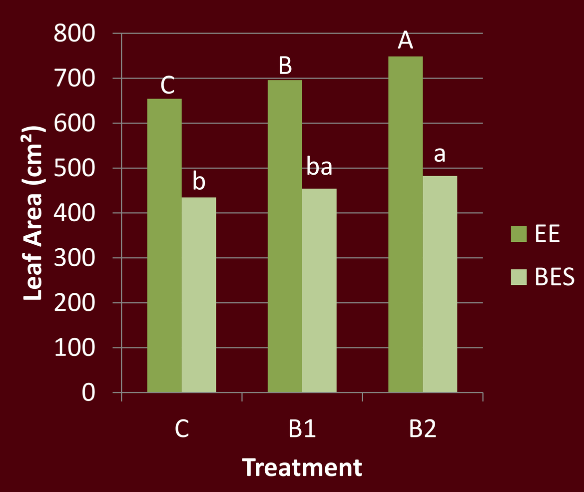

Fig. 3: Effect of EE and BES biochar on leaf area (cm²) (P≤0.05).

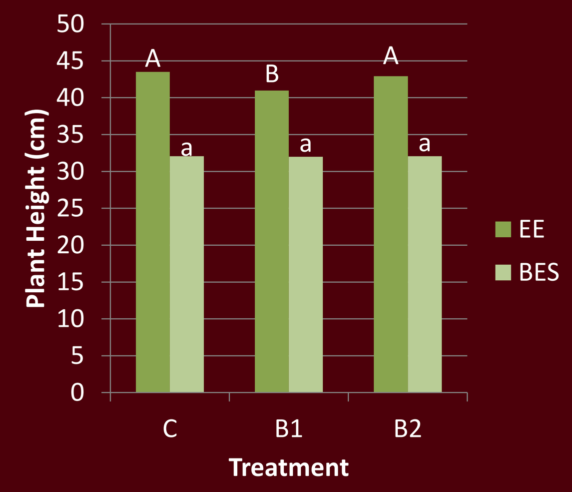

Fig. 4: Effect of EE and BES biochar on plant height (P≤0.05).

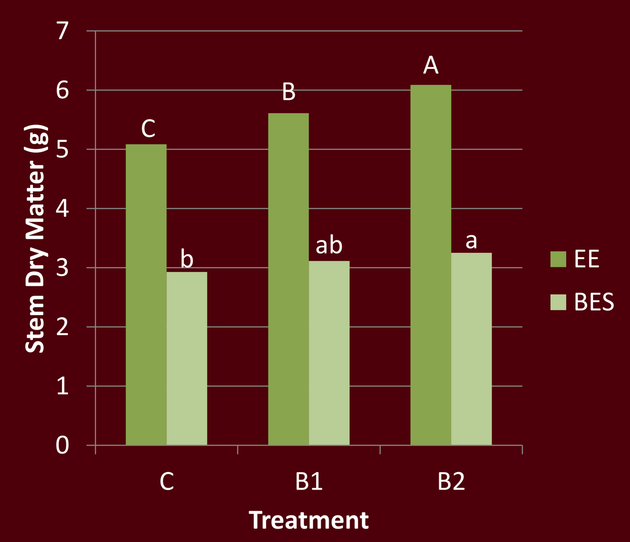

Fig.5: Effect of EE and BES biochar on stem dry matter (P≤0.05).

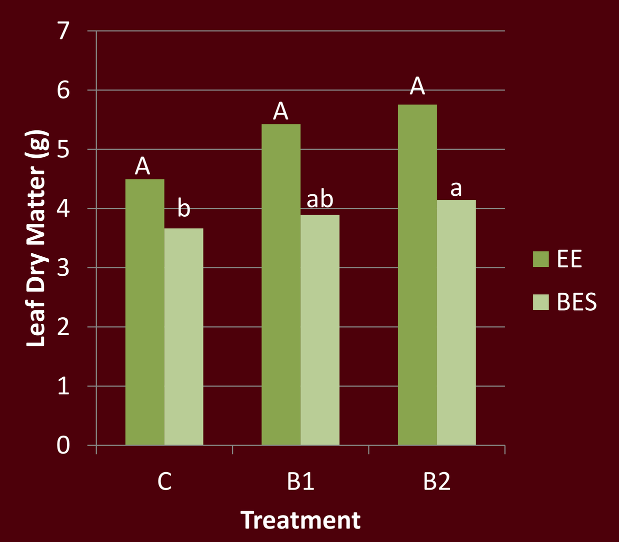

Fig. 6: Effect of EE and BES biochar on leaf dry matter (P≤0.05).

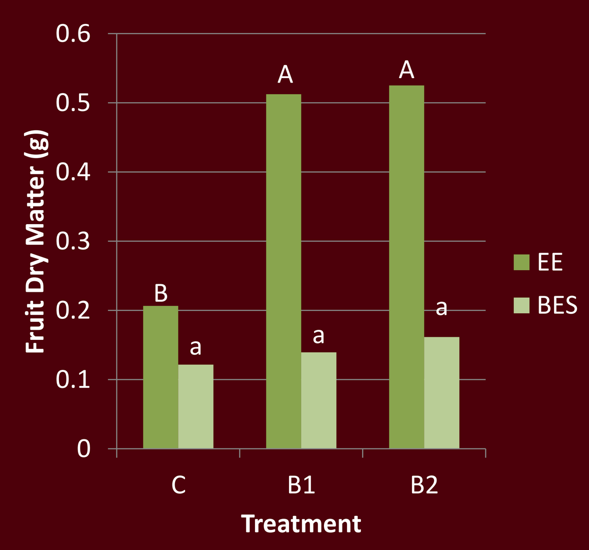

Fig. 7: Effect of EE and BES biochar on fruit dry matter (P≤0.05).

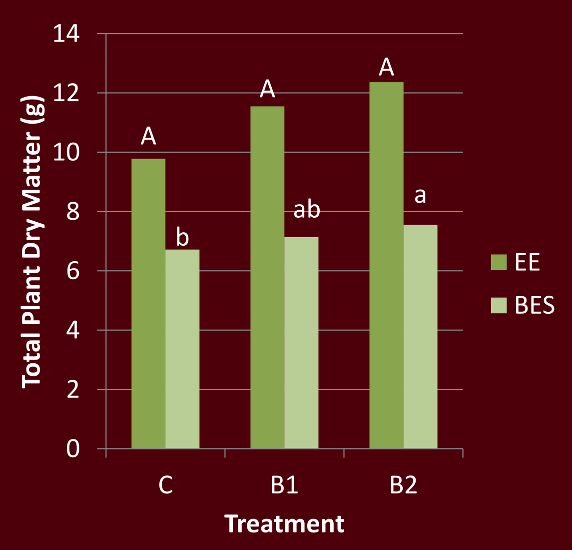

Fig. 8: Effect of EE and BES biochar on total plant dry matter (P≤0.05).

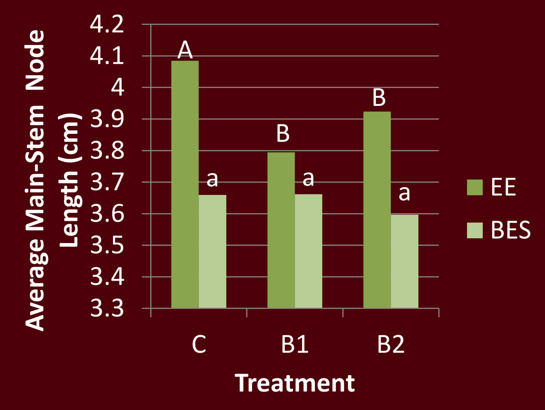

Fig. 9: Effect of EE and BES biochar on average main-stem node length (P≤0.05).

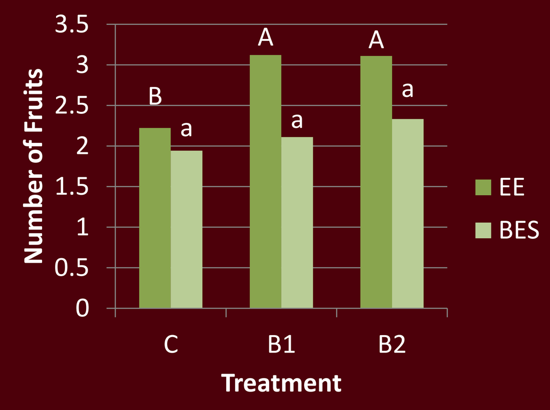

Fig. 10: Effect of EE and BES biochar on number of fruits (P≤0.05).

CONCLUSIONS

EE biochar significantly affected cotton growth and development by:

- Reducing plant height and chlorophyll.
- Increasing leaf area.
- Increasing stem and fruit dry matter weight.
- Increasing number of fruits.
- Decreasing average main-stem node length.

BES biochar significantly affected cotton growth and development by:

- Increasing leaf area.
- Increasing stem, leaf and total plant dry matter weight.

Variables unaffected by EE or BES biochar include:

- Number of nodes

Both types of biochars (EE and BES) had significant effects on cotton growth and development. The EE biochar significantly impacted growth and development and had higher numerical values in more areas than the BES biochar. This could possibly be attributed to the fine-textured composition of the EE biochar which may have made the nutrients contained within more accessible to the developing root system. Consequently, the pelletized form of the BES biochar may have inhibited nutrient release and subsequent plant uptake resulting in lower numerical values for most measured variables. Nonetheless, enhancements in areas such as leaf area and dry matter weight indicate that physiological functions vital to cotton growth and development can be benefitted by plant/biochar interaction.

PRACTICAL APPLICATIONS

Analyses of individual biochar rates demonstrated positive effects on cotton plant development. These experiments have pointed out the direction for the next series of biochar trials in cotton. Additional research is needed concerning the nature and ability of biochar to slowly release nutrients over time that can become made available for cotton production.

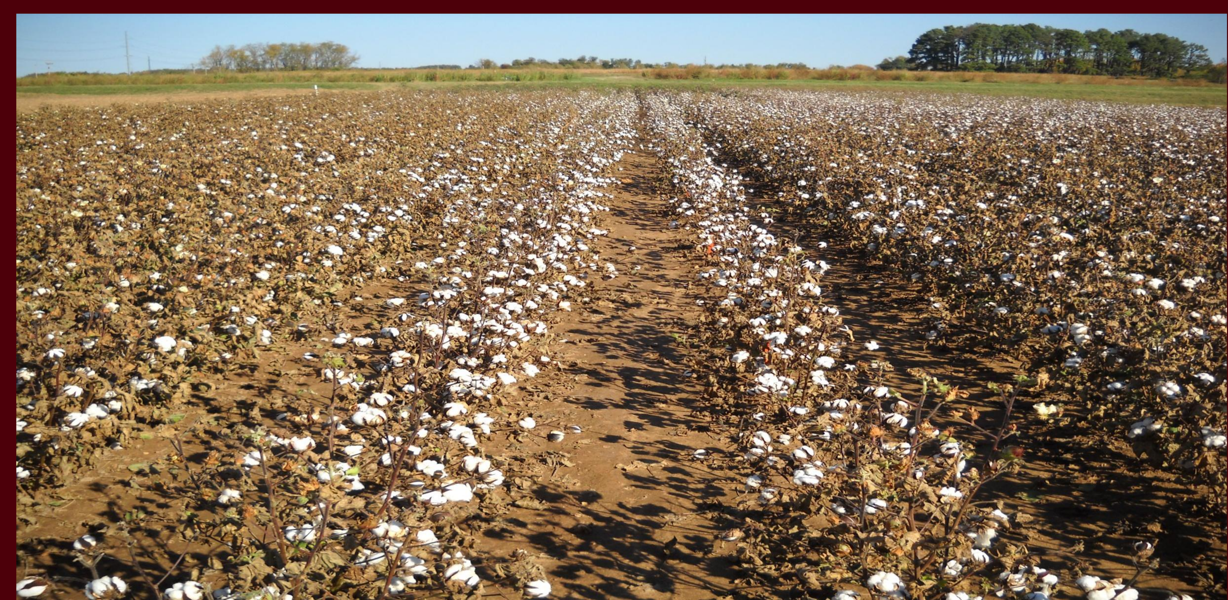

Plate 4: Biochar/cotton field trial conducted at the University of Arkansas Research and Extension Station, Fayetteville, AR.

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