Evaluating germination and growth of Cowpea *(Vigna unguiculata)* amended with biochar innoculated with fermented organic seaweed liquid extract

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RESEARCH OBJECTIVE

The objective of our research was to determine what concentration of seaweed liquid extract (SLE) inoculated in coconut husk biochar (CBC) would produce the best germination and growth of Cowpea *(Vigna unguiculata)*, while growing in nutrient poor sandy soils.

Prediction: Increasing concentrations of SLE would have increasing germination and growth of Cowpea, with the optimal concentration being between 2.5-5%.

BACKGROUND

Many **Small Island Developing States (SIDS)** are composed of sandy soils; having a low cation exchange capacity and carbon content (Alshankiti et al. 2016). Sandy soils cannot absorb or retain nutrients, water or microbes, leading to over-fertilization by farmers. Over-fertilization can cause eutrophication of aquatic ecosystems, with excessive nutrients causing drastic ecosystem and trophic level changes (Huang et al. 2017). In addition, the properties of sandy soils can contribute to food insecurity by restricting available crop growth.

Biochar is a stable carbon matrix with a high carbon content and high cation exchange capacity, assisting in absorbing and retaining nutrients, water and microbes essential for sustaining healthy soils (Lehmann et al. 2009). Biochar is made through the process of pyrolysis where organic matter is thermally decomposed in a high heat, low oxygen environment (Suman et al. 2017). Many organic materials can be used to make biochar on SIDS, such as coconut husks.

Organic biofertilizer is an effective, non-toxic alternative to potentially hazardous synthetic fertilizers. Seaweed (*Sargasum sp.*) biofertilizer is created through anaerobic fermentation, in which seaweed and water are placed in an airtight sealed container. Over 4-6 weeks, the seaweed decomposes leaving a concentrated liquid called seaweed liquid extract that contains living microbes, growth regulators and macro- and micro nutrients essential for promoting healthy plant growth and sustaining healthy soils (Jayasinghe et al. 2016).

Coconut husk biochar and seaweed liquid extract have been shown to improve agricultural conditions individually, thus we decided to test their impacts on plant germination and growth when used in conjunction with one another (Alshankiti et al. 2016; Vijayanand et al. 2014).

METHODS

Experimental Design

- 21-day germination exposure, no renewal
- Indicator species: Cowpea (*Vigna unguiculata*)
- Randomized block design with 3 replicates
- Sample size = 128 seedlings per tray (N=3456)

Compound (CBC 500g/m^2)	Concentration (%)
SLE:CBC	20
SLE:CBC	10
SLE:CBC	5
SLE:CBC	2.5
SLE:CBC	1.25
SLE:CBC	0.5
Miracle Gro (MG):CBC	0.4
CBC	Control
No Treatment	Sandy Soil

Evaluating Endpoints

- Germination rate was counted for the first seven days
- Germination success was counted on the last day of the study
- Shoot & root length measure using Image J (Subsample, n=810)
- R 3.2.4 statistical program: Generalized linear mixed effect model (GLMM)

PRELIMINARY RESULTS

Physiochemical Properties of Seaweed Liquid Extract

- The pH stayed relatively the same throughout all of our treatments
- We started with our stock treatment of 100%
    - Our stock treatment produced high electrical conductivity (EC) levels
    - May be due to high nutrient and salinity levels
- As we diluted each treatment the electrical conductivity went down
- The Miracle Gro® treatment was the only treatment besides the stock treatment that had a high electrical conductivity level

Physiochemical Properties of Soil treated with Coconut husk Biochar and Seaweed Liquid Extract

- The pH of our treatments stayed relatively the same throughout all of our treatments over the 21 days
- On Day 0 all of the treatments had higher EC levels, throughout the 21 days the EC went down dramatically throughout all treatments and were relatively the same between treatments
    - Due to plants absorbing the nutrients and rainfall runoff the EC was lower on Day 21 than on Day 0.

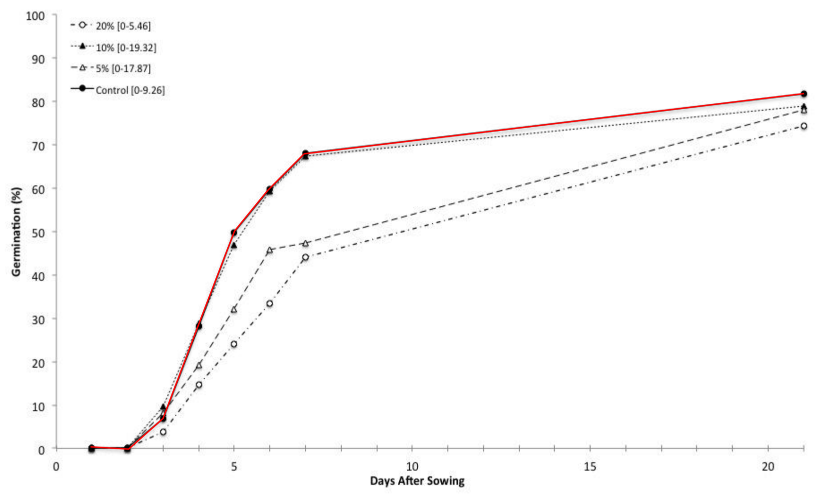


Figure 1a. Germination percentage of Cowpea seedlings (*Vigna unguiculata*) in Bahamian sandy soils treated with coconut husk biochar inoculated with seaweed liquid extract bioferilizer at 20, 10 and 5%. Values are presented as an average (n=3) with standard errors represented in figure legend [%].

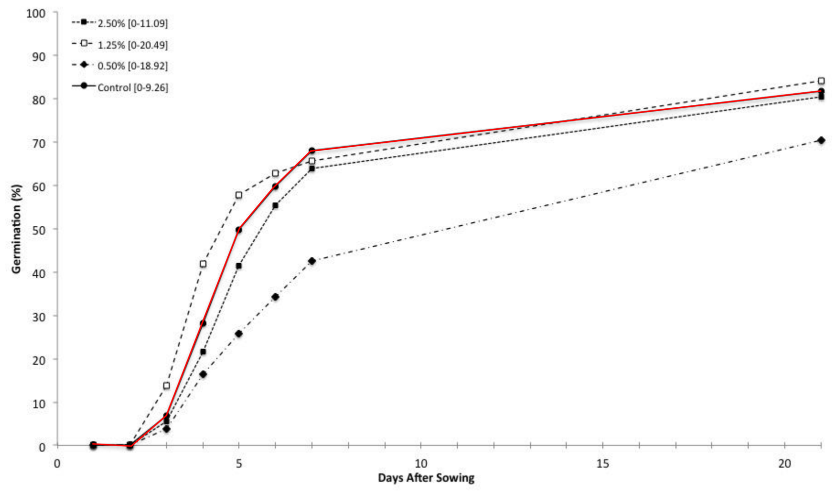


Figure 1b. Germination percentage of Cowpea seedlings in Bahamian sandy soils treated with coconut husk biochar inoculated with seaweed liquid extract bioferilizer at 2.5, 1.25 and 0.5%. Values are presented as an average (n=3) with standard errors represented in figure legend [%].

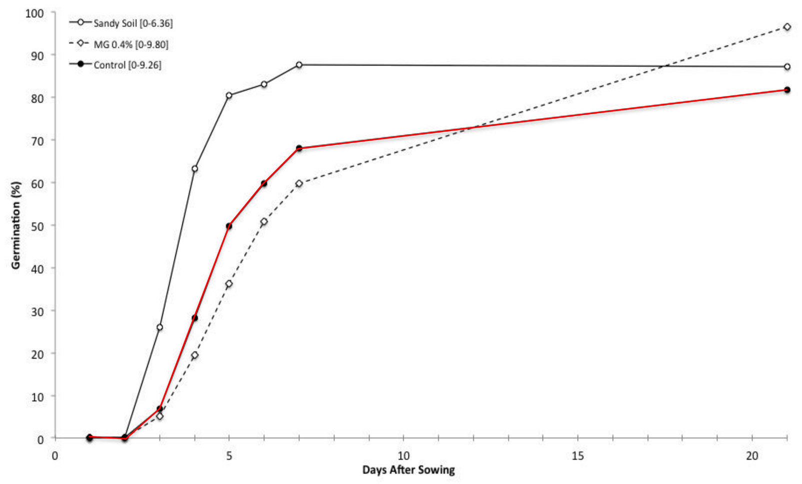


Figure 1c. Germination percentage of Cowpea seedlings in Bahamian sandy soils treated with coconut husk biochar inoculated with commercial fertilizer (*MG*, Miracle Gro®) and untreated sandy soils. Values are presented as an average (n=3) with standard errors represented in figure legend [%].

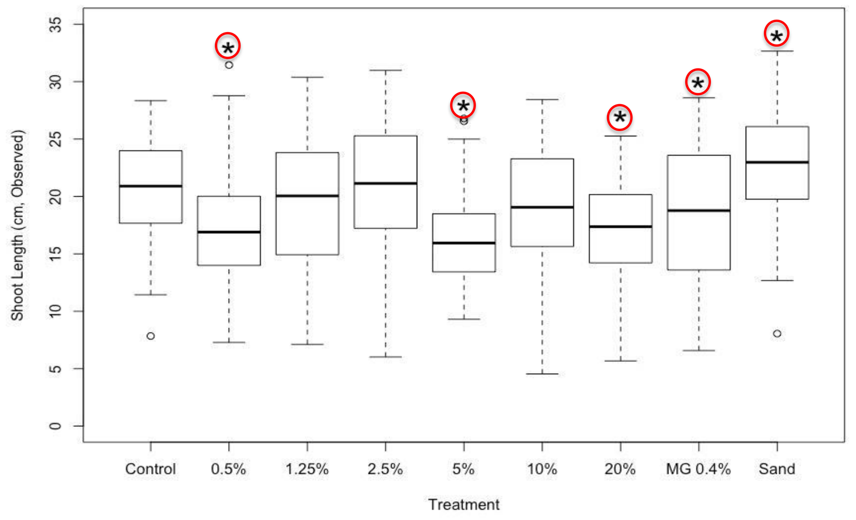
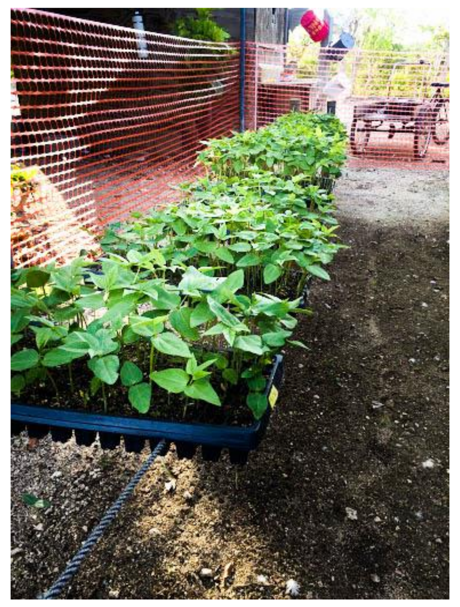


Figure 2. Boxplot of observed values for shoot length (cm) across treatments for Cowpea seedlings. Median values are represented by the thick horizontal bar with 25% and 75% interquartile range and outliners as open circles. Significant differences (P<0.05) between the control treatment, seaweed liquid extract (0.5, 5, 20%), Miracle Gro® (MG 0.4%) and sandy soil (*), slightly longer roots found with 20% SLE (P=0.04).



DISCUSSION

The treatment of cowpea that performed the best for overall germination of growth was the treatment of just sandy soil. The reason for sandy soils doing the best overall is because cowpea prefers a low nutrient environment and pH values between 5.5 and 6.5 (Cowpea, 2017). Our treatments consisted of coconut husk biochar (CBC) and seaweed liquid extract (SLE) in sandy soils with pH values ranging from 7.93 ± 0.27 to 8.64 ± 0.01 and high electrical conductivity (EC) values indicating high nutrient levels. CBC has a large surface area and a high capacity to hold water. Cowpea is a drought resistant crop; thus, oversaturation suppresses growth (Cowpea, 2017). The addition to CBC to sandy soils may have increased the moisture content above the tolerance of cowpea. Concentrations of SLE above 1.25% showed lower germination and growth compared to the control because SLE are typically high in nutrients; including calcium, phosphorus, potassium, and sodium (Hernandez-Herrera et al. 2014). In the Bahamas, soils are high in calcium carbonate due to the limestone properties, meaning within high concentrations of SLE, we were adding a lot more nutrients to what was already present in the soil.

In addition to germination and growth, the cowpea in the sandy soil treatment showed significantly higher shoot lengths. The 0.5, 5, 20%, and Miracle Gro® (MG) treatments had significantly lower shoot lengths. Longer shoot lengths are indicative of heathy plants. The low germination rate, survival and growth at high applications of SLE in our study may be due to the high salt content of our SLE. Previous studies found high concentrations of salt in SLE potentially leading to a reduction in germination and growth with tomato seedlings (Hernandez-Herrera et al. 2014). Salinity has shown various negative effects on plant growth like osmotic stress and mineral deficiencies. There were no differences in root lengths observed in the experiment. In conclusion, our study showed that cowpea grown in natural sandy soil demonstrated the greatest germination rate and growth. This provides promising economic benefits for SIDS, like the Bahamas, as cowpea can replenish essential nutrients to soils without using fertilizer. The optimal concentration of CBC and SLE in our experiment was 1.25%, demonstrating that lower concentrations have positive effects on germination and growth. As an organic biological fertilizer, SLE is an ecologically friendly alternative to commercial fertilizer.

FUTURE DIRECTIONS

Future research will look at the crop yield of cowpea, as well as the combination of CBC and SLE on productions crops (e.g. tomato, etc.). We will also look into using different compositions of biochar including wood, coconuts, and commercial products. Our soil treatments will be sent to a lab to be analyzed for macro and micro nutrients as well as the growth hormones Auxin, Gibberellin and Cytokinin.

ACKNOWLEDGMENTS & LITERATURE

ACKNOWLEDGMENTS

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