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The effects of biochar as a soil amendment on soil quality and plant growth

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The Effects of Biochar as a Soil Amendment on Soil Quality and Plant Growth: A Study for the North Carolina High County

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Biochar: Production, Characterization and Applications

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What is NEXUS?

- Research project to develop and integrate biomass greenhouse heating technologies to extend growing seasons for resource-limited farmers
- Biomass and renewable energy testing site with 20’ (7m) × 30’ (10m) off-grid greenhouse

NEXUS Project

Sustainable Greenhouse Production

Organic Waste
Available feedstock
on a small farms

Heat & Soil amendment

Extending growing season
Increasing productivity
GHG emissions reduction

More local food
Farmers' income increase
Clean local environment

Background

When used as a soil amendment, biochar forms a dynamic substrate which provides numerous benefits, including increasing:

1. nutrient availability,
2. increasing soil water retention,
3. improving crop yield, and
4. sequestering carbon for hundreds to thousands of years.

Background

- However, biochar's effectiveness largely depends on the biomass feedstock and the soil to which it is applied.
- Testing different feedstocks under different soil conditions is needed in order to gain a full picture of the potential of biochar.

Objectives

- To compare the effects of different types of biochar created from individual feedstocks on soil quality and plant growth in soils found in the North Carolina high country region, US.
- Understanding how different biochars interact with soil will allow farmers to make an informed decision about which biochar feedstock to use.

Research Questions?

- What are the agronomic differences between the biochar-soil treatments based on biochar feedstocks?
- Which feedstock will create the largest impact on adolescent plant growth in High County loam soil?
- Is there an observable effect between the agronomic properties of the biochar-soil treatments and plant yield?

Methodology

- Pyrolized four (4) feedstocks in single biochar burn using NEXUS biochar kiln:

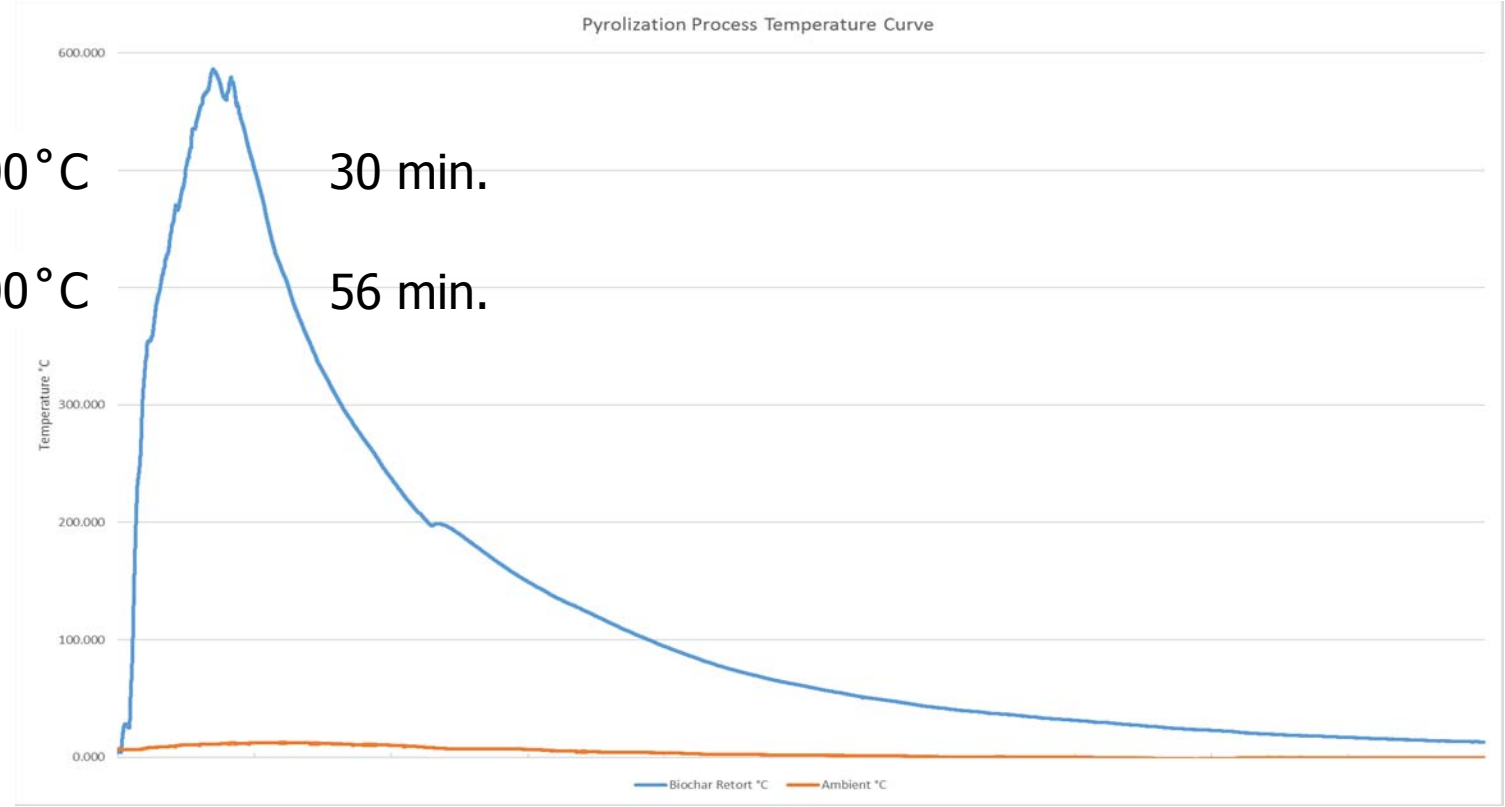
Biochar Kiln

One “batch” can produce 20lbs (10kg) of biochar (500 °C) from 60lbs (30kg) of biomass plus over 150,000 Btus (158,000 kJ)

Pyrolysis

500°C 30 min.

400°C 56 min.



Biochars

Sorghum

Fraser fir

Woodchip

Bone

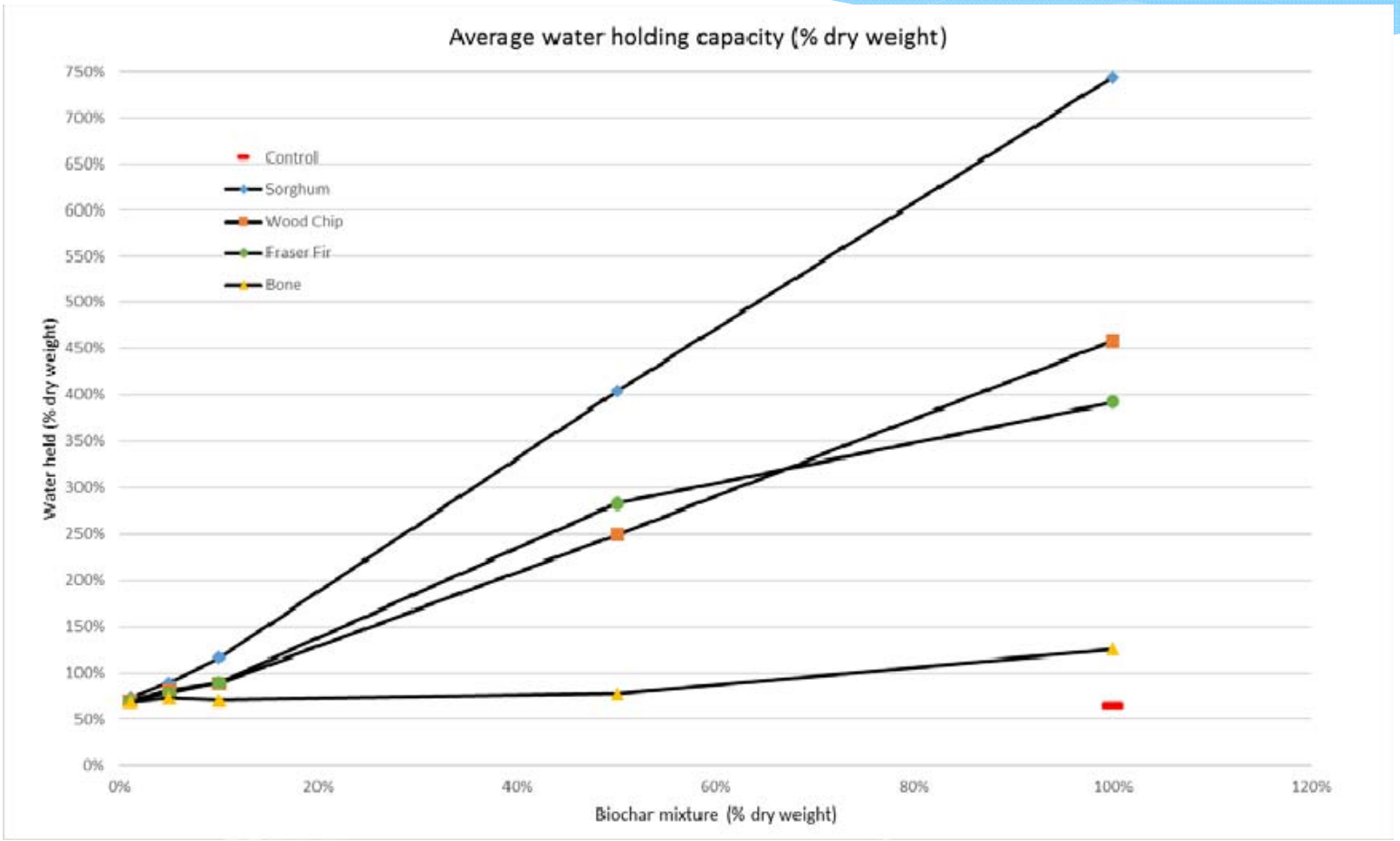
Water Holding Capacity

- Biochar was removed from the kiln and ground to roughly 2mm size.
- Our soil (Saunook loam obtained from a local farm – 12.7mm size) and biochar mixture rates of 1%, 5%, 10%, 50%, and 100% were all tested.

Water Holding Capacity

- Saturated soil for 24 hours, then allowed to drain for 24 hours.
- Dried in oven for 24 hours at 110°C.
- Measured difference in wet and dry mass for three samples of each treatment.

Water Holding Capacity



Growth Experiment

- Two nutrient solutions were prepared:
  1. Leachate from a commercial composting facility
  2. Hydroponics nutrients (i.e., FloraMicro + FloraGro).
- Created samples comprised of soil, nutrient, and **1%** biochar by dry mass (+20 MT/ha).
- Added sunflower seed.
- Watered equal amount daily.

Growth Experiment

- Matrix of all treatments and abbreviations (75 samples)

Treatment	Control (C) (No nutrient mix)	Hydroponics Nutrients (H)	Compost Leachate (L)
Control (C) (No biochar mix)	CC	CH	CL
Sorghum (S)	SC	SH	SL
Fraser Fir (F)	FC	FH	FL
Woodchip (W)	WC	WH	WL
Hog Bone (B)	BC	BH	BL

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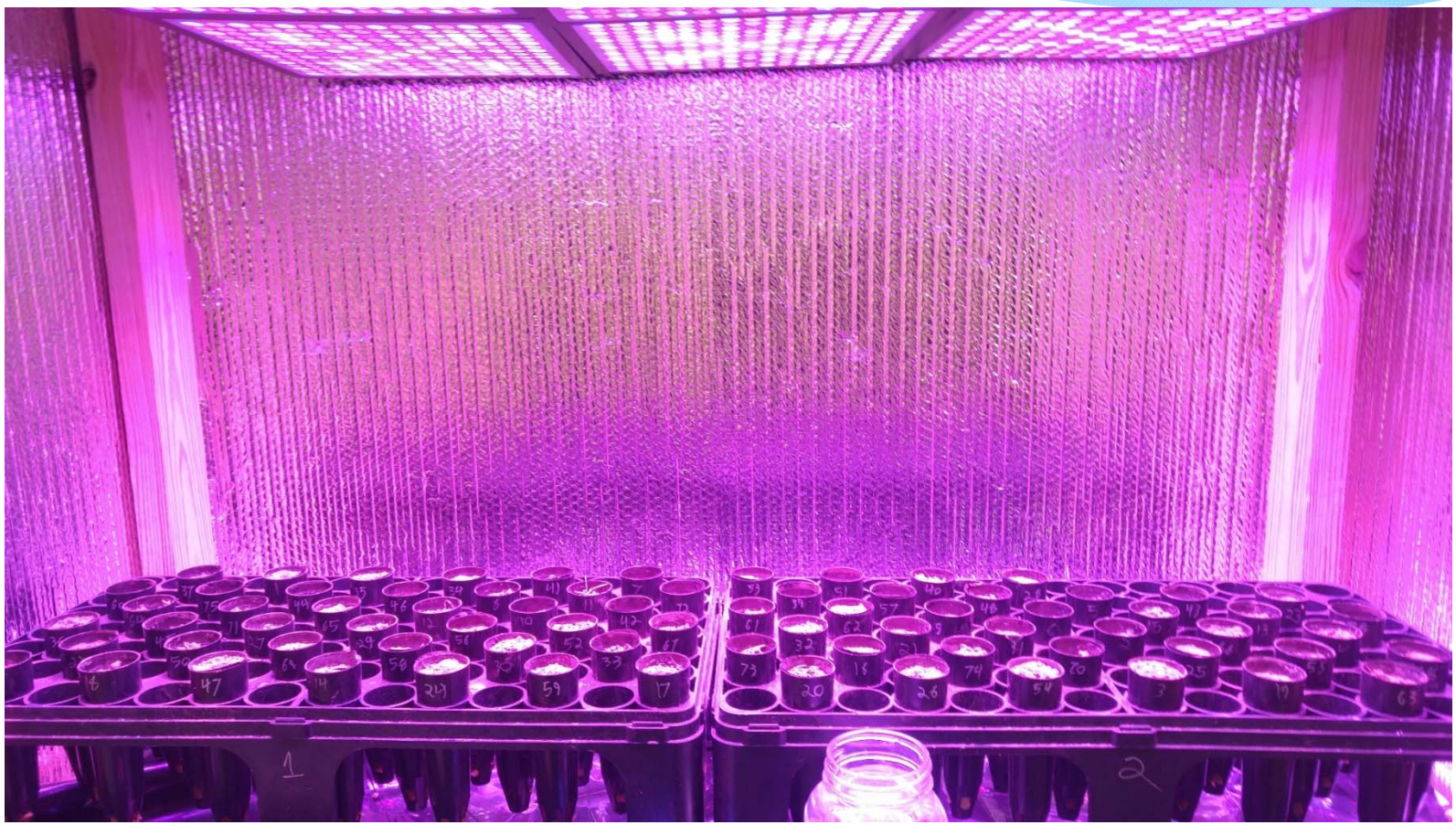
Growth Experiment



Growth Experiment

Growth Experiment

- Harvested after 35 days, collected six data points, and calculated five more.
- Collected:
  1. Shoot length
  2. Root length
  3. Root fresh mass
  4. Root dry mass
  5. Shoot fresh mass
  6. Shoot dry mass
- Calculated:
  1. Total length
  2. Total fresh mass
  3. Total dry mass
  4. Dry root to shoot ratio (RSR)
  5. Dry shoot mass to shoot length (mg/mm)

Data Analysis

- Soil analysis

	Humic Matter (g/100cc)	Weight by Volume Ratio (g/cc)	Cation Exchange Capacity (meq/100cc)	% Base Saturation	pH	P (mg/dm3)	K (mg/dm3)	Ca (mg/dm3)
Control soil	0.22	0.96	11.40	84.67	5.80	17	301	1248
Bone biochar mix	0.22	0.97	14.53	88.67	5.97	213	381	1792
Sorghum mix	0.22	0.94	11.13	85.33	5.73	24	391	1177
Fraser fir mix	0.22	0.94	11.23	85.33	5.83	19	313	1227
Woodchip mix	0.22	0.92	10.77	84.67	5.83	17	275	1162

Data Analysis

- Difference of means:
  - 1) Analyzed biochar, 2) nutrients, and 3) biocharXnutrient (synthesis) treatments.
  - Change in means as a percent of control mean.
  - Allows for dimensionless comparison across all measurements.

Data Analysis

- Difference of means by biochar isolated effects

	Sorgum	Fraser Fir	WoodChip	Bone
Shoot length (mm)	4%	-6%	-19%	8%
Root Length (mm)	-9%	-8%	-3%	3%
Total length (mm)	-4%	-7%	-10%	5%
Fresh shoot mass (g)	0%	1%	-5%	10%
Fresh root mass (g)	25%	36%	58%	10%
Fresh total mass (g)	8%	13%	16%	10%
Dry root mass (g)	13%	0%	9%	-22%
Dry shoot mass (g)	-1%	-3%	4%	12%
Dry total mass (g)	6%	-2%	7%	-5%
mg/mm	-2%	5%	29%	4%
RSR	12%	7%	9%	-8%

Data Analysis

- Effects of adding nutrients with sorghum biochar

	SC	SH	SL	CC	CH	CL
Shoot length (mm)	---	-19%	-17%	---	-25%	-7%
Root Length (mm)	---	-6%	4%	---	2%	-18%
Total length (mm)	---	-12%	-6%	---	-10%	-13%
Fresh shoot mass (g)	---	15%	-3%	---	3%	14%
Fresh root mass (g)	---	16%	18%	---	-6%	42%
Fresh total mass (g)	---	15%	6%	---	0%	24%
Dry root mass (g)	---	-27%	-14%	---	-10%	-9%
Dry shoot mass (g)	---	32%	4%	---	-7%	20%
Dry total mass (g)	---	1%	-5%	---	-8%	5%
mg/mm	---	62%	18%	---	23%	29%
RSR	---	-42%	-14%	---	4%	-26%

Conclusions

- Based on the results of the study, Sorghum biochar has provided the most promise for a useful soil amendment (highest WHC and high yielding).
- Conversely the addition of nutrients to control soils had a lesser and non-significant impact. Indicating that sorghum biochar may make the nutrients more available to the plants.

Conclusions

- Bone did show much higher levels of nutrients, specifically P in the soil tests. Bone biochar behaved differently than the other biochars.
- It is sometimes hard to tell what effects caused what (murky)…

Further Research

- This study had lots of breadth (five soil types and three nutrient types, including controls), but more research could be done in depth for any aspect (e.g., other % mixture rates, other soil types).
- The results of this experiment have a strong indication but are far from conclusive.
- Growth test should be both short term and multiple growing cycles long.

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Thank you

Grazie

謝謝

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спасибо

ありがとう

감사합니다

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