

# Biochar from biosolids as a soil amendment in a greenroof system

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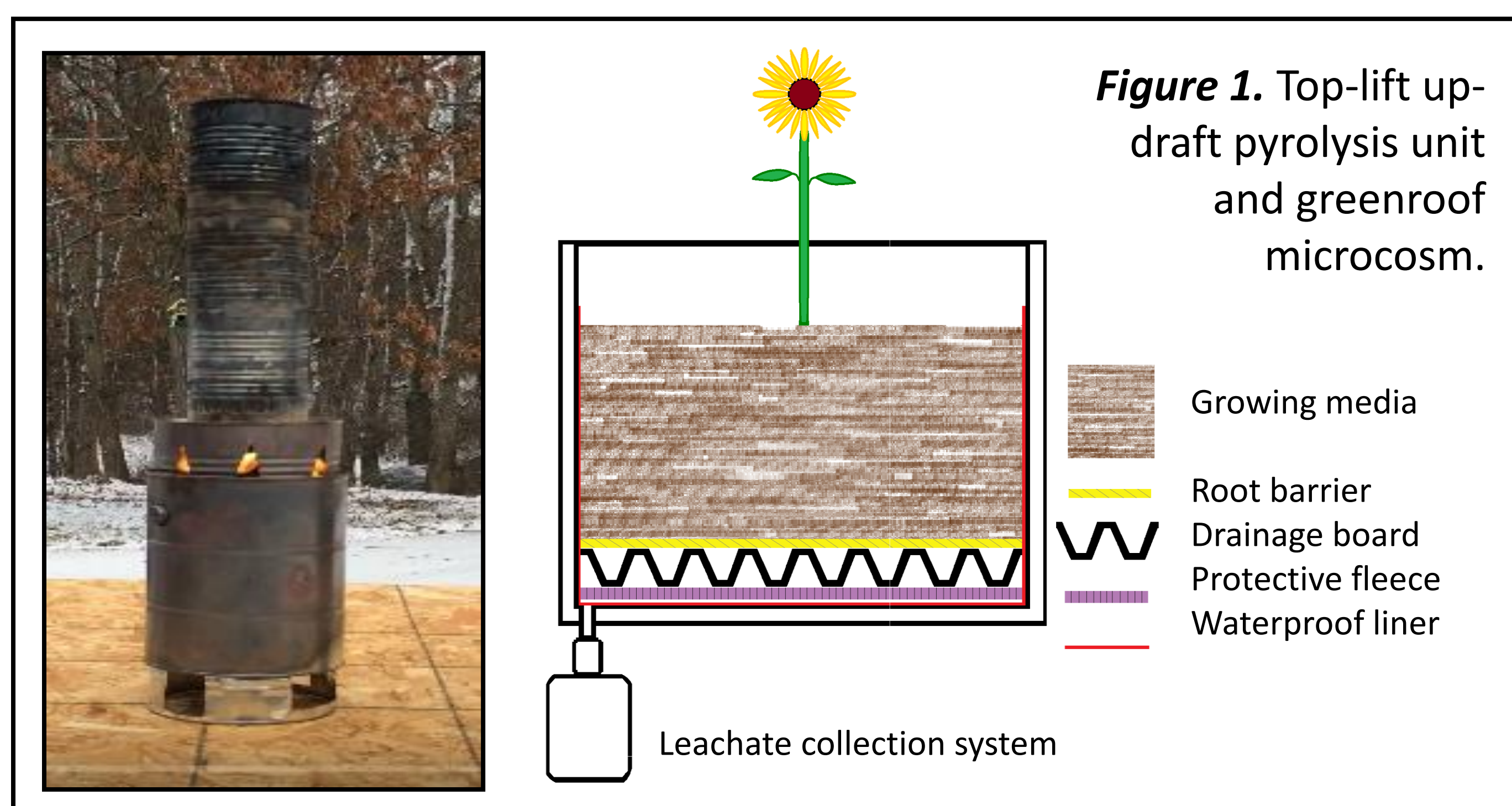
## INTRODUCTION

Greenroofs are constructed gardens on top of structures that help to improve energy use efficiency and increase greenspace in urban areas. Lightweight aggregates are used as growing substrates on roofs due to structural loading limitations. These soils have a limited ability to retain water and nutrients. Some studies have shown substrate improvement with amendments like biochar (BC) (Scharenbroch et al., 2013). Biochar is a charcoal-like substance that has been created through the process of pyrolysis. Biosolids (BS) from municipal wastewater treatment could be used as the feedstock for producing the biochar. This beneficial reuse diverts landfill waste while potentially improving greenroof substrate quality. Using biochar as an amendment to greenroof substrate might improve plant growth and also increase nutrient retention.

**Hypothesis:** Biochar made from biosolids and amended at 20% by volume to a greenroof substrate media will increase water and nutrient holding capacity, resulting in greater growth in sunflower plants and also a reduction in nutrients leachate.

## METHODS

- Forty-five gallons of biosolids cake was collected from Plover, WI wastewater treatment facility, screened through 1.3 cm screen and dried in soil ovens at 50°C for 48 hours.
- Biochar from biosolids was made using two top-lit updraft pyrolysis units (TLUD) (Figures 1 and 2). Pyrolysis occurred for one hour with temperatures ranging from 300-500°C. Biochar was wetted with water immediately following pyrolysis. All batches of biochar were homogenized for uniformity.



**Figure 1.** Top-lift updraft pyrolysis unit and greenroof microcosm.

Growing media  
Root barrier  
Drainage board  
Protective fleece  
Waterproof liner

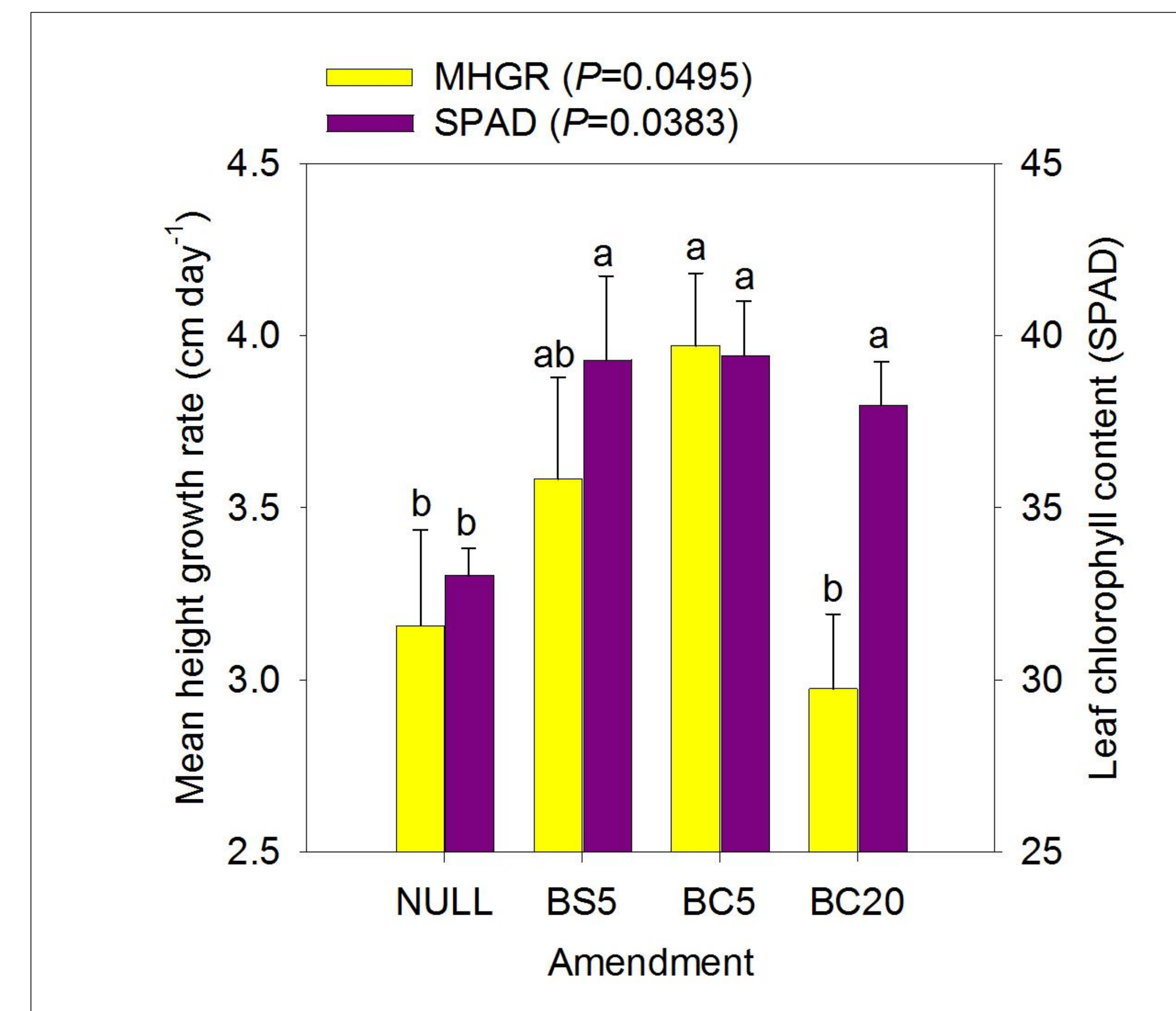
Leachate collection system

**Figure 2.** Dried biosolids (left) and biochar made from biosolids (right).

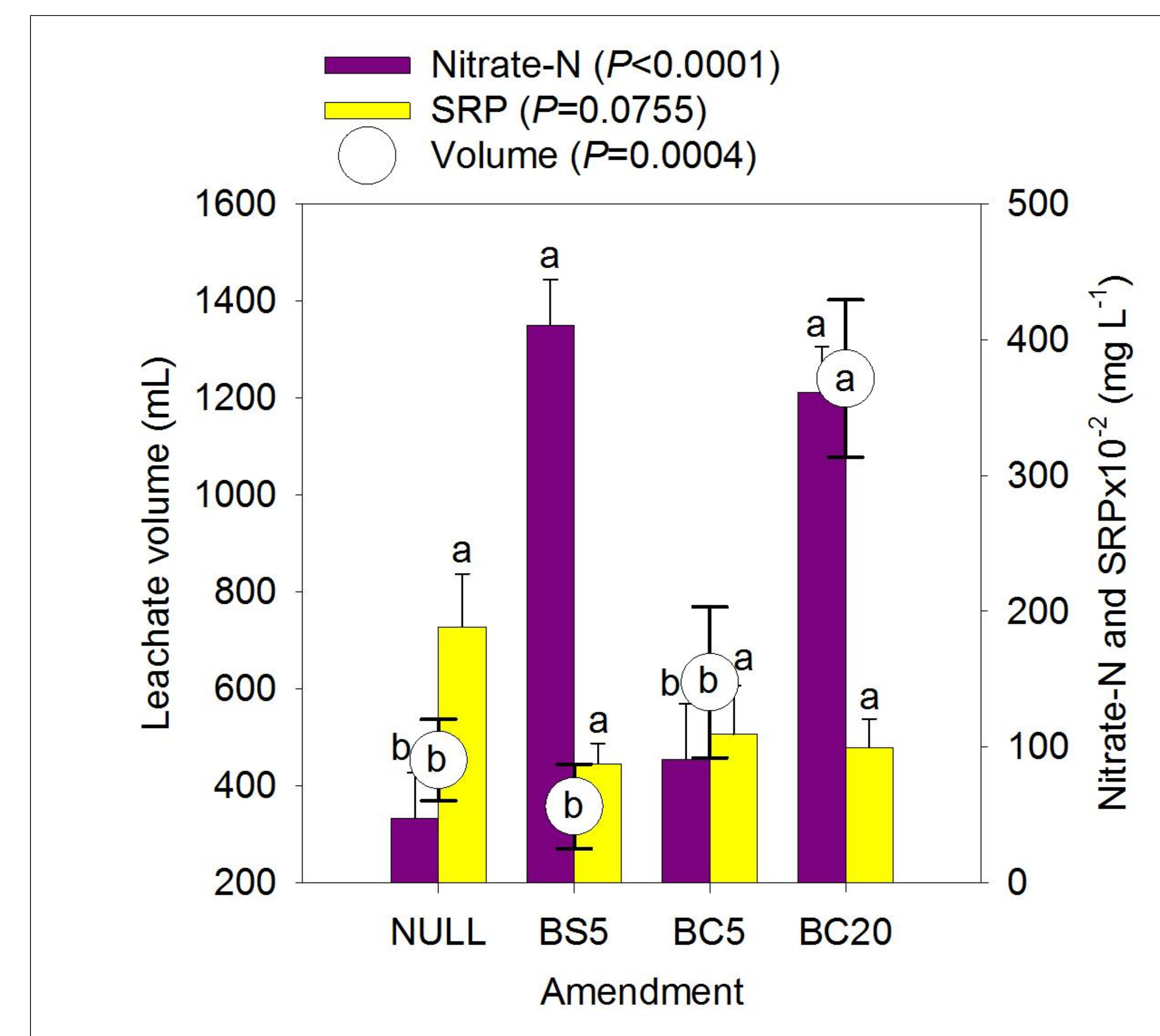


- Biochar and biosolids were added to greenroof aggregate at four rates by volume: none added (NULL), 5% biosolids (BS5), 5% biochar (BC5) and 20% biochar (BC20).
- Soils were placed to a 17.8 cm depth into twenty-four microcosms. Each microcosm (645 cm<sup>2</sup>) was outfitted with greenroof drainage and leachate collection systems (Figure 1). Six replicates for each of the four amendments were created for a total of 24 microcosms.
- Four sunflower seeds (*Helianthus annuus*) were sown into each microcosm on 1/13/2016. Nine days post-planting the two smallest sprouts were cut at root-stem interface; twenty-five days post-planting the smaller of the remaining plants was removed.
- Heights were measured every two-four days and height growth rate expressed as cm day<sup>-1</sup>. Leaf chlorophyll fluorescence was measured biweekly with a SPAD 502 Plus Chlorophyll Meter.
- Water (200-400 mL) was added every 3-4 days for a total of 7,350 mL over 51 days for each microcosm. Leachates volumes, EC and pH and determined as collection bottles filled.
- On 4/2/16 each microcosm received an 800mL flush. Leachate was collected on 4/5/16, the volume was recorded and soluble reactive phosphorus (SRP) and nitrate concentrations were measured.
- Plant available water (PAW) was determined by measuring gravimetric water contents after using pressure plates to bring soils to desired tensions. PAW was moisture content at field capacity (-10 kPa) minus permanent wilting point (-1500 kPa).
- On 3/25/16, four 2.5 cm diameter by 17.8 cm inches deep cores were collected from each microcosm, composited and sent to Midwest Laboratories, Omaha, NE for biochemical analyses.
- Statistical analyses were conducted with using JMP (version 11, SAS). Amendment differences were assessed with ANOVA using Student's t or Tukey-Kramer HSD for mean separation tests. All significant findings were reported at the 95% confidence level.

**Figure 3.** Mean height growth rates during weeks three through five and relative chlorophyll content at week eleven



**Figure 4.** Mean total water drained and nitrate and soluble reactive phosphorus concentrations in leachate after 800mL flush on 3/4/16



## RESULTS

- The BC5 amendment had the greatest mean height growth rate, significantly greater ( $P=0.0495$ ) than the NULL and BC20 amendments (Figure 3).
- Sunflowers grown in all amendments had significantly greater ( $P=0.0383$ ) average chlorophyll content in leaves when compared to the NULL (Figure 3).
- The BC20 amendment had the greatest ( $P=0.0004$ ) total water drained with an average of 17% lost from what was applied. The BS5 amendment retained the most water, losing only 5% (Figure 4).
- The BS5 leachate had the highest ( $P<0.0001$ ) concentration of nitrate-N, significantly greater than the BC5 and NULL amendments (Figure 4). NULL leachate had the highest ( $P=0.0755$ ) concentration of SRP.
- The BC20 had the highest OM at 11.9%, followed by BS5, BC5 and then NULL ( $P<0.0001$ ). Potassium (K) concentration in BC20 was significantly lower than the other amendments ( $P=0.0223$ ). The NULL was the most alkaline, and BC20 was the most acidic ( $P<0.0001$ ) with pH values of 8.48 and 6.45 respectively. The BC20 had 4.9% lower PAW than BS5. Leachate EC was greatest ( $P<0.0001$ ) in BS5 and pH was greatest ( $P=0.0007$ ) in NULL (Table 1).

**Table 1.** Substrate and leachate physiochemical properties with ANOVA  $P$  values mean and mean separation tests displayed on significant values.

Response	NULL	BS5	BC5	BC20	$P$ value
SOM (%)	7.38 d	10.65 b	9.25 c	11.85 a	<0.0001
Bray P (mg kg <sup>-1</sup> )	145	180	168	182	0.1298
K (ppm)	969 a	964 a	930 a	703 b	0.0223
Mg (ppm)	406	477	426	450	0.4513
Ca (ppm)	1847	2253	1953	1940	0.0651
Na (ppm)	165	189	176	226	0.0676
pH	8.48 a	7.10 c	7.75 b	6.45 d	<0.0001
CEC (cmol <sub>c</sub> kg <sup>-1</sup> )	15.82	18.55	16.48	17.73	0.3194
PAW (%)	10.92	15.48	12.15	12.00	0.0929
Leach. EC (μS cm <sup>-1</sup> )	10300 c	15200 a	12230 b	13330 ab	<0.0001
Leachate pH	7.66 a	7.28 ab	7.32 ab	6.98 b	0.0007

## DISCUSSION & CONCLUSIONS

The greatest growth rates observed were in the BC5 amendment, and the lowest with the BC20, which rejects our hypothesis. Negative effects of BC on plant growth with high concentrations of BC and with BC's of non-woody feedstocks have been observed due to changes in pH, nutrient immobilization and hydrophobicity (Spokas et al., 2012). Decreases in plant yield have been observed in the first year of growth with higher BC application rates (Gaskin et al., 2010). The nitrate concentration in leachate was likely reduced in BC5 due to increased growth and uptake by the sunflowers and lower initial N content in the amendment. **These findings suggest that BC added at 5% by volume improves greenroof substrate nutrient availability and plant growth while also limiting nutrient losses in leachate.** Continued research is needed to examine the effects on plant growth from different BC feedstocks, pyrolysis methods and rates of application in greenroof substrates and the effect they have on nutrient losses in greenroof systems.

## REFERENCES

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