Biochar as a media amendment in container plant production of viola and daylily: Greenhouse gas emissions, plant growth, and leachate N

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Abstract

In two separate experiments, this study investigated the effects of increasing amounts of biochar to standard nursery and greenhouse substrates on greenhouse gas emissions (CO_2, CH_4, and N_2O), plant growth, and N loss via leachate.

Experiment 1: A peat-based greenhouse substrate was amended with biochar in the production of viola (*Viola cornuta* L. 'Sorbett XP Deep Orange').
Experiment 2: A bark-based nursery substrate was amended with biochar in the production of daylily (*Hemerocallis* x 'EveryDaylily Cream PBR' L.).

***Findings*: In general, biochar use decreased N_2O and CO_2 fluxes in daylily, suggesting biochar may be beneficial in mitigating portions of global climate change as contributed by container plant production. While biochar seemed to inhibit top shoot growth in daylily, little effect was observed for top shoot viola growth. In fact, higher levels of biochar improved root dry weight in viola. Additionally, greater effects on N loss reduction were observed in treatments with higher levels of incorporated biochar for both experiments.**

***Going Forward*: Results suggested that future studies should focus on testing a lower range of rates of biochar, along with varied application methods, to measure growth and environmental impacts. Additionally, the improved N use efficiency observed in these trials highlight the importance of better understanding of N management and developing biochar practices in container plant production that increase N retention.**

Introduction

Increasing atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are thought to be driving factors in global climate change (Dlugokencky et al. 2005, Florides and Christodoulides 2008). Agriculture accounts for approximately one-fifth of the annual increase in emissions of these trace gases (Cole et al. 1997). Thus, developing mitigation strategies to reduce trace gas emissions from the agricultural sector is crucial to lessen the impacts of climate change.

The nursery, greenhouse, and floriculture industry in Alabama is estimated at $629.2 million annually (ACES 2013). Given the magnitude of the green industry and its contribution to national, state, and local economies, it is crucial to understand how industry management practices can be altered to mitigate climate change.

Research into potential uses of biochar in agricultural systems has examined its effects on growth, yield, soil carbon sequestration, and movement of nutrients within and out of these systems, including as trace gases. Utilizing biochar as a soilless substrate component may represent a mechanism for increasing C sequestration and for mitigating trace gas emissions from growth substrates used in these systems by adding a highly recalcitrant form of carbon into the landscape at planting.

Methodology

Experiment 1: Biochar-amended peat in production of viola

Treatments: Biochar (Premium Biochar; Mother Earth®, Vancouver, WA) was added to a standard 80:20 (v:v) peatmoss: perlite (PM:P) blend in the following percentages:

1-) 0% biochar (100% 80:20 PM:P)
2-) 5% biochar (remaining 95% is 80:20 PM:P blend)
3-) 10% biochar (remaining 90% is 80:20 PM:P blend)
4-) 20% biochar (remaining 80% is 80:20 PM:P blend)
5-) 30% biochar (remaining 70% is 80:20 PM:P blend)

Amendments: Lime, SNC, and wetting agent incorporated at mixing
Plant Species: *Viola cornuta* L. 'Sorbet® XP Deep Orange'
Experimental Design: RCBD (n=12)

Experiment 2: Biochar-amended bark in production of daylily

Treatments: Biochar [granulated coconut char (GC 8 X 30S; General Carbon Corp., Patterson, NJ)] was added to a standard 6:1 (v:v) pinebark: sand (PB:S) blend in the following percentages:

1-) 0% biochar (100% 6:1 PB:S)
2-) 10% biochar (remaining 90% is 6:1 PB:S blend)
3-) 20% biochar (remaining 80% is 6:1 PB:S blend)
4-) 30% biochar (remaining 70% is 6:1 PB:S blend)

Amendments: Lime and CRF (12-month release) incorporated at mixing
Plant Species: *Hemerocallis* x 'EveryDaylily Cream PBR' L.
Experimental Design: RCBD (n=6)

Data Collected:

- Trace gas efflux (methodology described below)
- Shoot dry weight at termination
- Root dry weight at termination
- Total leachate volume and leachate N (daylily only)

Measuring Trace Gas Efflux

Custom-made gas efflux chambers were designed and constructed using GRACEnet protocols (Baker et al., 2003).

Entire pot with plant placed inside cylinder.

Top of efflux chamber placed on top and tight band wrapped around top and bottom to create seal. Top contains center sampling port.

Samples collected with syringes and injected into evacuated glass vials at 0, 15, 30, and 45 minutes after chambers have been closed (Parkin and Kaspar, 2006).

Analyzed with gas chromatography.

GHG emissions calculated from the rate of change in the concentrations of trace gases in the chamber headspace.

Results

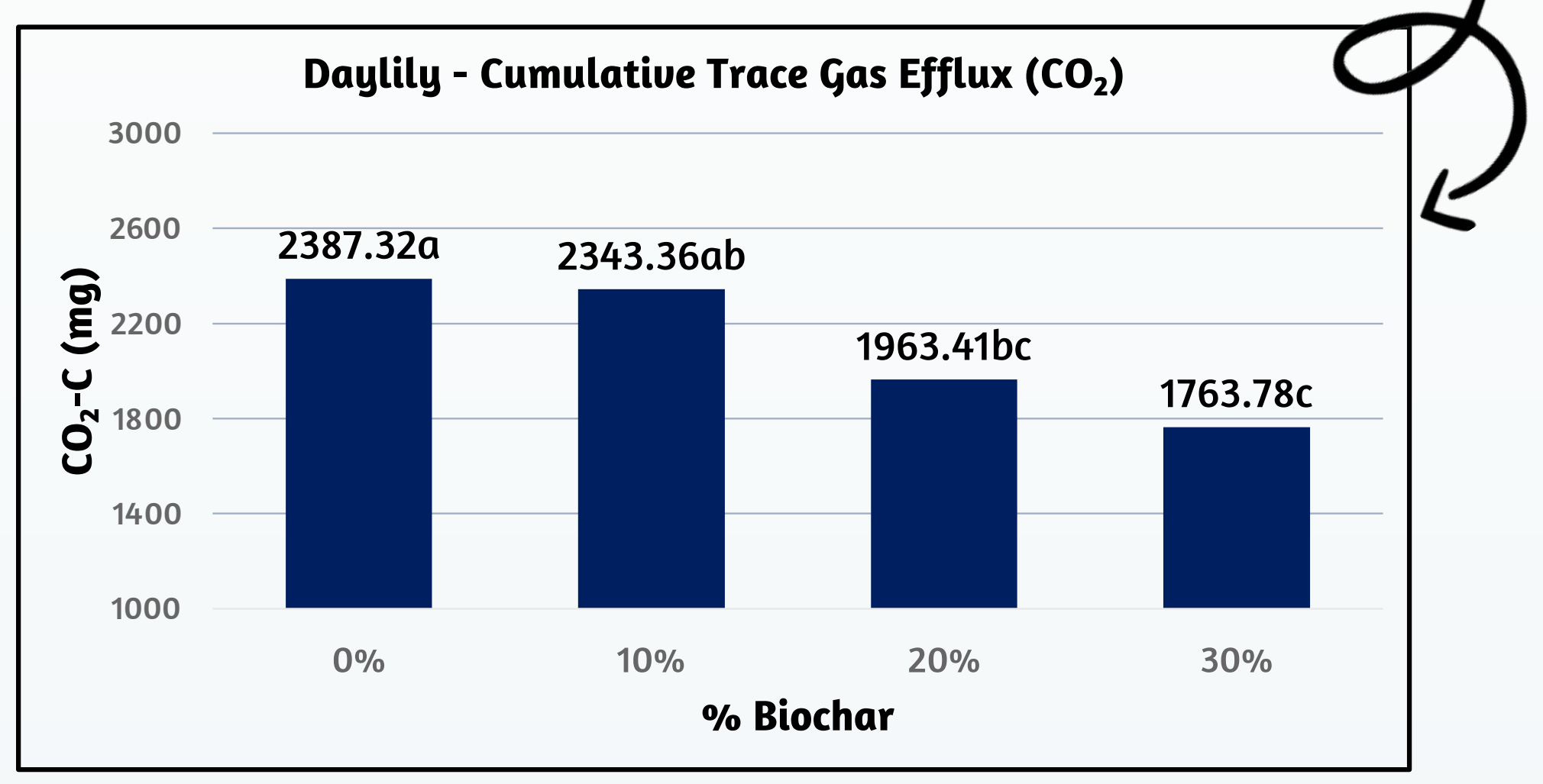
Greenhouse Gas Emissions:

Viola Experiment:

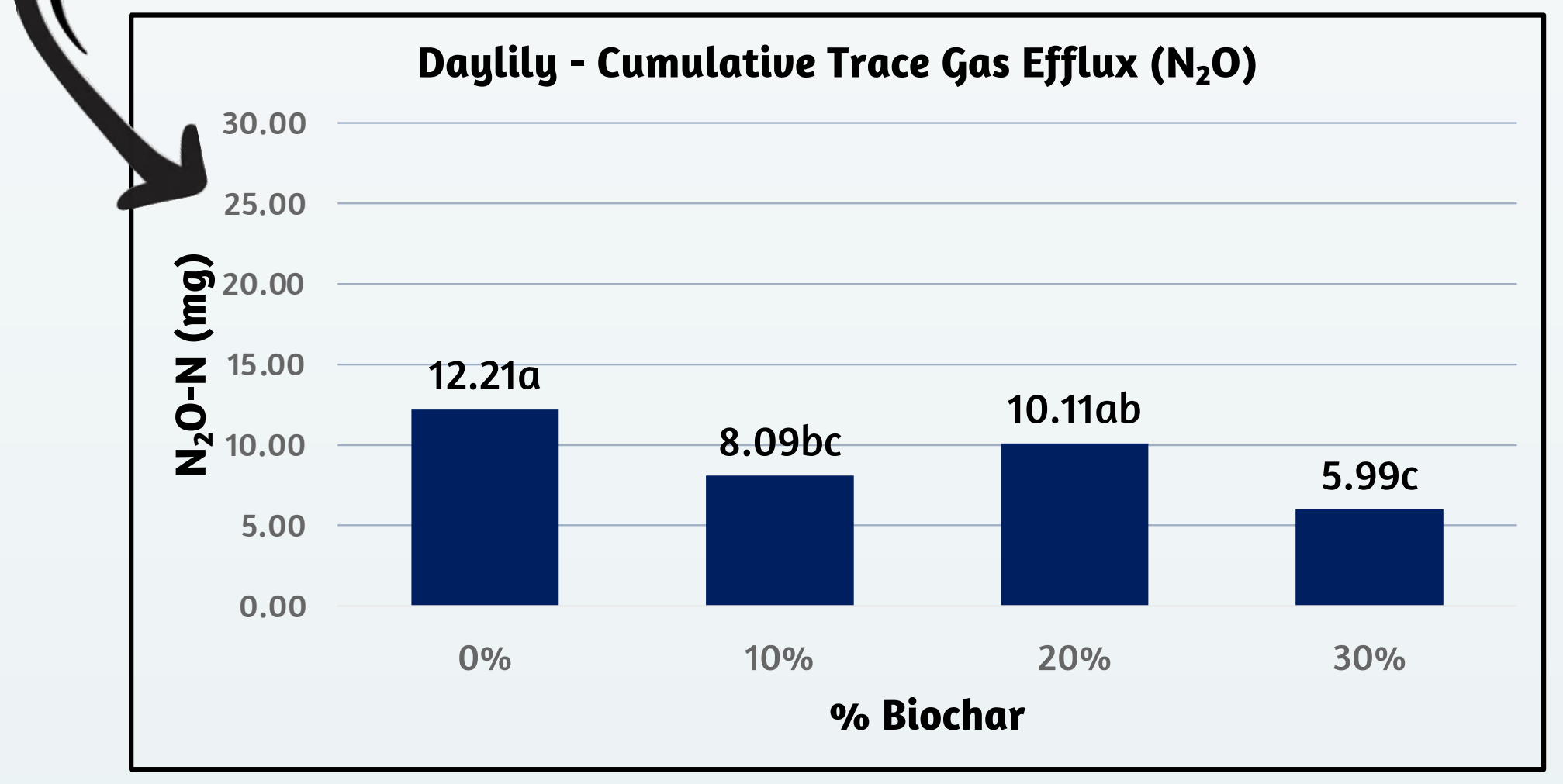
- No significant differences for daily cumulative trace gas efflux (CO_2, CH_4, and N_2O) regardless of biochar percentage.

Daylily Experiment:

- CO_2 efflux declined with increasing biochar percentages.



- N_2O efflux was less for plant-pot systems containing 30% biochar as compared with the 100% PB:S industry standard substrate.

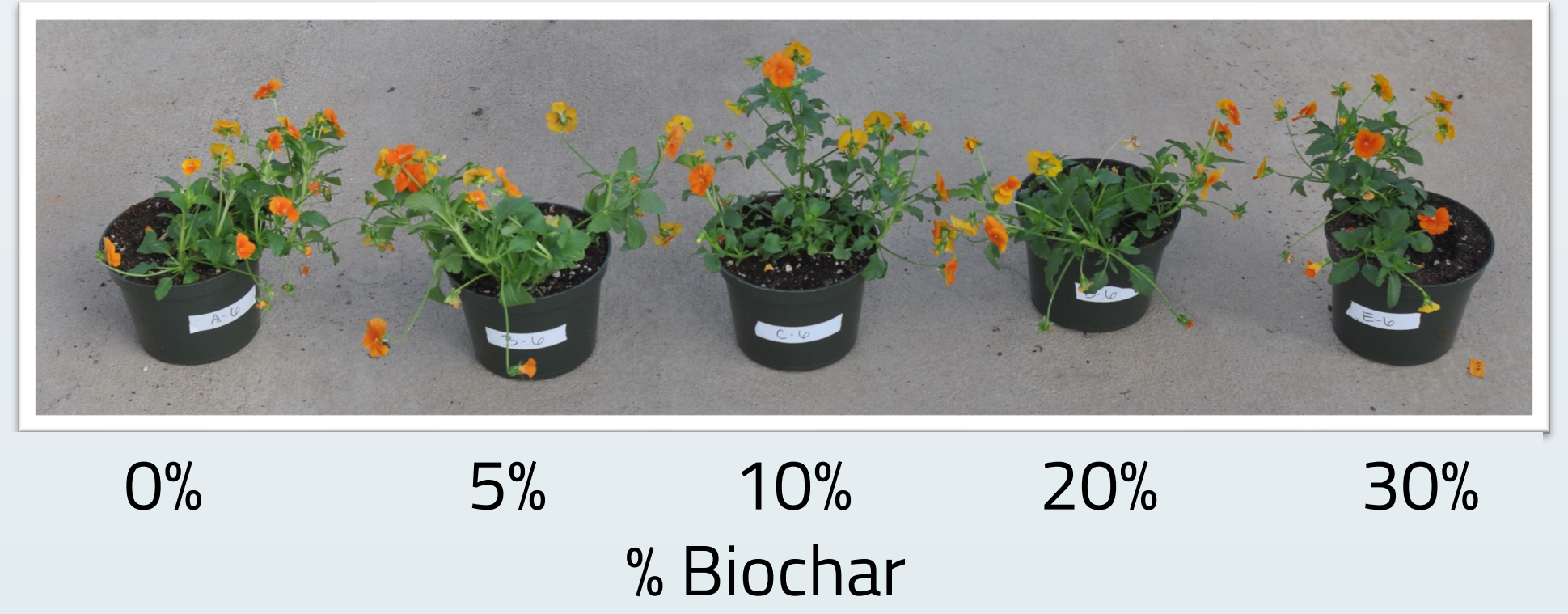


- CH_4 (daily and cumulative) not significantly affected.

Plant Growth:

Viola Experiment:

- No effect on top dry weight.



- Root dry weight significantly higher at 30% biochar.

Daylily Experiment:

Daylily biomass data [top, root, and total dry weights (DW)] for the biochar treatment levels.

Biochar (%)	Top DW (g)	Root DW (g)	Total DW (g)
0	4.25a	12.64a	16.89a
10	2.12b	4.98b	7.10b
20	1.30bc	3.68b	4.98b
30	0.40c	2.80b	3.20b
P value	<0.001	0.004	0.001

Results (continued)

Leachate Nitrogen (Daylily Experiment):

Cumulative leachate[z] N content[y] (NO_3, NH_4, and Total N in mg) for the daylily outdoor study for the biochar treatment levels.

Biochar (%)	NO_3	NH_4	Total N
0	979.99a	267.22a	1247.21a
10	730.70b	115.12b	845.82b
20	717.96bc	57.06c	775.02bc
30	635.29c	42.19c	677.48c
P value	<0.001	<0.001	<0.001

[z] Leachate was collected (from irrigation and rainfall events), held in 3.8 L (1 gal) jugs, measured weekly for total volume using graduated cylinders, and a 50 ml subsample collected for leachate N analyses.

[y] Cumulative N content (NO_3, NH_4, and Total N = NO_3 + NH_4) in leachate was calculated by adding N contents across all sample dates.

Takeaways

- For some species, CO_2 and N_2O flux may be reduced by amending soilless substrates with biochar (as evidenced by daylily in this study).
- A lower range of biochar rates may be needed to offset plant growth differences for some species.
- Biochar additions reduced total N in leachate in the bark-based experiment.
- Going forward, local and sustainable sources of biochar should be identified and tested as substrate amendments for more ornamental species.

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