Evaluation of Four Biochars as Potential Media Amendments for Container Plant Production

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ABSTRACT

Biochars, organic matter heated through pyrolysis, are one potential amendment nursery stock growers could use to reduce reliance on horticultural grade bark and peat moss, but the impact of biochars on landscape plants grown in soilless potting mixes is unknown. Biochars from four parent materials, dried dairy manure (DM), ponderosa pine sawdust (PP), ground wood waste (GWW) and a commercial biochar made from non-food biomass (CB), were tested as alternate amendments in potting mixes in two trials (DM and PP tested 2015; GWW and CB tested 2016) in 1-gallon containers. Amended biochar media contained 0, 5, 10, 15 or 20% biochar by volume, 70% aged bark and sphagnum peat moss to bring each mix's volume to 100%. Douglas spirea (2015, 2016), mockorange (2015) and firechalice (2016) were grown in the mixes for three months. At harvest, increases in shoot heights were recorded for spirea and mockorange, whereas plant diameters were measured for firechalice. Shoot dry weights were determined for all plants. Physical properties (air capacity, water-holding capacity and total porosity) were evaluated for all mixes and were found suitable for container production. Chemical analyses of each raw biochar were completed and nutrient levels varied depending on parent material, especially the CEC which ranged from ~2 cmole(+)/kg (DM and PP) to greater than 30 cmole(+)/kg (CB and GWW). Plant growth in response to biochar type also varied. Spirea and mockorange shoot dry weights and heights were negatively impacted by >5% DM biochar. High salts (electrical conductivity = 58 $mS\cdot cm^{-1}$, extractable chloride = 11,993 $mg\cdot kg^{-1}$) in the DM biochar were likely responsible. Shoot dry weight of spirea and mockorange and the height of spirea grown in PP mixes were equivalent to control plants, but mockorange height decreased at least 17% with incorporation of PP biochar. Mixes amended with GWW or CB biochars produced plants with equivalent height (spirea, $p = 0.1132$) and shoot diameter (firechalice, $p = 0.431$) regardless of treatment. In contrast, spirea and firechalice plants produced the most shoot dry weight in the 10% CB mix, whereas firechalice shoot dry weight decreased at least 7.3% with any concentration of GWW biochar. One of the four biochars evaluated increased plant growth (10% CB), whereas three of the biochars (DM, PP and GWW) were detrimental to the growth of at least one plant species when grown in soiless media in 1 gallon containers.

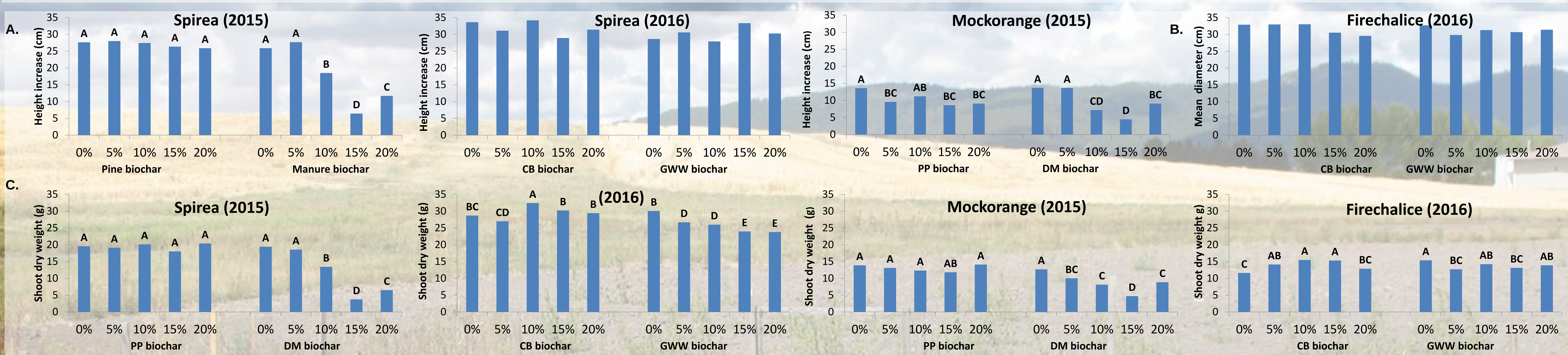

Figure 1: Height increase (A) or plant canopy diameter (B) and shoot dry weight (C) of spirea, mockorange and firechalice grown in potting mixes amended with varying amounts of ponderosa pine (PP), dried dairy manure (DM), commercial (CB) or ground wood waste (GWW) biochar. Different letters within a graph indicate significant differences as determined by using Least-Square means at the 5% level (n = 4)..

Table 1: Average chemical properties of media components including four biochars made from different parent materials and sphagnum peat moss (n = 3). ᶻ EC = electrical conductivity, ʸ CEC = cation exchange capacity.

Media components	NO_3-N (mg/kg)	NH_4-N (mg/kg)	P (mg/kg)	K (mg/kg)	Ca (meg/100 g)	Mg (meg/100 g)	S (mg/kg)	Na (meg/100 g)	Cl^- (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	B (mg/kg)	pH	EC ᶻ (mS/cm)	CEC ʸ (cmole (+)/kg)
GWW	2.2	7.5	109.8	1726.1	8.6	0.6	19.5	2.6	37.7	3.7	3.3	11.1	0.0	0.4	8.9	3.3	46.3
CB	10.8	53.4	230.2	5397.0	2.9	2.8	112.1	7.6	564.3	2.0	17.5	2.9	0.7	0.7	7.3	4.8	30.7
DM	0.4	8.5	6899.3	14378.7	10.9	4.6	592.0	34.8	11993.3	5.8	23.0	19.7	1.7	4.3	10.4	58.6	2.6
PP	0.5	1.5	37.7	398.3	2.1	0.6	19.0	0.4	128.0	3.2	118.7	14.3	0.8	0.6	5.6	1.1	2.0
Peat	3.9	132.0	60.0	33.0	2.5	1.0	273.0	0.1	173.7	15.2	650.0	104.0	1.4	2.9	4.3	1.6	130.0

INTRODUCTION

- Biochars are carbon rich solids produced after heating organic matter in in the absence of oxygen.
- Field applications of biochars have improved pH, CEC and absence of some soil nutrients.
- Biochars could be a beneficial alternative to peat in soiless substrates, possibly improving media properties and plant growth.

MATERIALS AND METHODS

- Biochars made from four different parent materials were obtained. Two biochars were tested in each trial: DM and PP in 2015, and GWW and CB in 2016.
- Container media contained 0, 5, 10, 15 or 20% biochar by volume, 70% aged bark and sufficient peat moss to bring each medium's volume to 100%. Initial pH and EC were measured and ground agricultural limestone incorporated into mixes until a pH over 5 was obtained. Micromax (micronutrient fertilizer) was incorporated at a rate of 0.89 kg/m^3. Osmocote® 15-9-12 was added at a rate of 5.9 kg/m^3 in 2015 and 8.6 kg/m^3 in 2016.
- Douglas spirea (2015, 2016), mockorange (2015) and firechalice (2016) were planted into 1 gallon pots containing experimental mixes. Containers were arranged in a randomized complete block design (5 replicates X 10 treatments X 4 blocks) in a modified pot-in-pot system outdoors. Plants were provided supplemental liquid fertilizer (100 ppm N, 2015 or 150 ppm N, 2016) four times over the three month trials. Plants were watered three times a week using micro-emitter irrigation.
- At harvest, final shoot height or diameter was measured. Plants were cut at the medium surface then dried at 40ºC for 1 week to determine shoot dry weights. Shoot dry weights, heights or diameters were averaged by block and then treatment effects were detected by using the General Linear Mixed Model (PROC Glimmmix, SAS).
- Physical properties of all media were determined as described by Holstead (1983) and chemical properties determined by the Analytical Sciences Lab at the University of Idaho and Soiltest Farm Consultants, Inc.

WORK CITED

Holstead, C.I. 1983. Good health, long life to the pot plant. Grower talks 47 (4): 60-63.

SAS. 2012. Users Guide Statistics. Ver. 9.4. SAS Institute Inc., Cary, NC, USA.

RESULTS

Media composition:

- Physical properties of all mixes were found suitable for container production. Air capacity ranged from 17 to 36%. Water-holding capacity ranged from 47 to 56%.Total porosity ranged from 67 to 80% (data not shown).
- Nutrient levels of biochars varied; some exceeded the levels in peat indicating biochars could be nutrient sources (Table 1).
- GWW, CB and DM had high pHs (7.3 to 10.4). DM had the highest salt content (EC of 58.6 mS/cm, Cl^- 11,993 mg/kg).
- CEC of all biochars were much lower than that of sphagnum peat moss (Table 1). GWW had the highest CEC among the biochars but was 2.8 fold less than that of peat.

Plant growth:

- 2015 trial: Spirea grown in mixes amended with up to 20% PP biochar were of similar height and weight to control plants. Mockorange weight was unaffected by PP biochar concentration, whereas height decreased at least 17% with PP incorporation (Fig. 1). Greater than 5% DM negatively impacted spirea and mockorange dry weight and height, causing at least a 28.6% reduction for both growth variables and species. Even 5% DM reduced mockorange shoot dry weight by 21%.
- 2016 trial: Mixes amended with GWW or CB produced plants with similar heights (spirea, $p = 0.113$) and shoot diameter (firechalice, $p = 0.431$) regardless of treatment. Shoot dry weight was affected by treatment. Incorporation of 10% CB biochar resulted in the heaviest spirea plants (32.42 g), whereas plants in all other treatments were similar to control plants. Incorporation of any percentage of GWW biochar negatively impacted spirea dry weight. Five, 10 or 15% CB biochar mixes increased firechalice dry weight by at least 21% compared to control plants. Firechalice shoot dry weight decreased at least 7.3% with incorporation of GWW biochar.

CONCLUSIONS

- CB biochar (10%) improved spirea and firechalice shoot dry weight.
- DM, PP and GWW biochars were detrimental to the growth for at least one plant species when grown in 1 gallon containers.
- Previously described biochar benefits (improved CEC, pH, water retention) were absent from all biochar amended media.