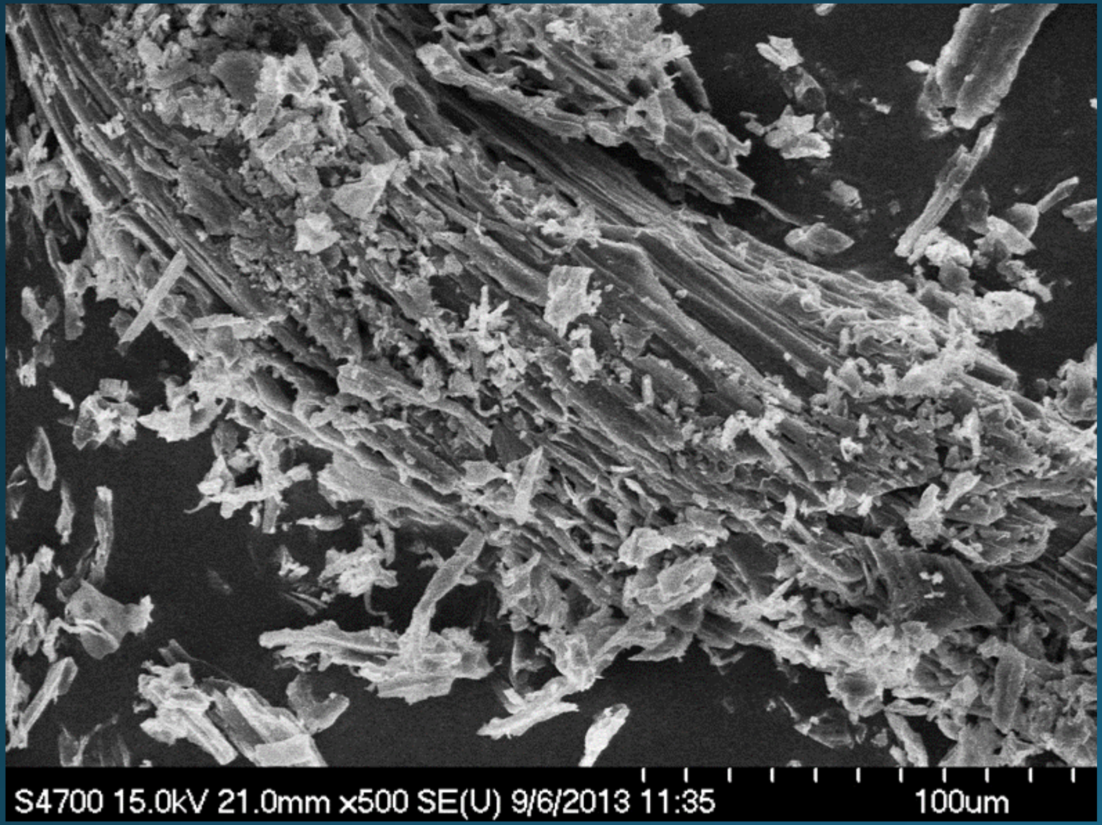
Advances in using biochar as a media amendment

By: Clarice P. Matt
Botanist
Tri-Cities, WA

What is biochar?



A carbon-rich, recalcitrant co-product of pyrolysis intended for use as a soil amendment.

All Biochar is NOT created equal

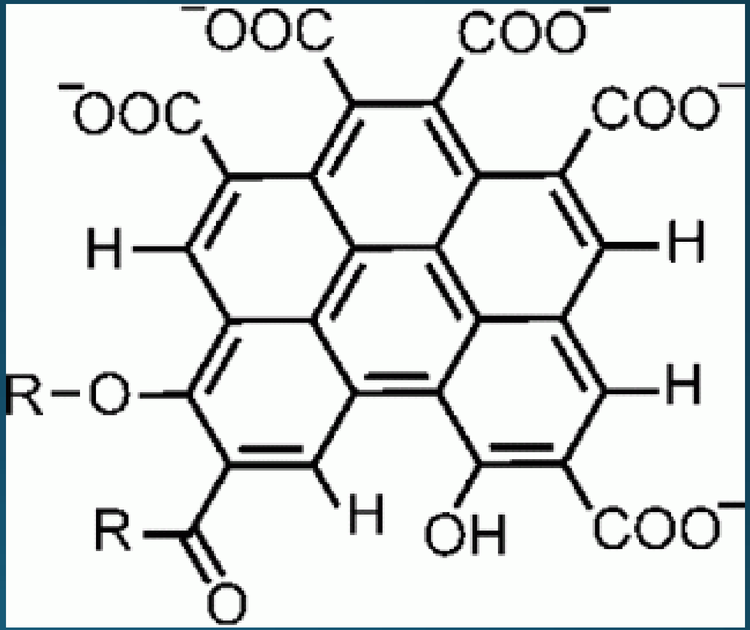
- Final characteristics are dependent on:
  - Feedstock
    - Nutrient retention
    - Porosity
  - Pyrolysis conditions (temperature and heating time)
    - C conversion to stable forms
    - pH
    - Surface area
    - CEC

J. Lehmann, 2007. *Nature*

Shared characteristics of Biochar

Key attributes:

- Highly aromatic structure
- High surface area
- Highly porous nature
- Recalcitrant
- Alkalization effects



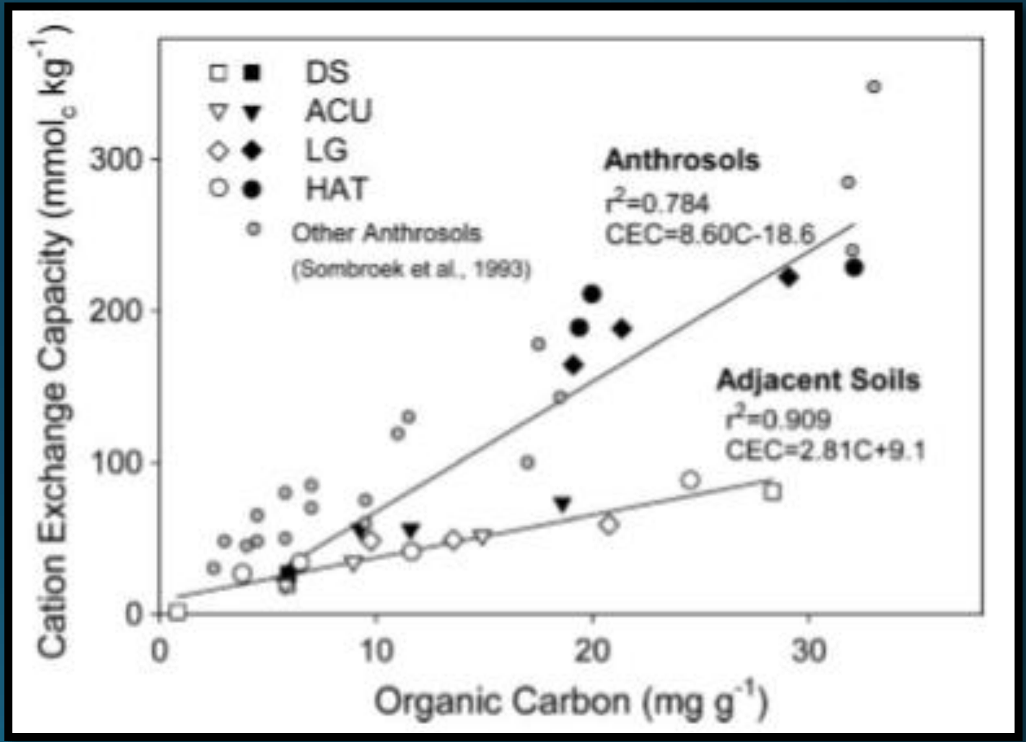
Moa et al., 2012. *Environmental Science and Technology*.

Terra Preta or Amazonian Dark Earths

- Created from slash and char practices of indigenous peoples.
- Known for their blackened appearance and high fertility.
- SOC dates range from 500 to 7000 years before present.

The *Terra Preta* Phenomenon

- Observed enhanced sustained fertility and carrying capacities of soils.
- High fertility is attributed to the high SOC in the form of char.

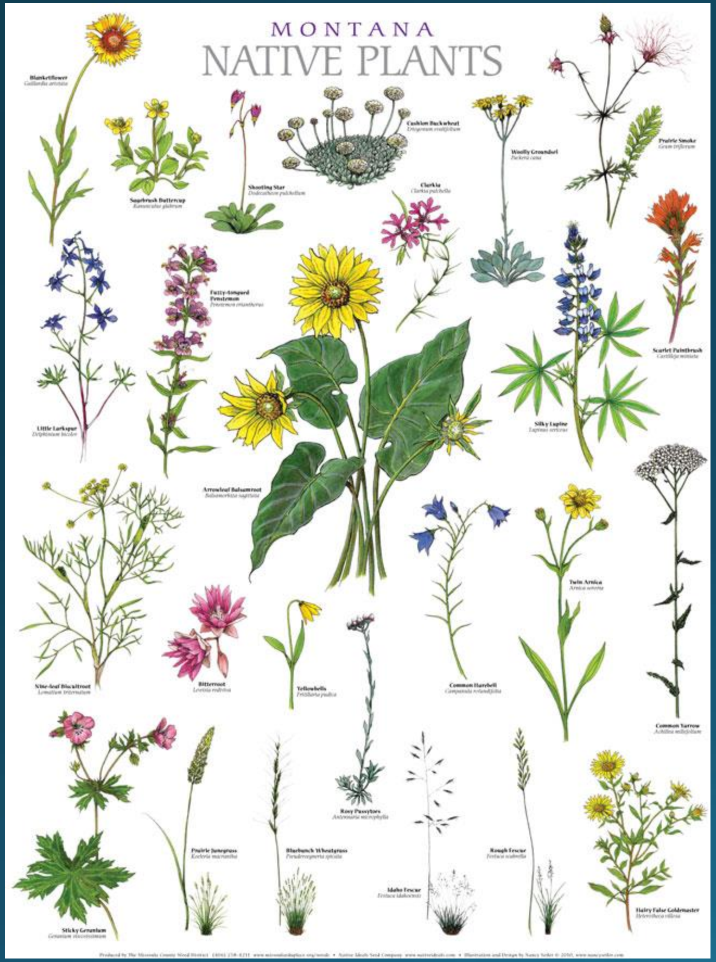


Liang et al., 2006. Soil Science Society of America Journal

The Potential role of biochar in the nursery

- Increase plant productivity and nutrient use efficiency.
- Reduce reliance on peat-based growing substrates.
- Incorporate C biosequestration into restoration practice to mitigate climate change.

My contribution to biochar research



Assess the potential for biochar to amend soilless growing media for the propagation of Rocky Mountain native plant species.

My experiment

- Amended standard 3:1:1 (peat:perlite:vermiculite)
- 4 treatment rates (percent total volume):
  - 0%, 15%, 30% and 45%
- 4 study species (2 short season and 2 long season)
  - *Clarkia*, *Festuca*, *Gaillardia* and *Pinus*
- 4 harvest dates
- 4 replicates
- Duration: 12 or 26 weeks
- Total seedlings, n=768

Study objectives

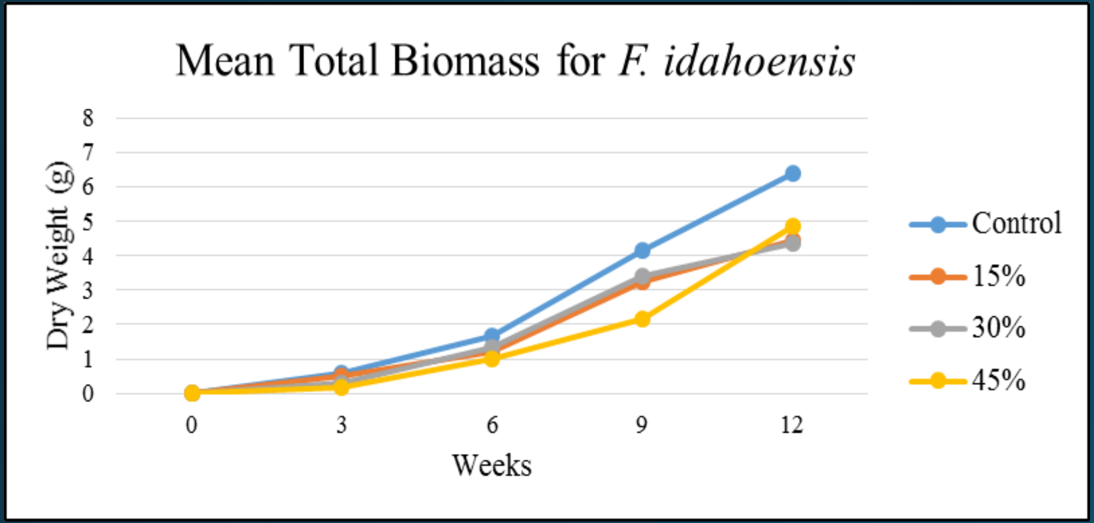
To determine:

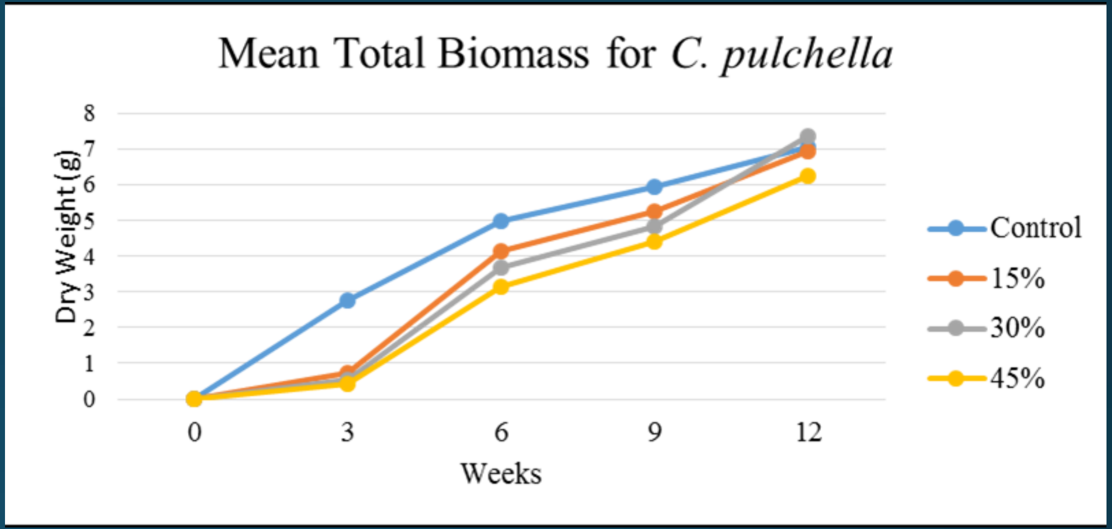
1. Effects on plant growth
2. Effects on substrate (pH and EC)

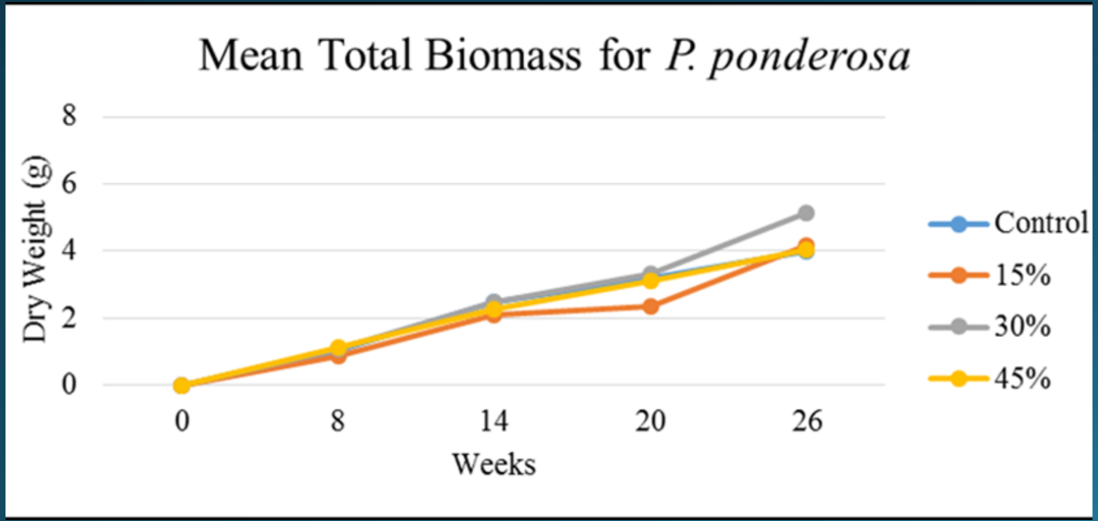
Data Collection

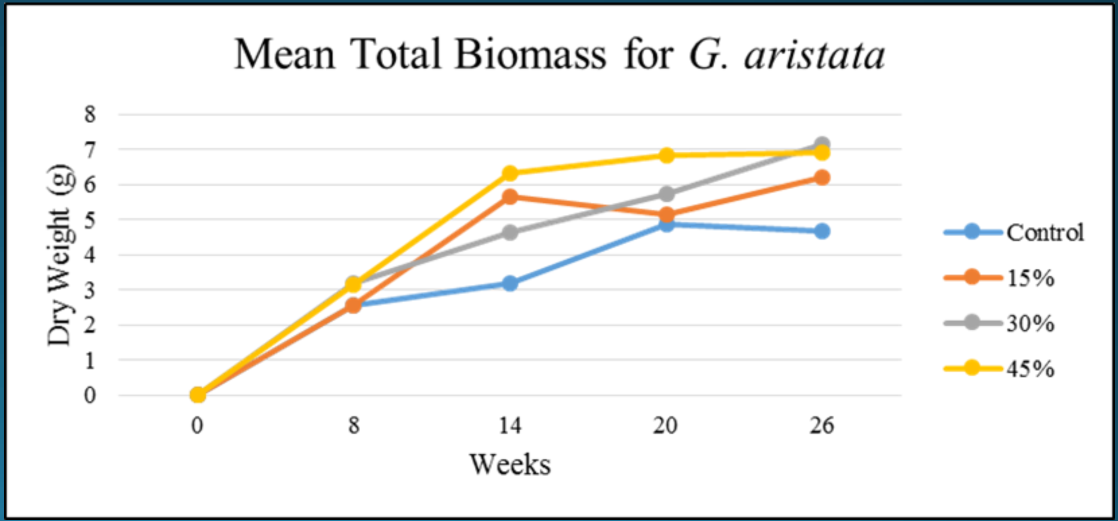
Species:	Subgroup	Growth Habit	Study measurements	Harvest Dates (from Day 1)*
Clarkia pulchella	Short season	Annual forb	Overall height (cm), shoot biomass, root biomass, final plant tissue nutrients.	3,6,9 and 12 weeks
Festuca idahoensis	Short season	Perennial graminoid	Length of longest leaf, bunch diameter, shoot biomass, root biomass, final plant tissue nutrients.	3,6,9 and 12 weeks
Pinus ponderosa	Long season	Long-lived tree	Overall height (cm), shoot biomass, root biomass, final plant tissue nutrients.	8,14,20 and 26 weeks
Gaillardia aristata	Long season	Perennial forb	# true leaves, shoot biomass, root biomass, final plant tissue nutrients.	8,14,20 and 26 weeks

Growth over time

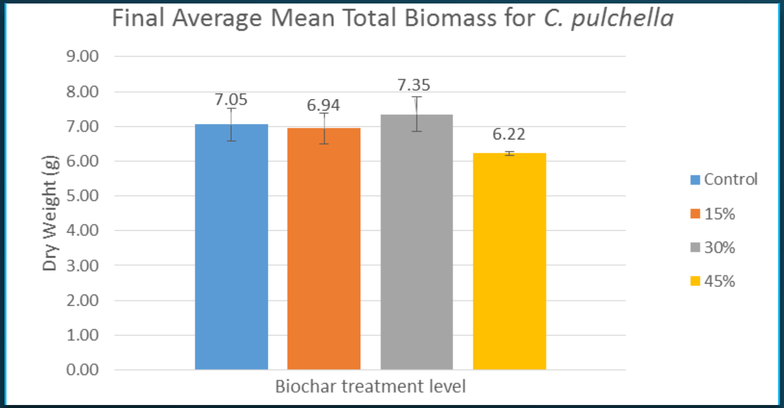


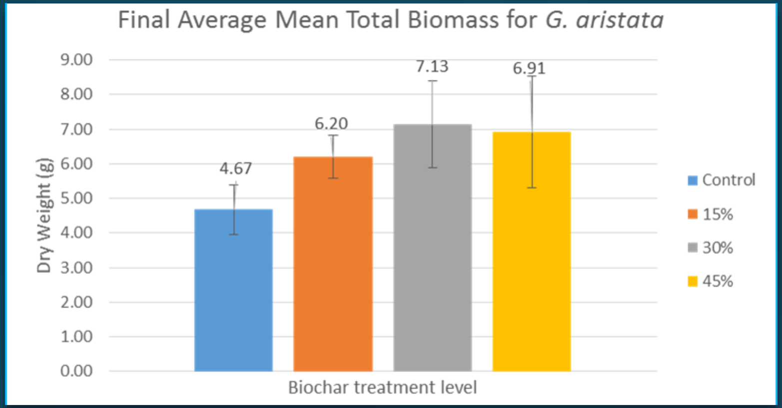


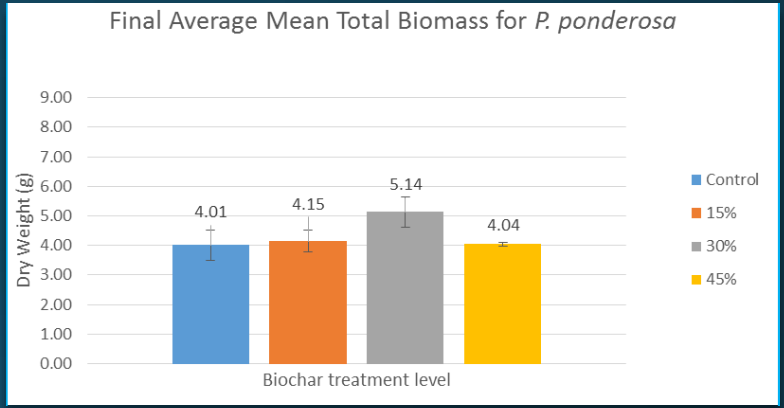




Final Mean Total Biomass







No statistically significant treatment effect (p-value=0.3).

No statistically significant treatment effect (p-value=0.438).

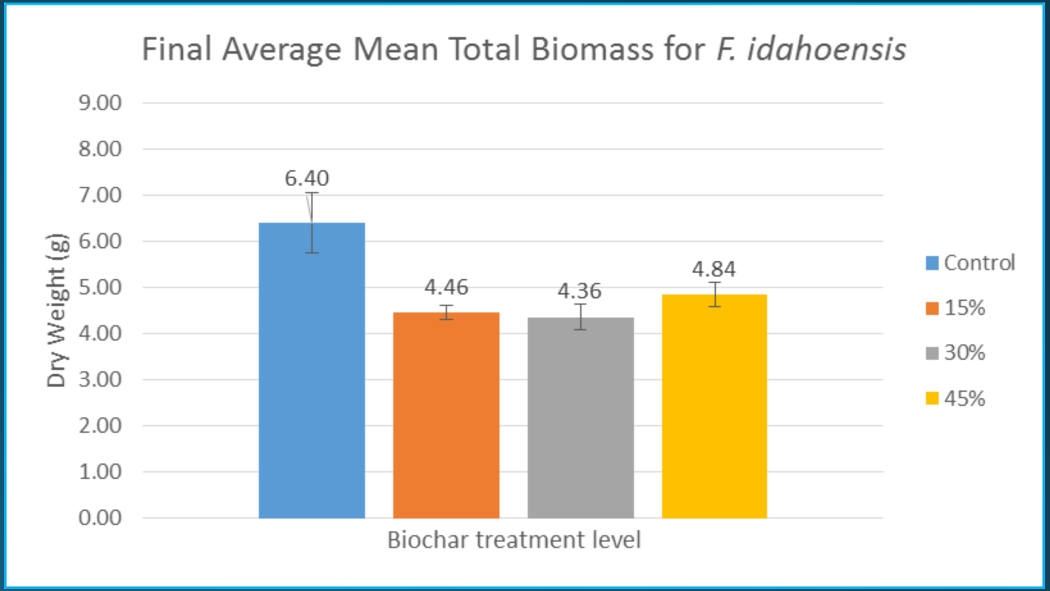
Note: High amount of within treatment variability which could have obscured real differences in treatment.

No statistically significant treatment effect (p-value=0.209).

Final Mean Total Biomass

- ❖ Only study species in which biochar negatively affected biomass accumulation.

- ❖ All biochar treatments were significantly less than the control group (p-value=0.00829).



Substrate chemistry

- Only significant treatment effects for media pH :
  - *Gaillardia* (p-value=0.0033)
    - Controls were higher than the 30% and 45% treatments
  - *Pinus* (p-value=0.02616).
    - Controls were higher than the 45% treatments
- No significant effects on media EC for any of the species.
- Very little variation between treatments and among species.

Watering Frequency

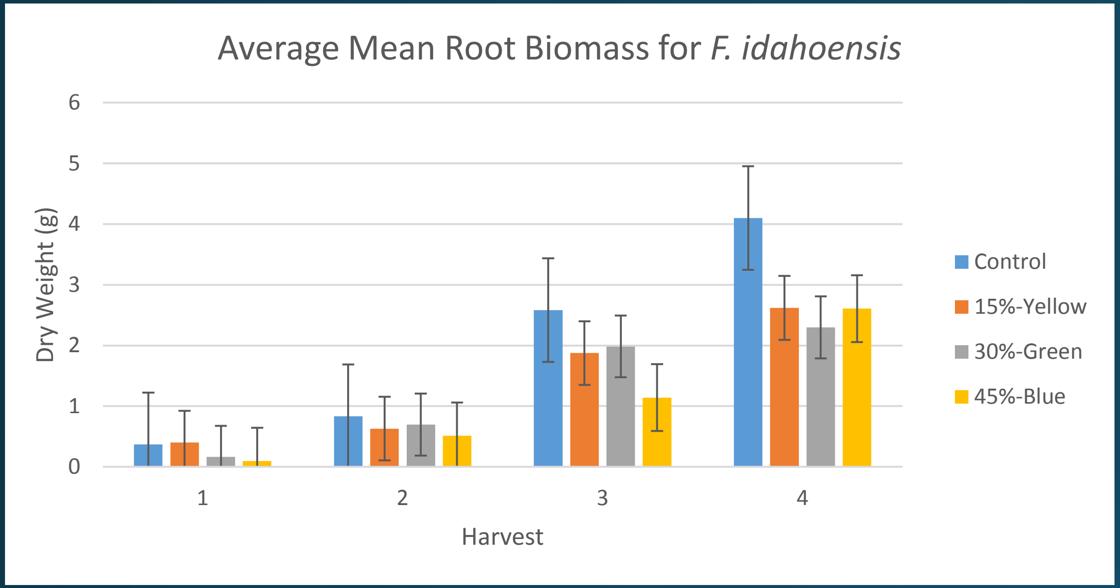
- As biochar amendments increased, watering frequency decreased.
- Potential explanation for pH (*Gaillardia* and *Pinus*) and growth results (*Festuca*).
- Suggests that biochar amended media could:
  - Reduce overall water use and associated labor costs
  - Seedlings could retain more water directly in the root zone after outplanting

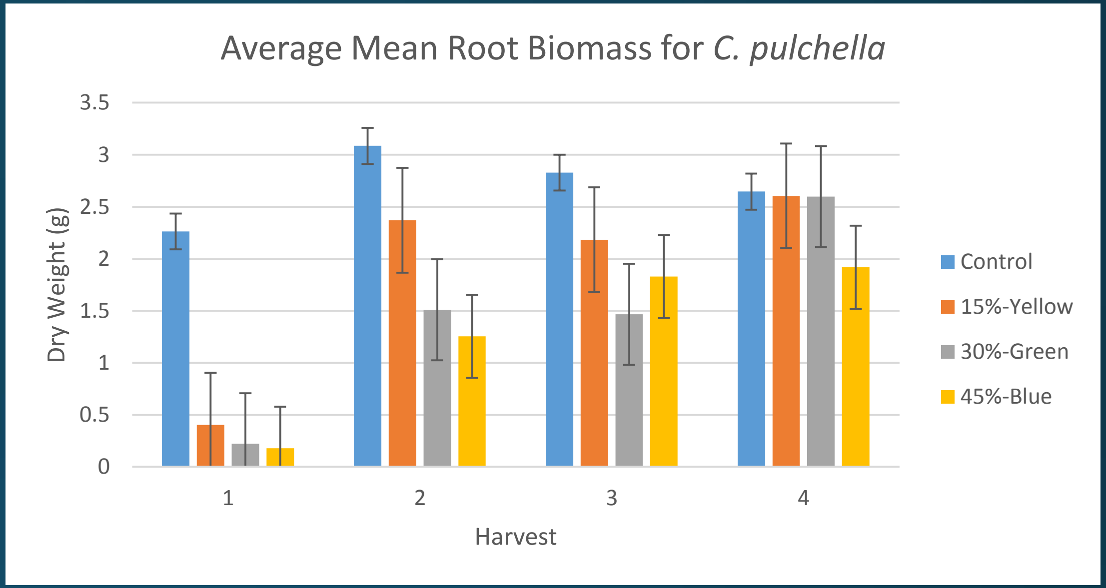
Biochar treatment	*Clarkia*	*Festuca*	*Gaillardia*	*Pinus*
Control	38	31	53	49
15%	36	26	51	44
30%	32	21	44	39
45%	27	20	41	37

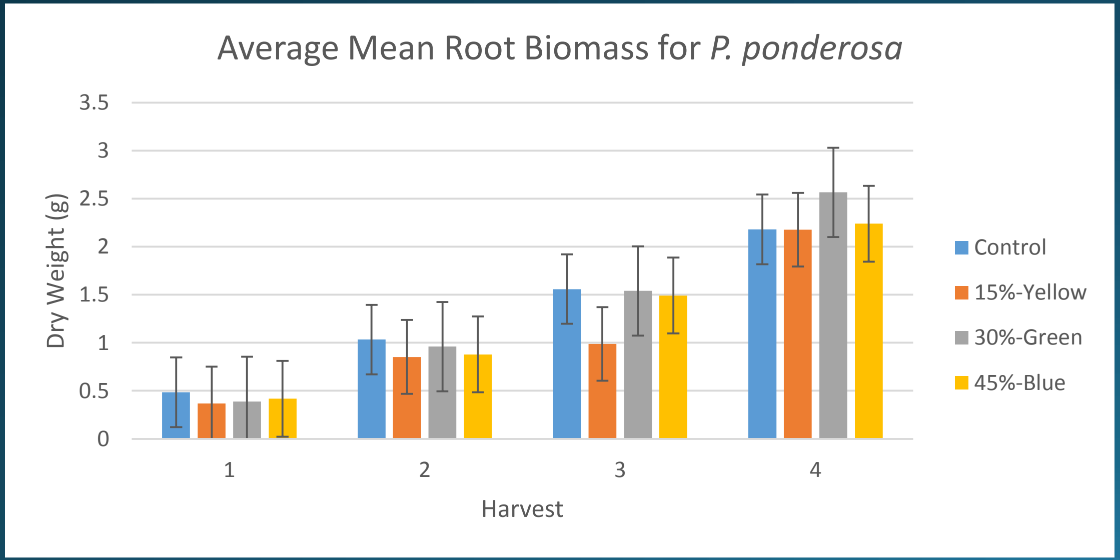
Nutrient concentrations

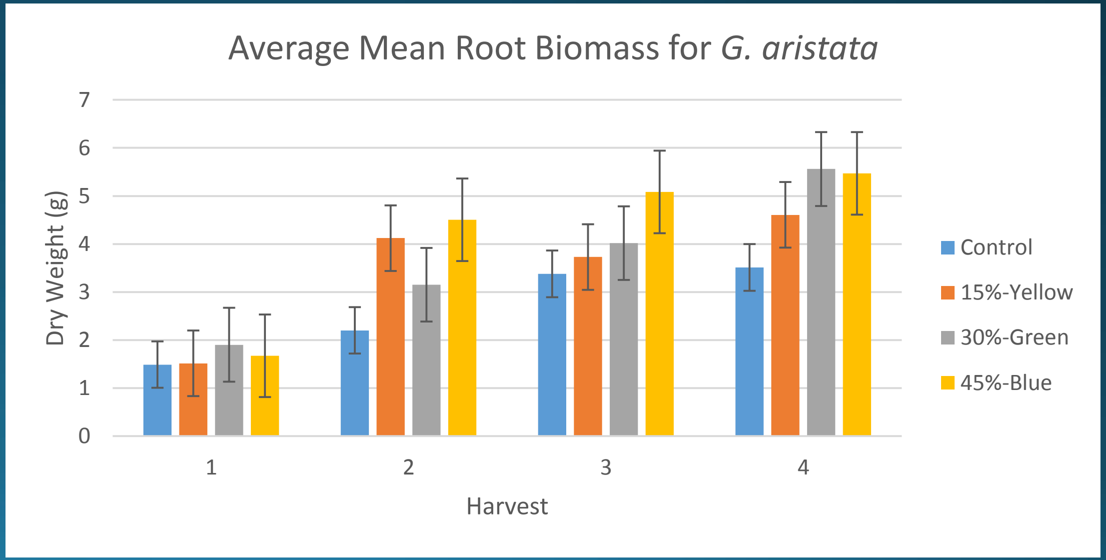
- In general, no treatment effect on plant tissue nutrient concentration.

Biochar effect on root growth



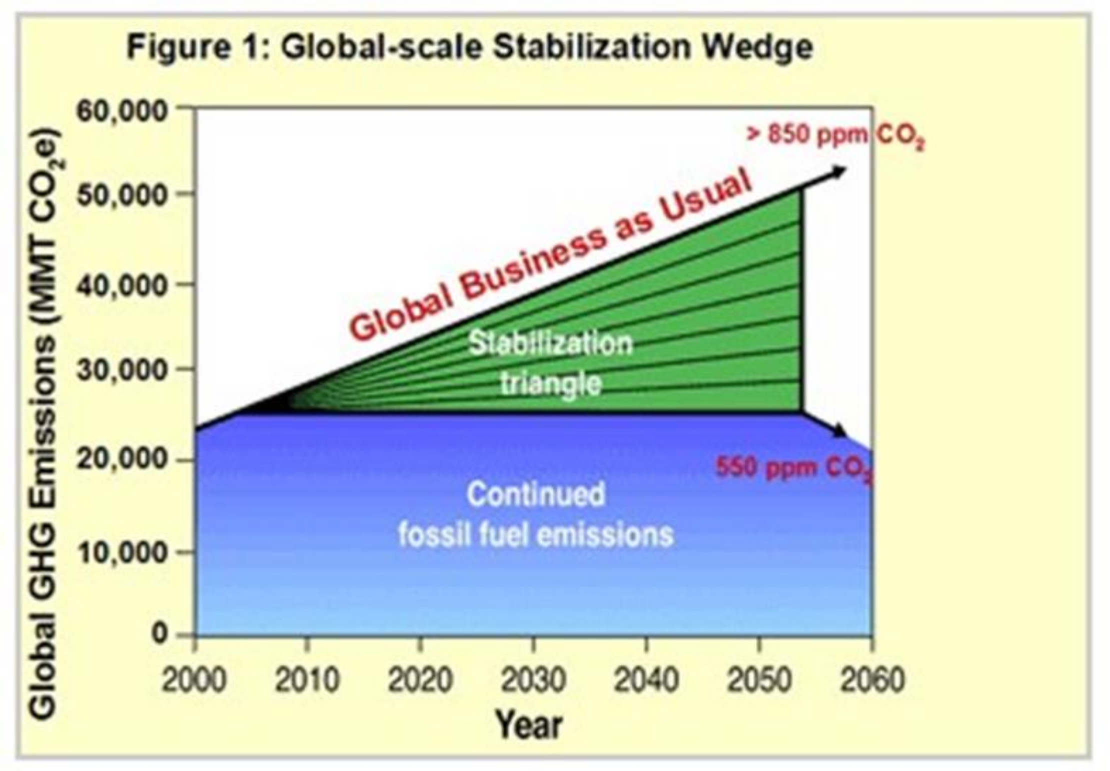






Why does biochar matter?

- Promote sustainability
  - Reduce peat use
  - Maximize nutrient use
- Biochar and climate change
  - Stability of C in soils
  - Biochar cycle
  - Stabilization wedge theory
- Bring value to biochar
  - Close the bioenergy loop



Pacala and Socolow. 2004. Science

Conclusions

- No "biochar effect" on plant growth
- No negative effects on plant growth for ¾ species.
- No detrimental effects on substrate pH and EC or plant tissue N, P ,and K.
- Can replace up to 45% of standard growing media with biochar!
  - C sequestration
  - Sustainability in container nursery practice

Literature Cited

- Caron, J., and L Rochefort. 2013. "Use of Peat in Growing Media: State of the Art on Industrial and Scientific Effort Envisioning Sustainability." Acta Horticulturae 982: 15–22.
- Graber, E.R., Y.M. Harel, M. Kolton, E. Cytryn, A. Silber, D.R. David, L. Tsechansky, M. Borenshtein, and Y. Elad. 2010. Biochar impact on development and productivity of pepper and tomato grown in fertigated soilless media. Plant Soil 337:481-496.
- Gundale, M.J. & DeLuca, T.H., 2006. Charcoal effects on soil solution chemistry and growth of Koeleria macrantha in the ponderosa pine/Douglas-fir ecosystem. *Biology and Fertility of Soils*, 43(3), pp.303–311. Available at: http://link.springer.com/10.1007/s00374-006-0106-5 [Accessed June 16, 2013].
- Liang, B. et al. 2006. Black Carbon Increases Cation Exchange Capacity in Soils. *Soil Sci. Soc. Am. J.* 70:1719-1730.
- Mao, J.D. et al., 2012. Abundant and stable char residues in soils: Implications for soil fertility and carbon sequestration. *Environmental Science and Technology*, 46(17), pp.9571–9576.
- Northup, J.I., and R. J. Gladon. "Biochar as a Replacement for Perlite in Greenhouse Soilless Substrates." *ProQuest Dissertations and Theses* Master of (2013): 65. Web.
- Pacala, S. & R. Socolow., 2004. Stabilization wedges: solving the climate problem for the next 50 years with current technologies. *Science (New York, N.Y.)*, 305(5686), pp.968–972.
- Tian, Y., X. Sun, S. Li, H. Wang, L. Wang, J. Cao, and L. Zhang. 2012. Biochar made from green waste as a peat substitute in growth media for Calathea rotundifola cv. Fasciata. Scientia Hort. 143:15-18.