Question: What is Biochar?

Answer: A wide range of products obtained through thermal conversion of biomass

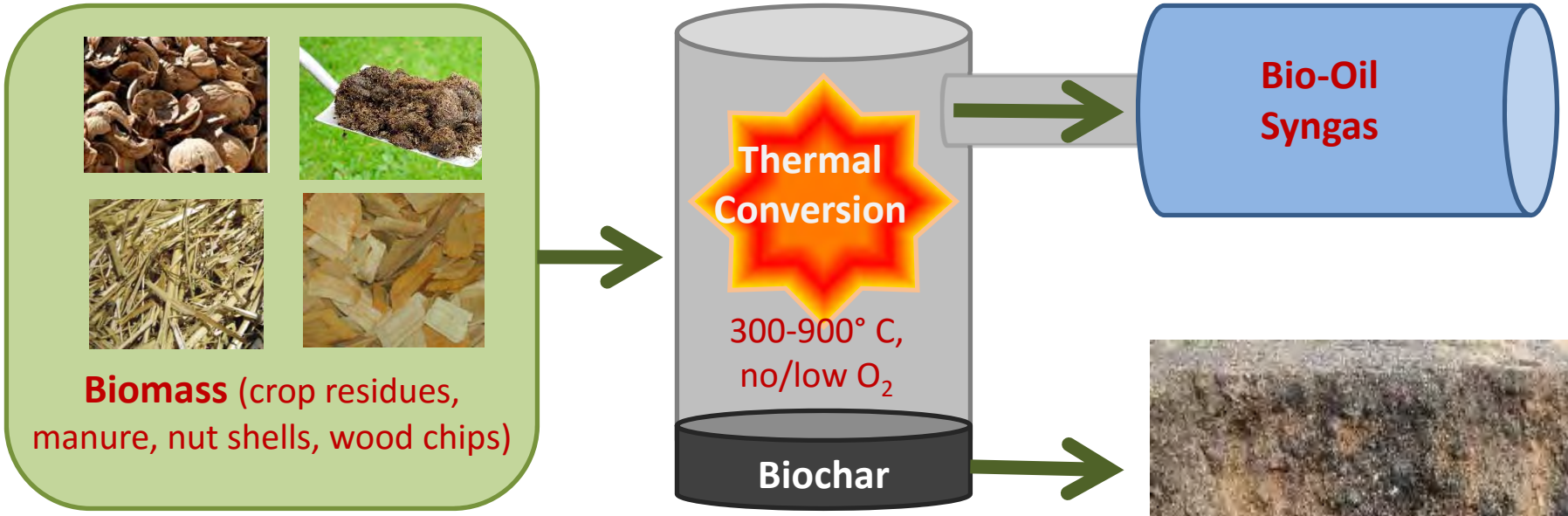
Sanjai J. Parikh

Department of Land, Air and Water Resources
sjparikh@ucdavis.edu --- biochar@ucdavis.edu

University of California – Davis

What are Biochars?

Biochars are charcoal products created from thermal conversion biomass in low/no oxygen, and are typically used as a soil amendment.



Biochar may be produced intentionally as a soil amendment or as a waste byproduct in the production of bioenergy.

Biochar properties are a function of feedstock material production parameters.

Why Biochar?

"Terra Preta de Indio" – Amazonian Black Earth

- Brazil and other parts of South America
- 500 to 2500 yrs B.P.
- Addition of charcoal (black carbon/biochar) for soil management
- Today, high organic matter content and more fertile
- Now have a wide range of agricultural and environmental applications

http://www.biochar-international.org/files/graphics/terra-preta.jpg

Potential Reasons to Use Biochar in Soil

- Carbon Sequestration
- Drought Resilience
- Soil Fertility
- Reduce Nutrient Leakage
- Crop Yield and Quality
- Greenhouse Gas Emissions
- Soil Remediation
- Soil Microbiology
- Raise soil pH

- Benefits inconsistent
- Multiple variables
- Some potential drawbacks
- Biochar is not a specific product → umbrella term

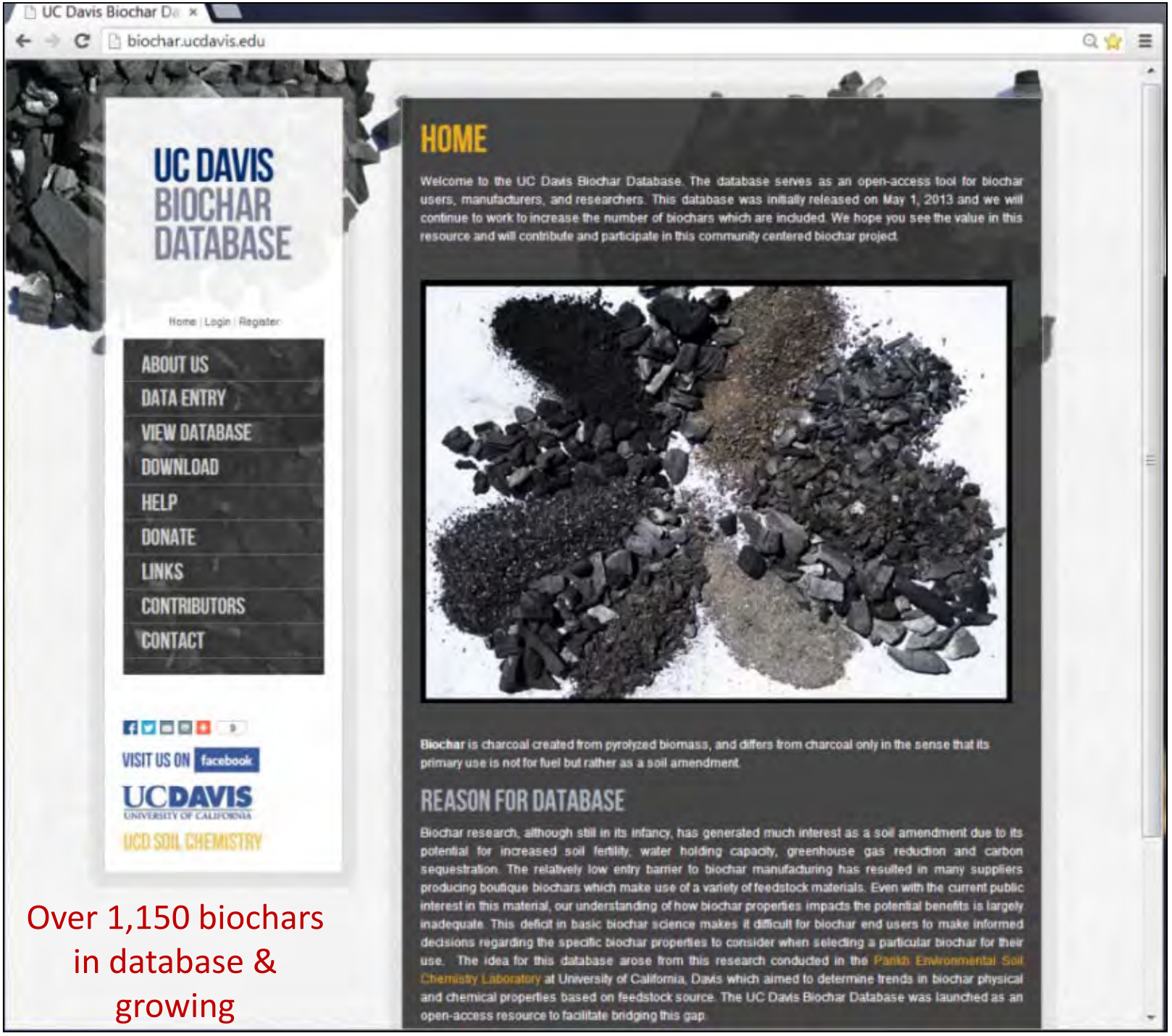
How do biochars differ?

Some Key Characteristics

- pH
- H/C ratio
- C/N ratio
- Porosity
- Elemental composition
- Surface area
- Ash content
- Cation exchange capacity (CEC)
- Water holding capacity

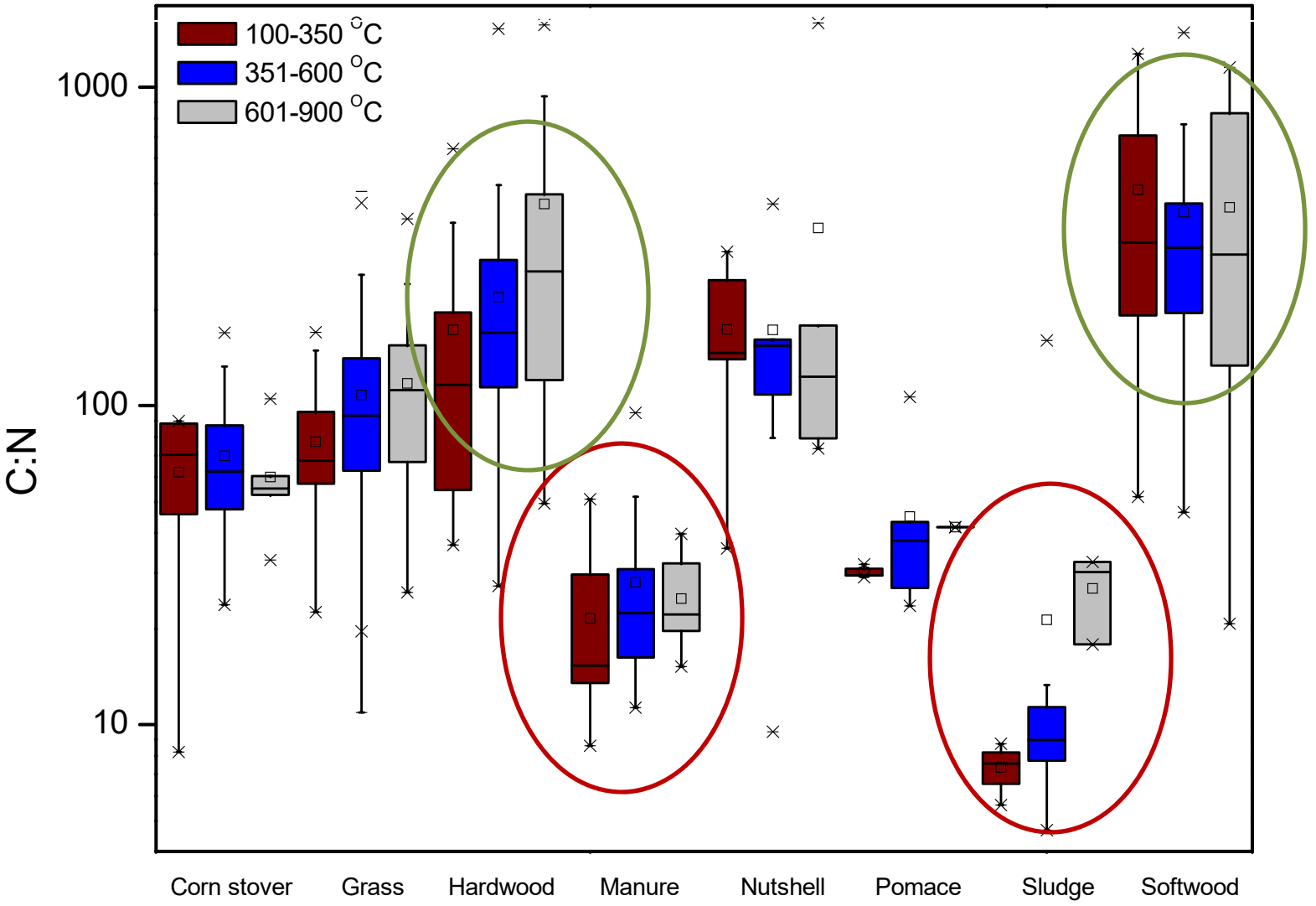
- function of production temperature, production method, residence time, and feedstock

biochar.ucdavis.edu



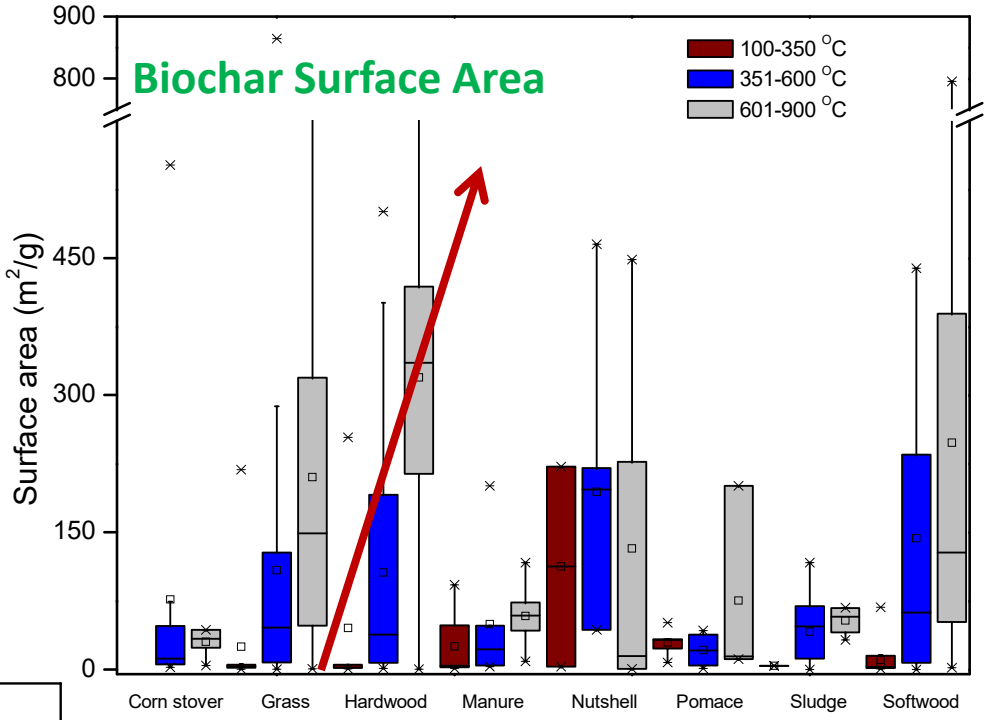
Over 1,150 biochars in database & growing

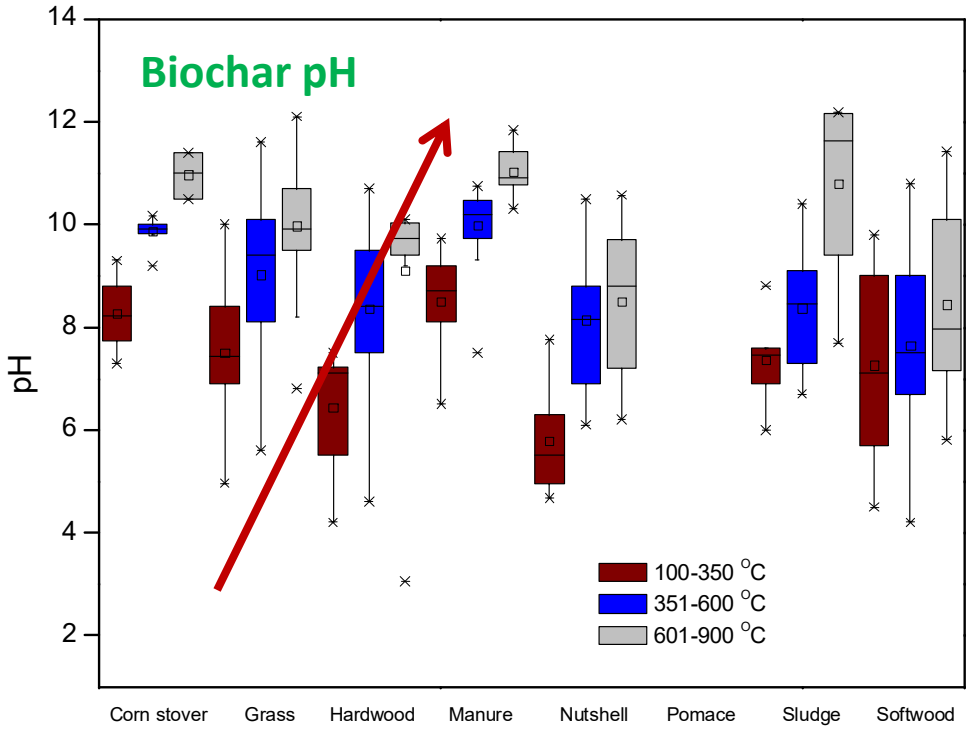
Feedstock Impacts



Data from The UC Davis Biochar Database: biochar.ucdavis.edu

Production Temperature Impacts





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Meta-analysis studies

"Biochar is not a single entity but rather spans a wide range of black carbon forms."

- **50% of studies show yield increases with biochar** (or black carbon)
  → *50% report decreases or no significant decreases*

- Agronomic benefits in degraded soils are often emphasized, negligible and negative results not given as much attention.

Spokas et al. 2012

Biochar does not always provide benefits.

We must determine the conditions for biochars, soils, and cropping systems where maximum benefits can be realized for a desired outcome.

- S… …il
  - …e
  - Range: -28% to +39%
- Greatest benefits:
  - Acidic soils: +14%
  - Neutral soils: +13%
  - Course texture: +10%
  - Medium texture: +13%

Biochar provides benefits when it can impact:
- pH ("liming"), porosity, nutrient availability

Jeffery et al. 2011

Biochar defined in California

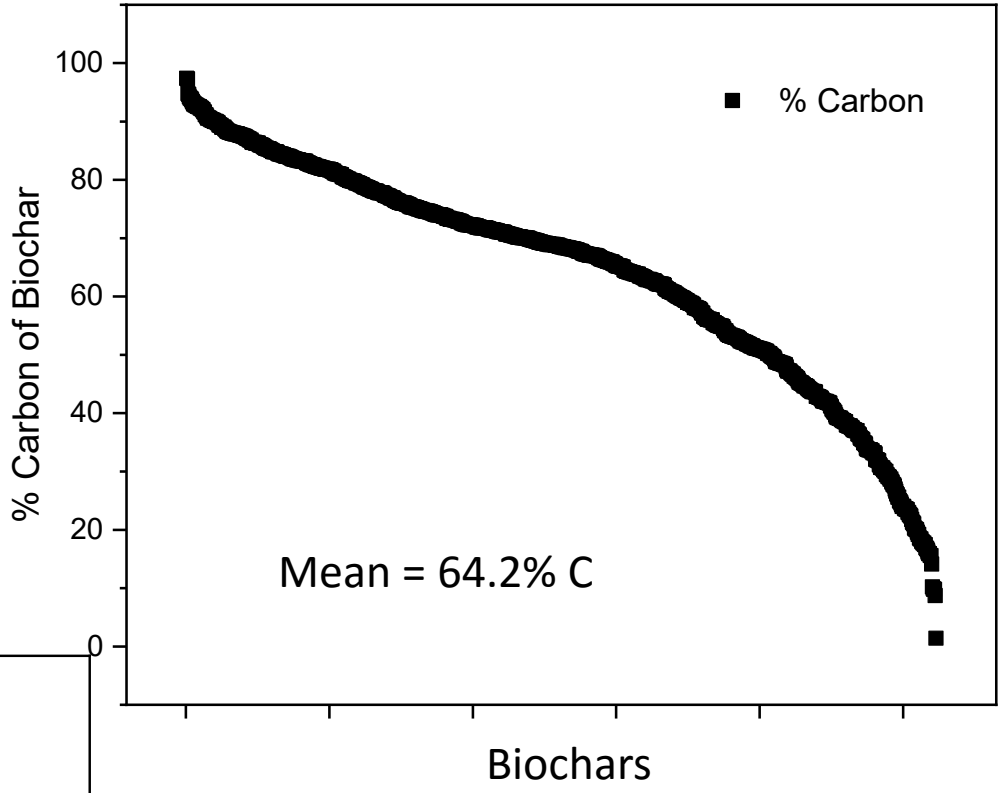
September 25, 2016

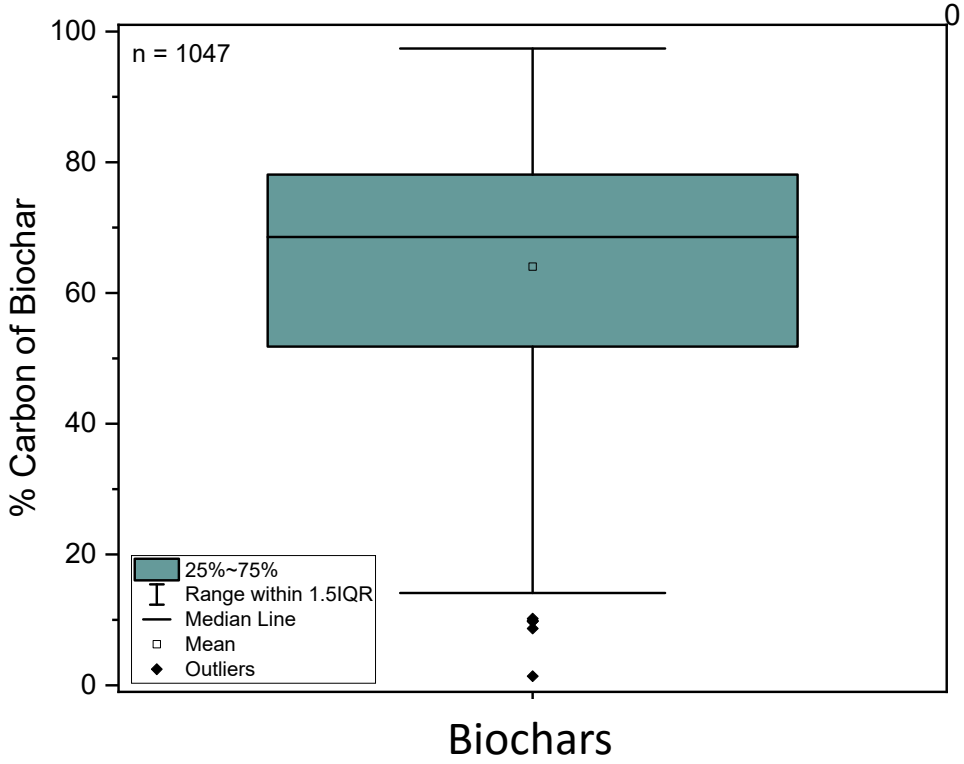
Governor Brown signs biochar legislation bill – AB2511

AB 2511: This bill clarifies that "biochar" is a soil amendment that is included in the definition of "auxiliary soil and plant substance" and, therefore, subject to licensing and labeling laws, and defines "biochar" to mean materials derived from thermochemical conversion of biomass in an oxygen-limited environment containing at least 60 percent carbon.

Carbon content of "biochars" can vary greatly

Carb data from 1047 biochars collected from peer-reviewed publications.





Most biochars have ~52-78% C

Nearly half of all "biochars" do not meet the CA definition of biochar.

Data from The UC Davis Biochar Database: biochar.ucdavis.edu

Governor's Office of Planning & Research (OPR)

Biochar Research Advisory Group

Chairs: Sanjai J. Parikh (UC Davis), Amrith Gunasakara (CDFA)
Coordinated with: Michael Maguire (OPR)

Intended Purpose

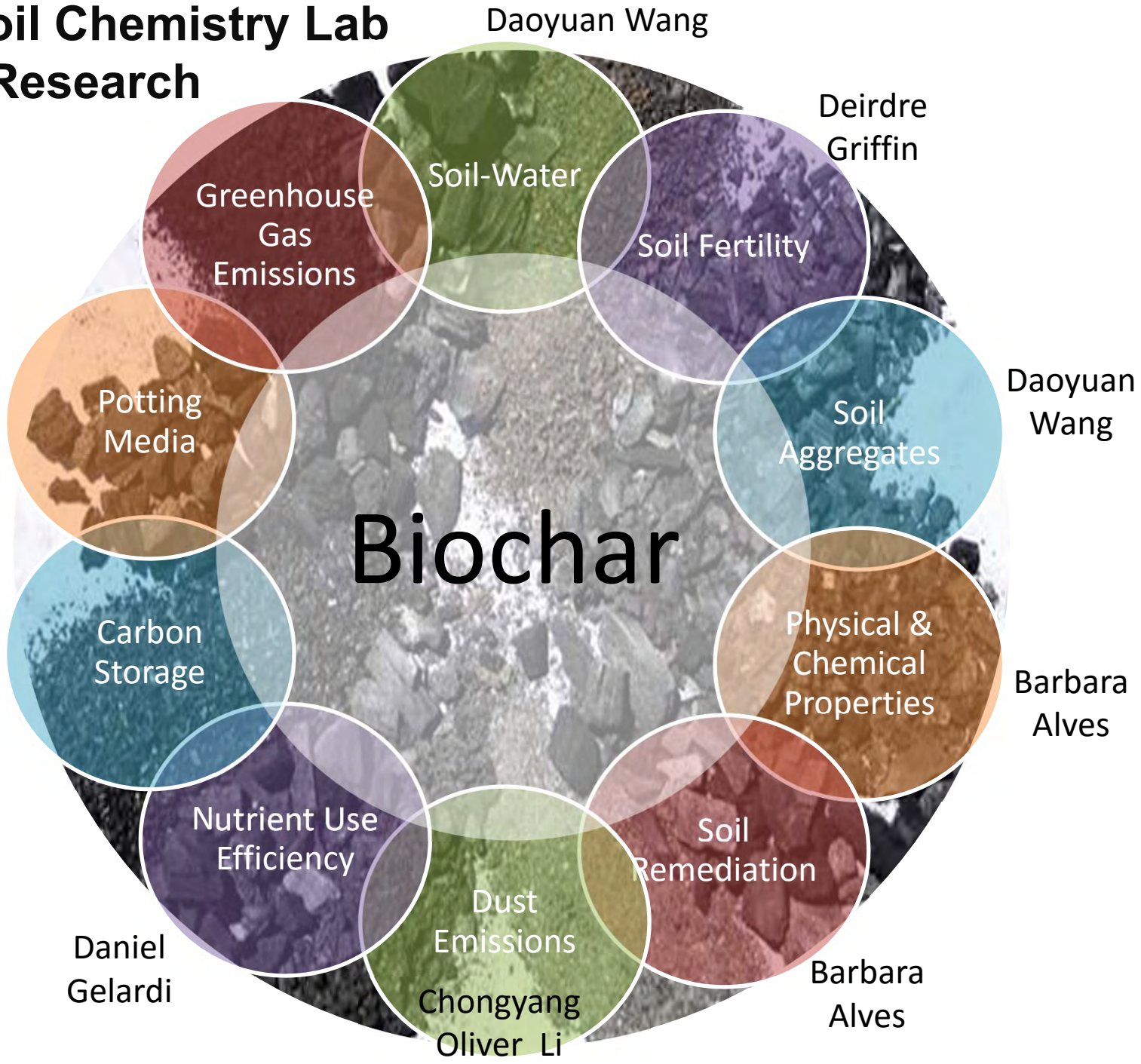
- Assist the state of California with identifying research gaps in the scientific literature, as they pertain to California specific environmental, economic, and regulatory conditions

Sanctioned by

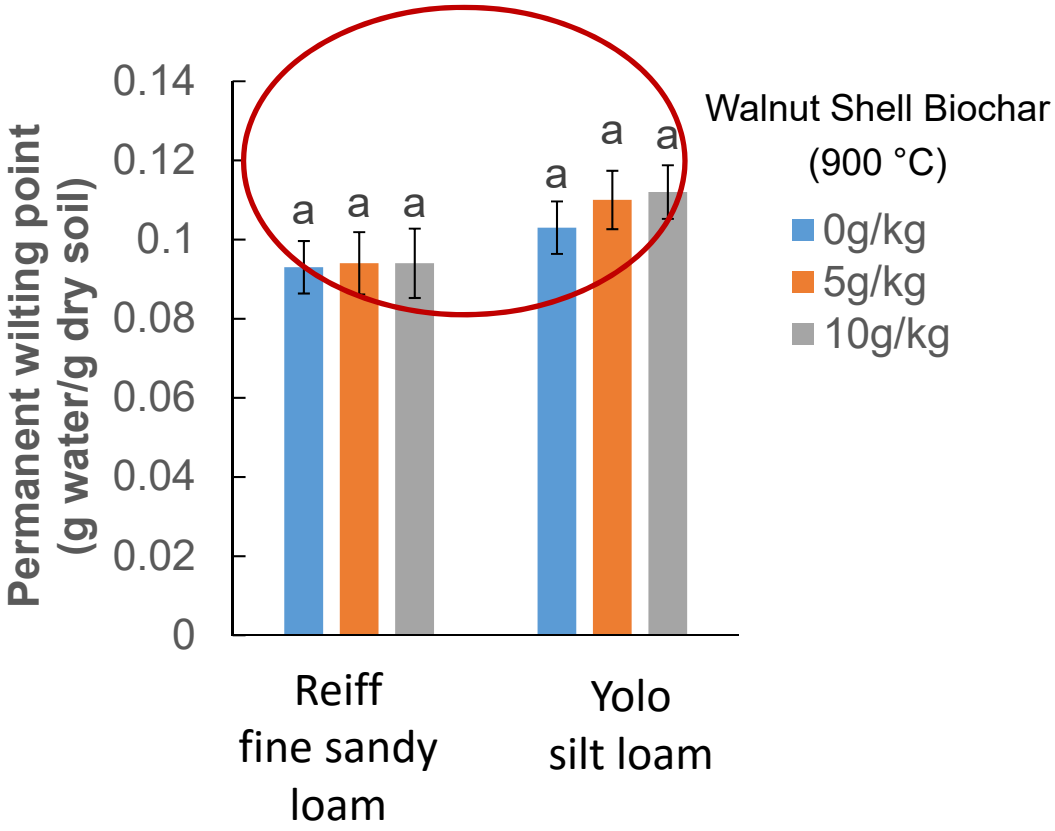
Participating state/federal government entities, academic institutions, and non-profits include, but are not limited to:

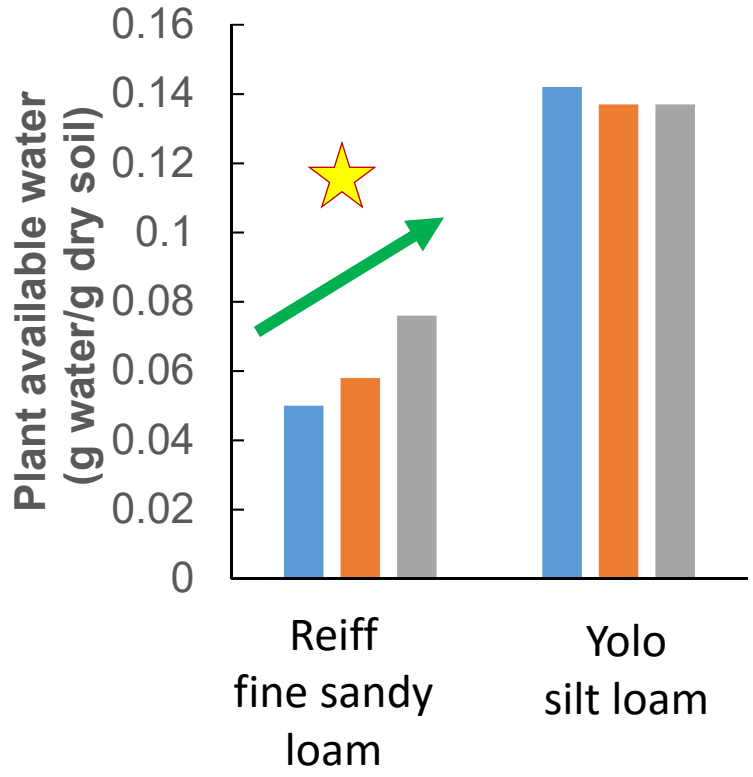
- Governor's Office of Planning and Research (OPR)
- Governor's Office of Business and Economic Development (Go-Biz)
- California Department of Food and Agriculture (CDFA)
- State Water Resources Control Board (SWRCB)
- California Energy Commission (CEC)
- California Natural Resources Agency (CNRA)
- California Department of Forestry and Fire Protection (CAL FIRE)
- Sierra Nevada Conservancy (SNC)
- California Association of Resource Conservation Districts (CARCD)
- California Department of Resources Recycling and Recovery (Cal Recycle)
- Air Resources Board (ARB)
- US Forest Service (USFS)
- University of California (Riverside, Merced, Davis, Cooperative Extension)

Parikh Soil Chemistry Lab
Biochar Research



Impact of Biochar on Soil Water





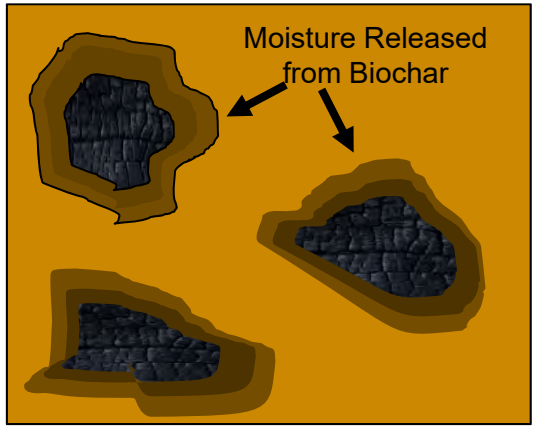
- *Wilting Point: no impact on permanent wilting point in either soil*
- *Plant Available Water: slight increase in the fine sandy loam*

Wang et al., in preparation

Can water within biochar become available as the bulk soil dries?

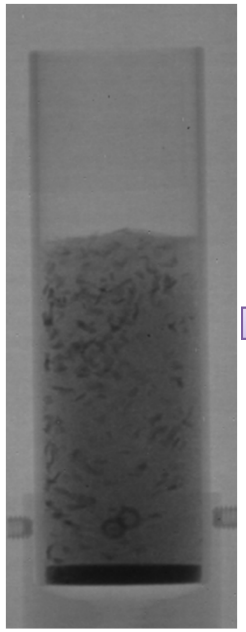
Biochar in wet soil

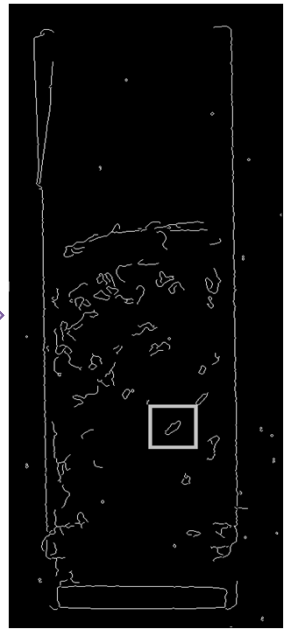
Drying



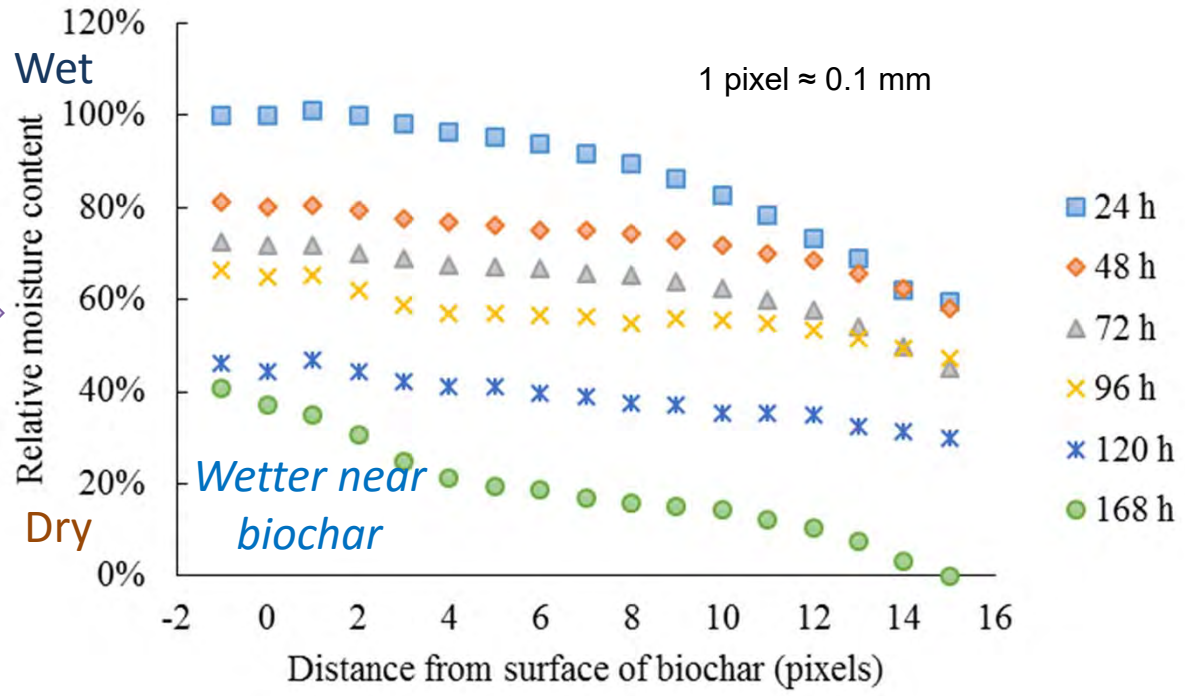
Biochar in dry soil

Moisture Distribution Around Biochar with Drying (7 days)





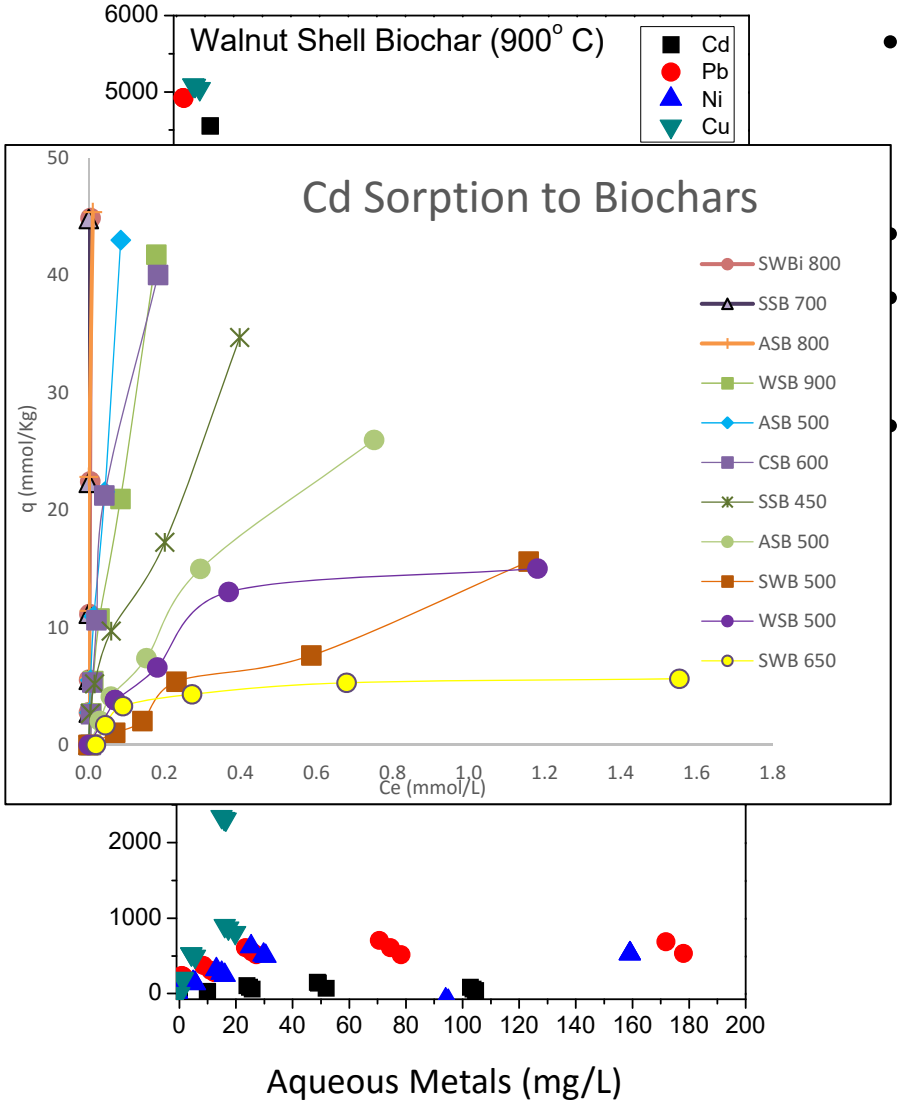
Neutron Imaging



Wang et al., in preparation

Reducing Heavy Metal Bioavailability

- Biochars have differing reactivity
- Walnut shell biochar binds more metals than pine wood biochar

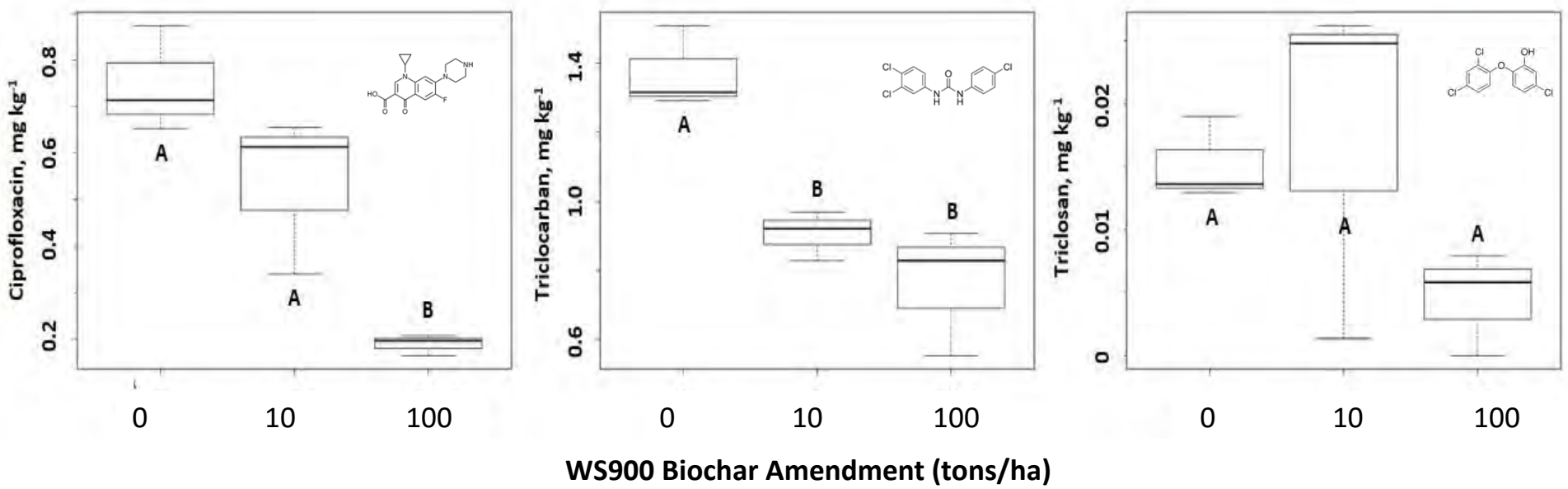


Bair et al JEQ, 2016

- California's Salinas Valley sits on the Monterey Shale formation and soils are enriched in Cd.
- Spinach is a Cd hyperaccumulator
- Management strategies to reduce Cd uptake are needed
- Currently examining >10 biochars

Plant uptake of pharmaceuticals from biosolid amended soils

- Screening of various biochars (e.g., softwood thermosequence) showed highest binding of selected pharmaceuticals to walnut shell biochar (900 °C)



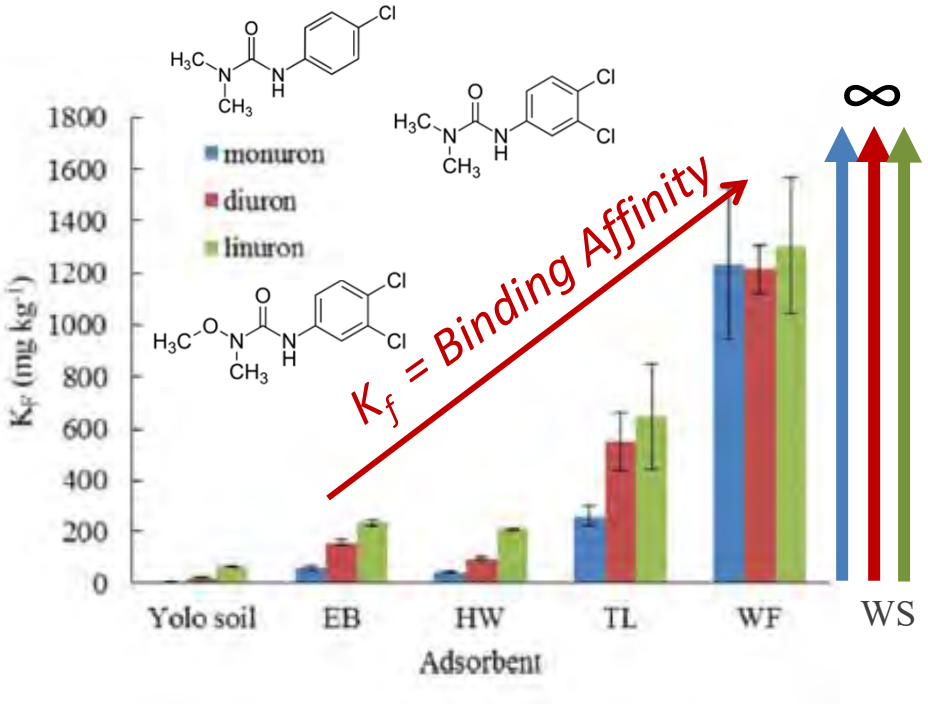
In many cases WS900 biochar reduced the plant uptake and/or translocation of applied pharmaceuticals

- Cipro: reduction in leaves (carrots and lettuce)
- TCC: reduction in leaves (carrots and lettuce) and roots (lettuce)
- TCS: reduction in roots (carrot)

Bair et al. In preparation

Could Biochar Reduce Pesticide Efficacy?

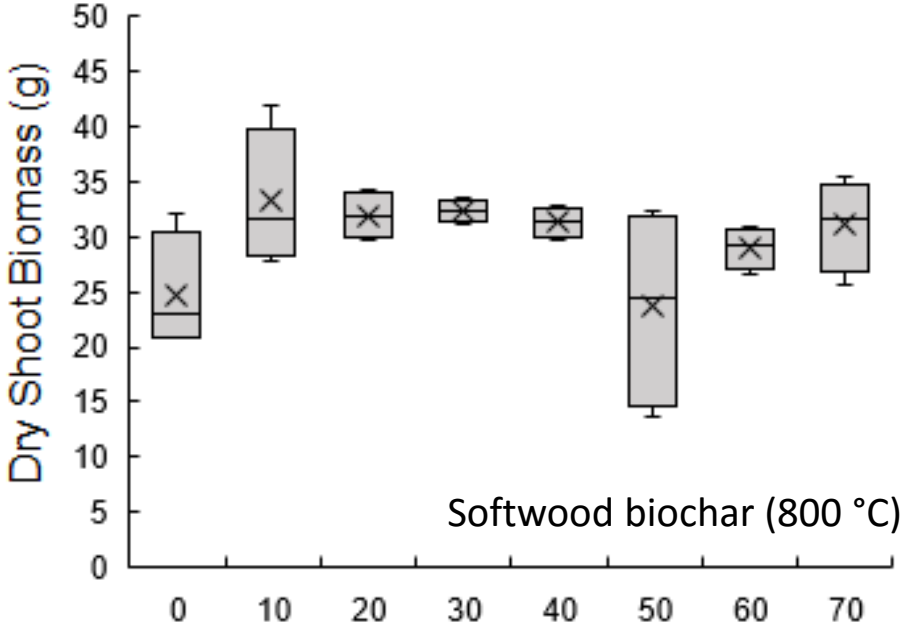
Freundlich binding constant (K_F)

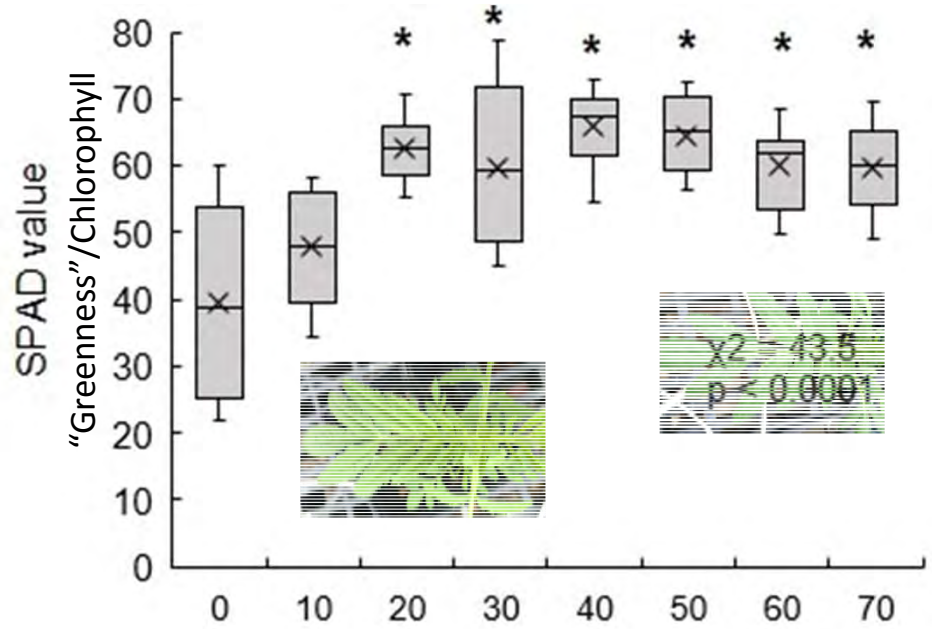


- *Varied affinity of herbicides for biochars*
- *Suggests biochar may reduce the efficacy of soil applied herbicides*
- *walnut shell biochar binding > soft wood > turkey litter > hog waste > wood/algal digest.*

Wang et al. 2015, J. Environ. Sci. Health

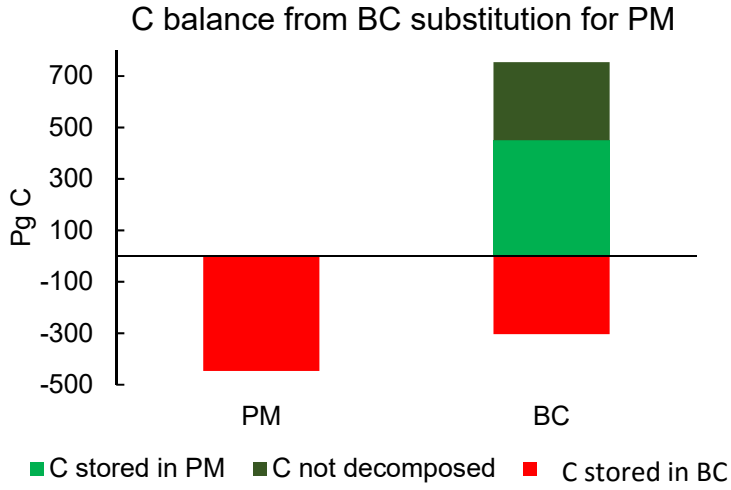
Can Biochar Replace Peat Moss it Potting Media?





% Biochar replacement of peat moss

In collaboration with Mike Woelk (Corigin) and Josiah Hunt (Pacific Biochar)



Assumptions:

Half-life ($t_{1/2}$):

- PM = 13.5 yr
- BC = 100 yr*

C content:

- PM 50%
- BC 68%
- 450 Pg C in global peatlands
- BC made from wastestream

*conservative estimate

Margenot et al.
Industrial Crops & Products. 2018




Biochars?

- variable product – not all the same or equal
- benefits can be real, but can also be highly variable
- will not *always* provide benefits
- benefits most likely when *optimized* for specific climate-soil-plant-cropping systems, AND an intended outcome
- knowledge base is rapidly growing
- additional information on physical, chemical, and biological *mechanisms* is needed

Biochars have potential to be part of "the solution"; a thoughtful, prescriptive, and prudent approach is most likely to yield consistent benefits

Acknowledgements

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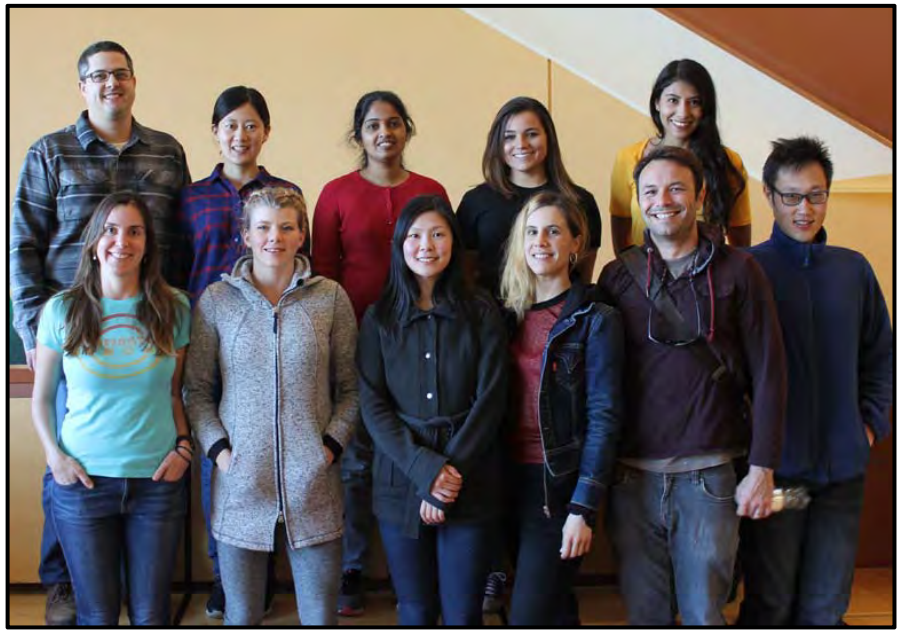

February 2018. Back row, left to right: Sanjai Parikh, Xiaoming Wan, Shalini Rajput, Natalie McElroy, Andrea Aguilera. Front Row: Barbara Alves, Mary Derting, Daniel Rath, Xiao Ma, Dani Gelardi, Devin Rippner, Chongyang Li. Missing: Deirdre Griffin, Daniel Rath

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