Effect of Feed Source and Pyrolysis Conditions on Properties of Sugarcane Bagasse Biochar

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Sugarcane & Bagasse

Estimated 885,000 acres of Sugarcane for sugar production in the US in 2017

Production of 26.873 million metric tons of sugarcane from 338,560 ha in TX, LA, FL

(Salassi et al., 2014. BioEnergy Research, 7:609)

Investment in new processing and harvesting equipment, adoption of new technologies, use of improved crop varieties and acreage expansion

The Leftovers That Linger

- Major by-products of crystalline sucrose manufacture from cane:
  - sugarcane bagasse, sugarcane molasses, filter mud (factory)
  - sugarcane extraneous leafy material (ag. residue)
- Fibrous bagasse is the most important by-product by volume
  - primary source of fuel - generation of steam and electricity to operate sugarcane factories
  - In LA, estimated 4 M tons produced, 15% (~ 0.7 M) tons surplus
  - Leafy residue can represent 13 tons/ac
- Commercially-viable value-added products:
  - animal feed, mulch, fuel, biochar, particle board, 2nd gen. biofuels

Pictures taken from: afdc.energy.gov; bioenergyconsult.com; tower.co.za; energy.agwired.com

Sugarcane & Bagasse

Sugarcane & Bagasse

Objectives

- Produce biochars sourced from both mill and field residues: fresh and aged sugarcane bagasse and sugarcane leafy trash
- Biochars were produced at various pyrolysis conditions and characterized for various properties
- Evaluate sugarcane bagasse biochar as sorbent for removal of heavy metals

Collection of Samples - Detrasher System at Cora Texas

American Biocarbon LLC Dry Cleaning System
Co-Located at Cora Texas Factory, Louisiana

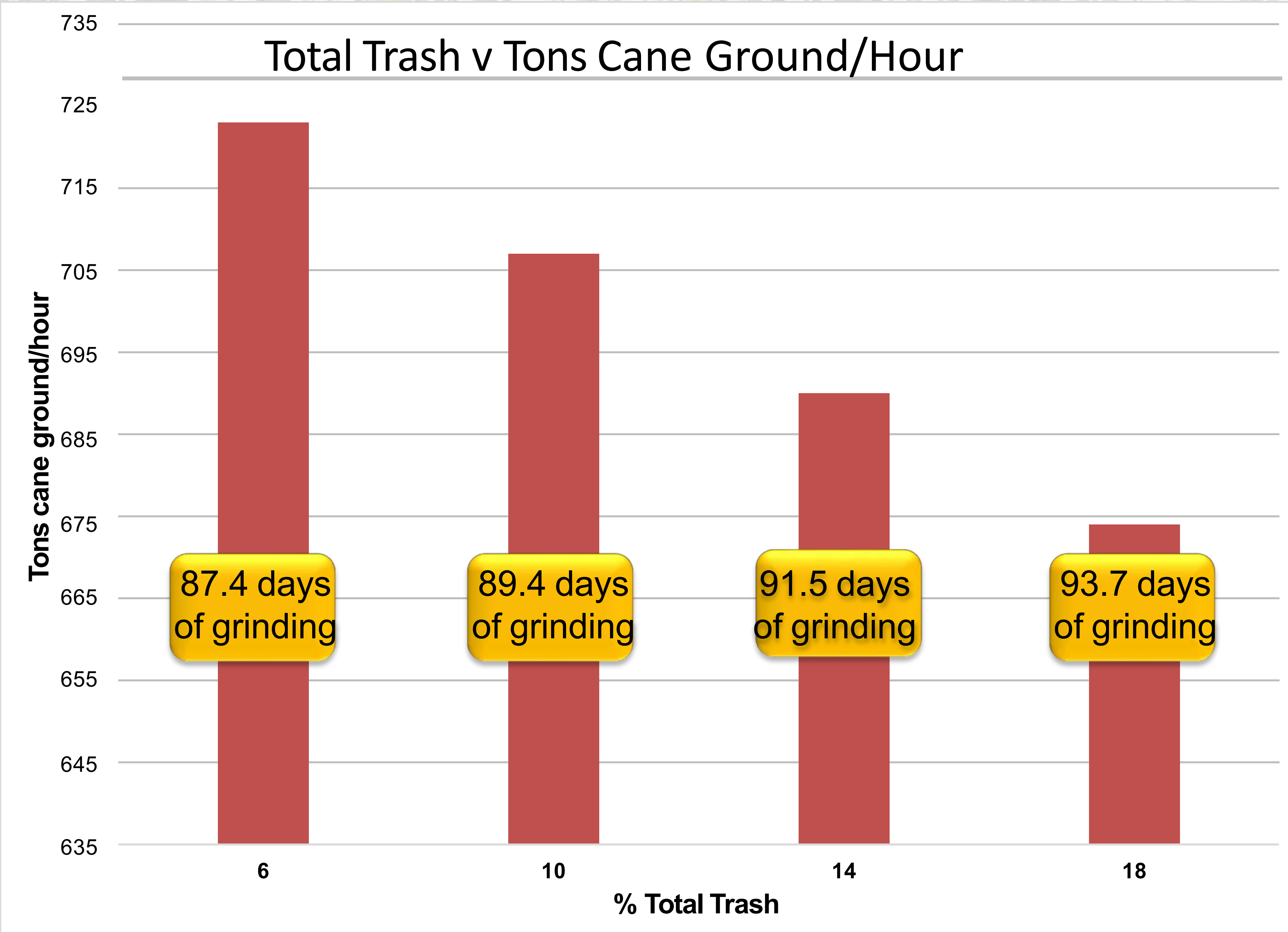
- Blown off sugarcane trash (leaves and tops) were utilized to manufacture **biochars**

Before the Detrasher

After the Detrasher

Approx. 2 min across Detrasher

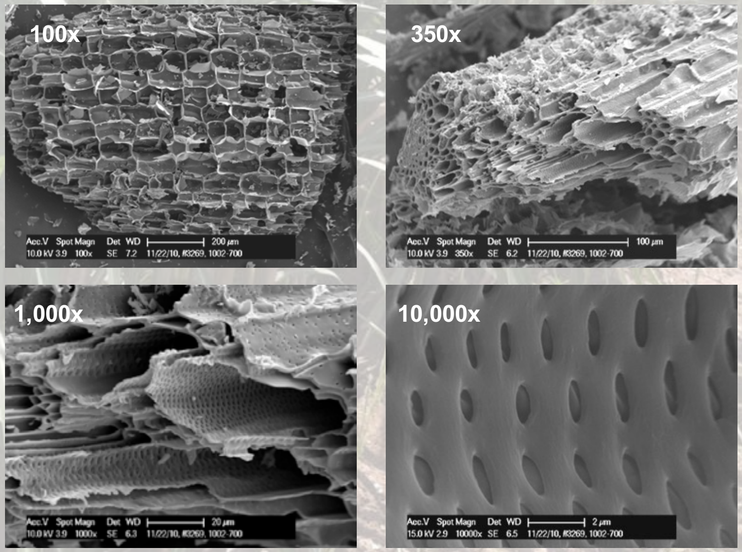
Before and After the Detrasher



- Based on 1,515,571 tons for 2016 season with zero downtime
- Approx 4 ton/hr increase in processing with every 1% decrease in trash

Excess bagasse and trash residue converted into biochar

4 M t bagasse; 13 t/ac leafy residue



Biochar Production

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Bagasse source (3): Fresh | Trash | Old

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Peak temperature (4): 350 500 650 800 ^{o}C

(6 ^{o}C min^{-1} ramp rate; 60 min at peak temp)

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(6 °C min^{-1} ramp rate; 60 min at peak temp)

Steam Activation (2): Activated, Not Activated

(DIW at 3mL min^{-1} for 45 min on UP N_2 flow)

Biochar Assays and Analysis

- Moisture
- Volatile matter
- Ash content
- Fixed carbon

(TGA701)

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Surface Area (total, external, micropore)
(Nova 2200 Surface Area Analyzer)

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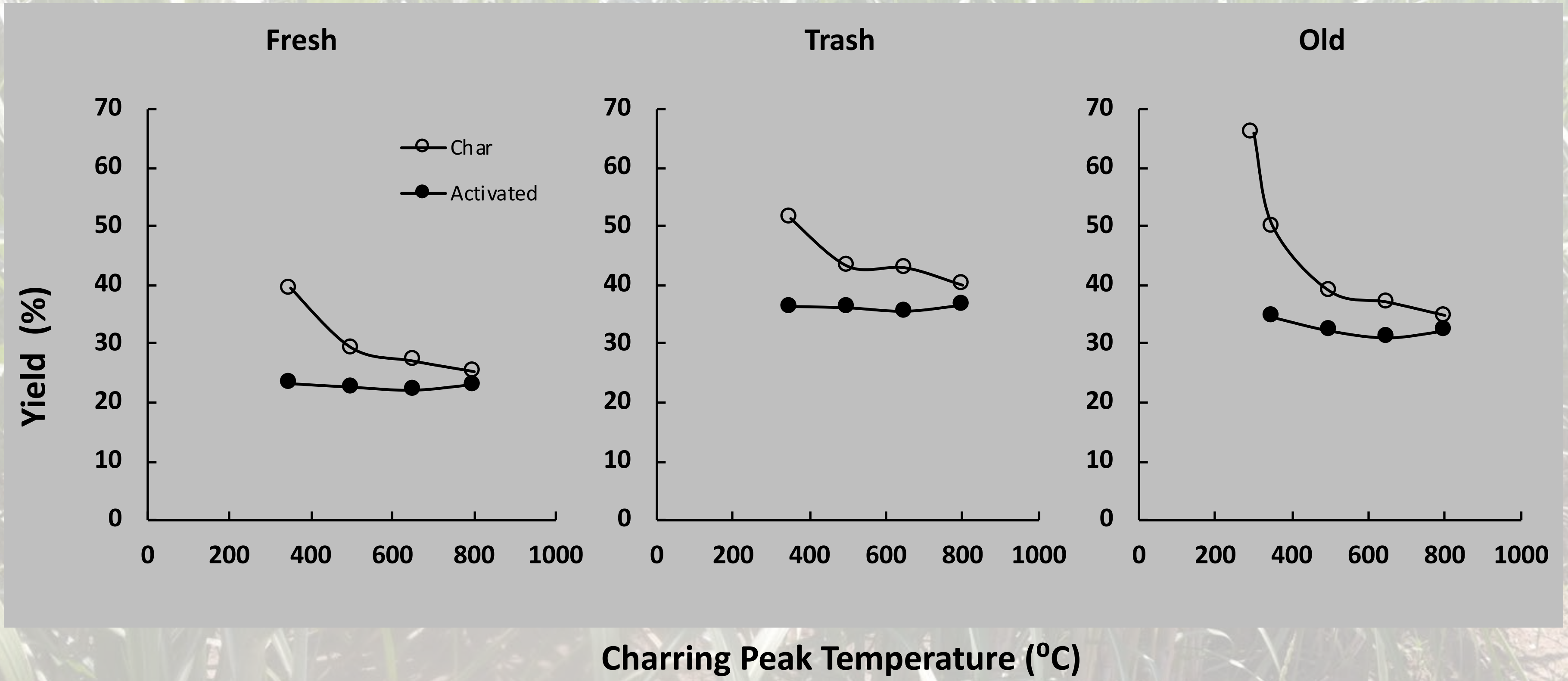
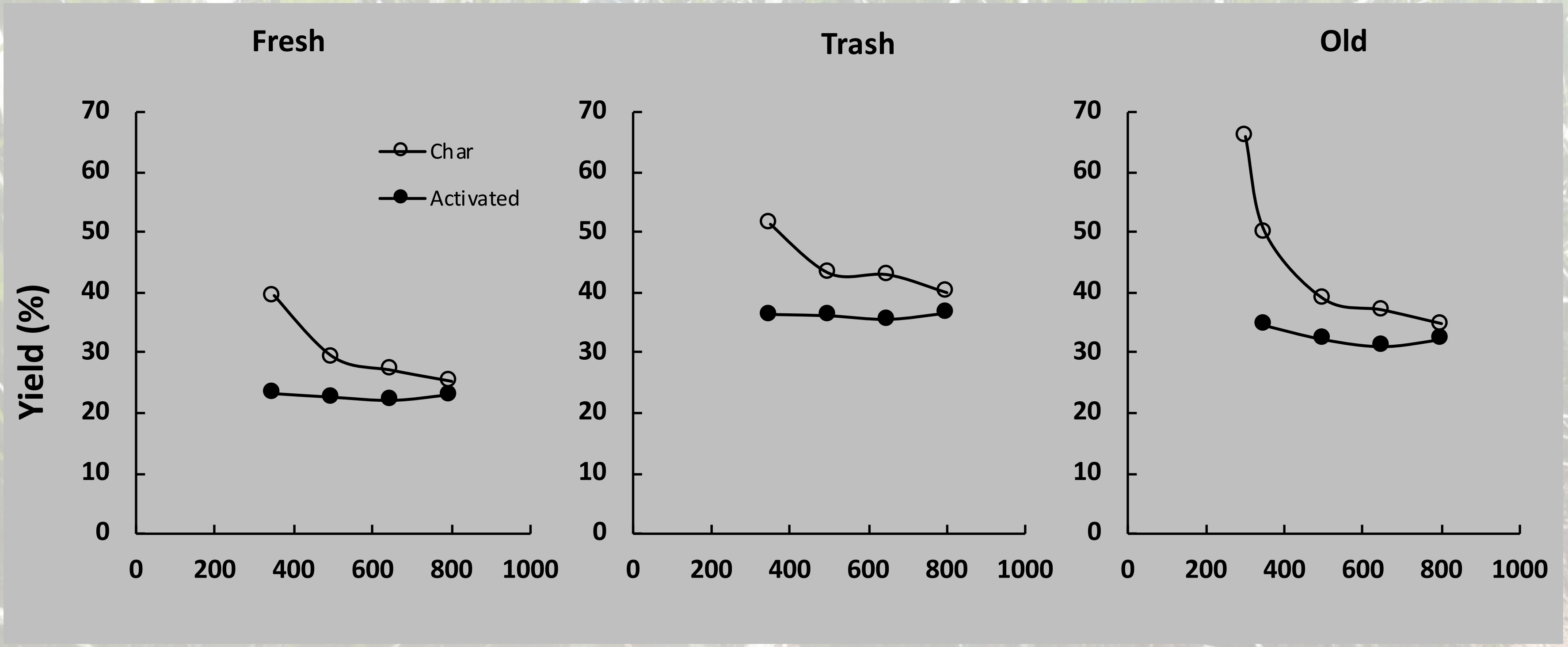
Sorption Isotherms for Cd, Cu, Pb
(0.25g at 1:100 solid:solution ratio, pH 5.0 buffer solution)

Biochar Yield



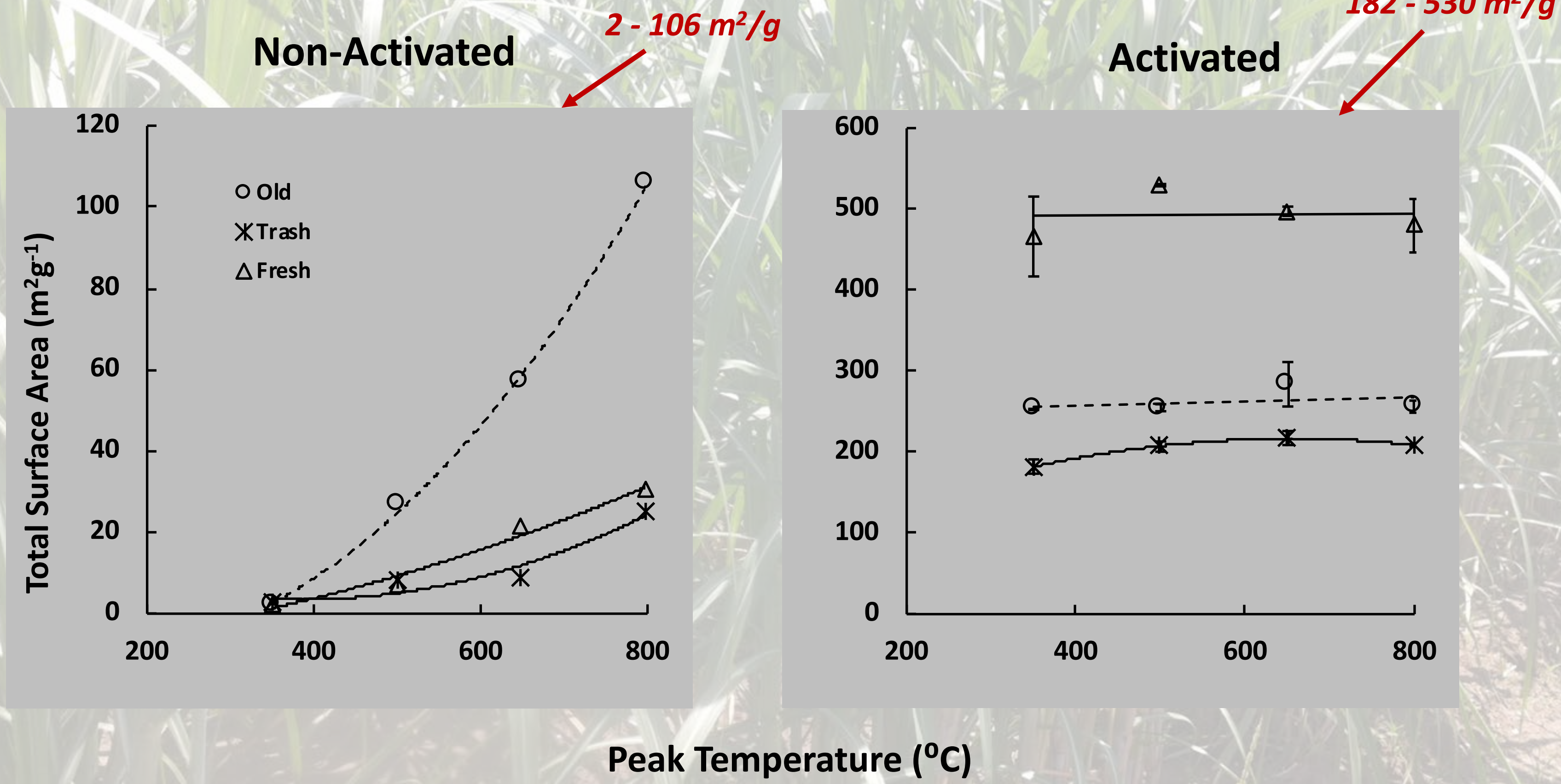
Biochar Yield



Charring Peak Temperature (^oC)

Trash ≈ ‘old’ > Fresh

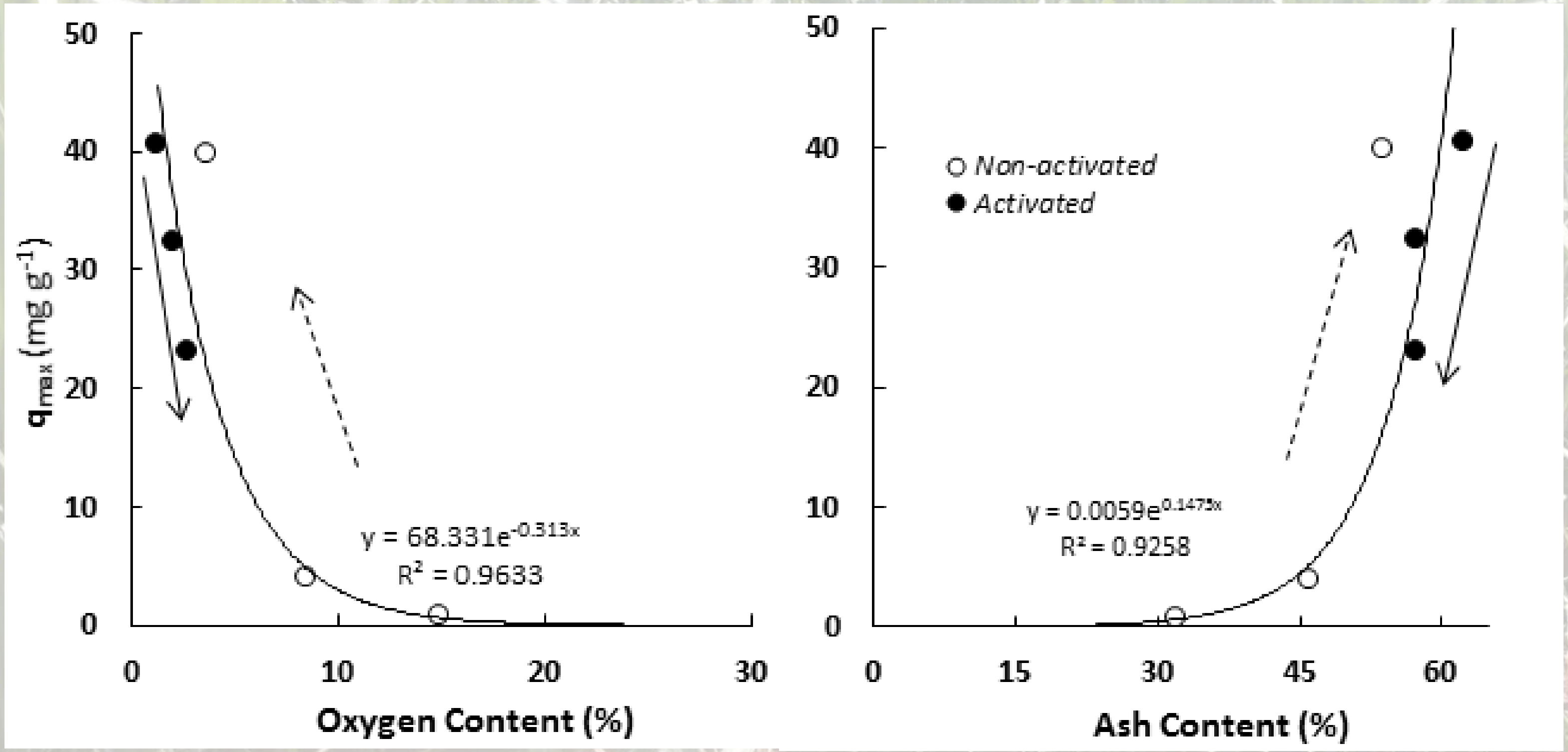
Biochar Surface Area



'Old' >> Fresh or Trash
(Temp. dependent)

Fresh >> Trash or 'old' bagasse

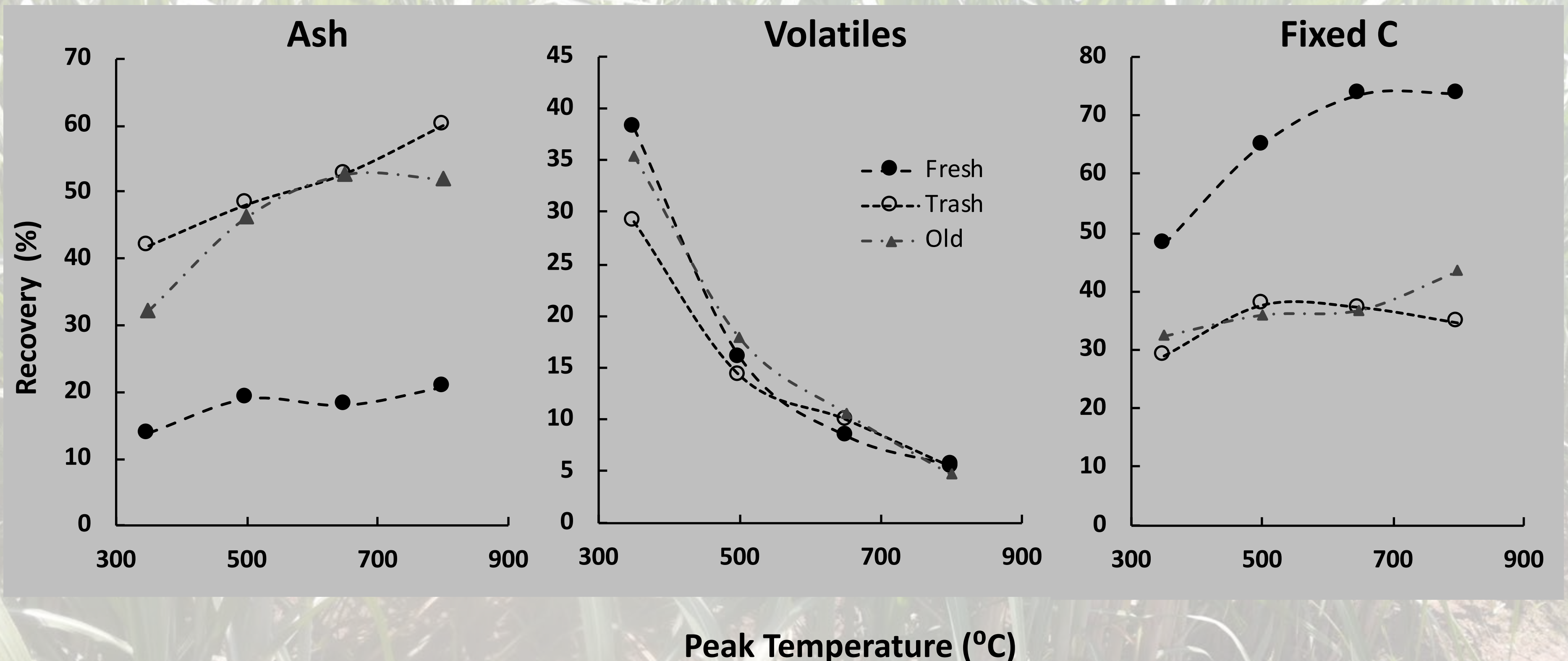
Adsorption



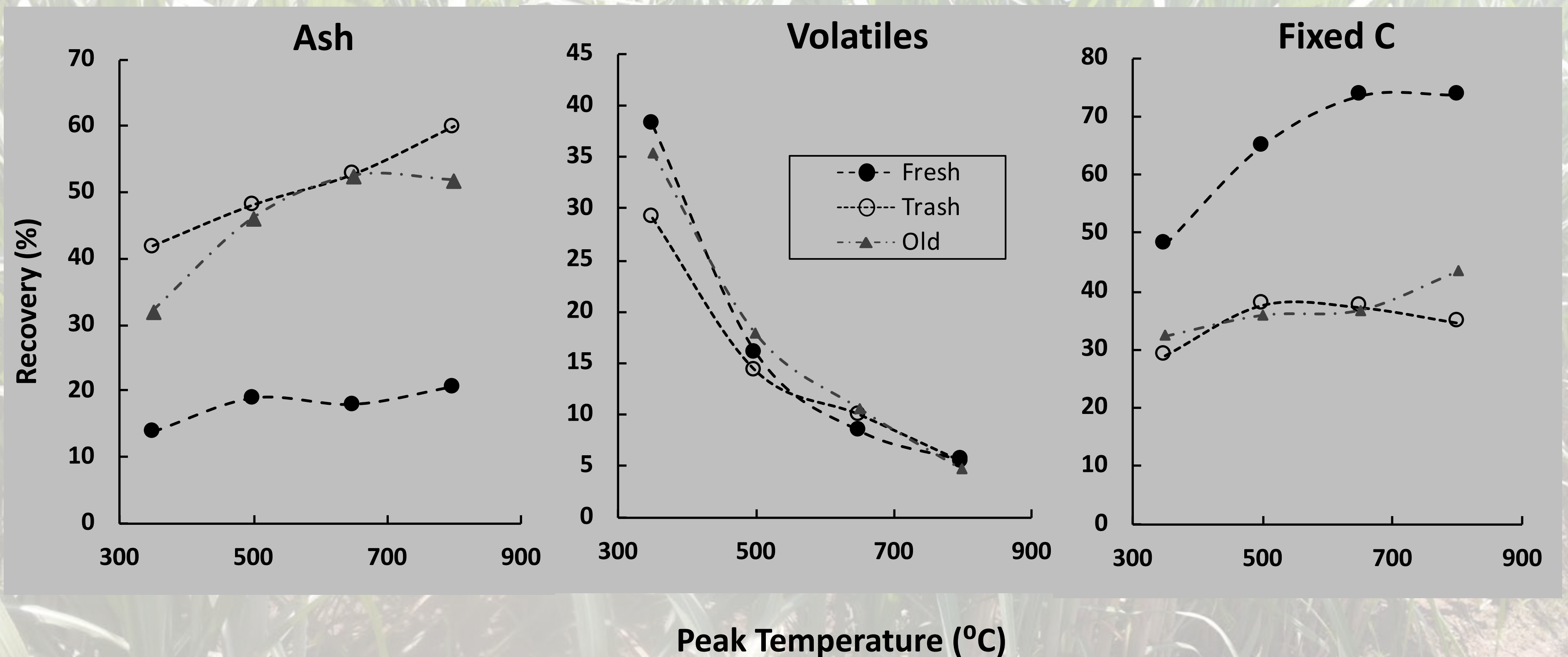
Cu sorption capacity (q_{max}) and oxygen and ash content of old bagasse biochars (arrows point to the direction of increase in pyrolysis temperature of activated [solid line], and non-activated [dissected line] biochars

solid regression line are exponential fit for all observations

Biochar TGA Analysis



Biochar TGA Analysis

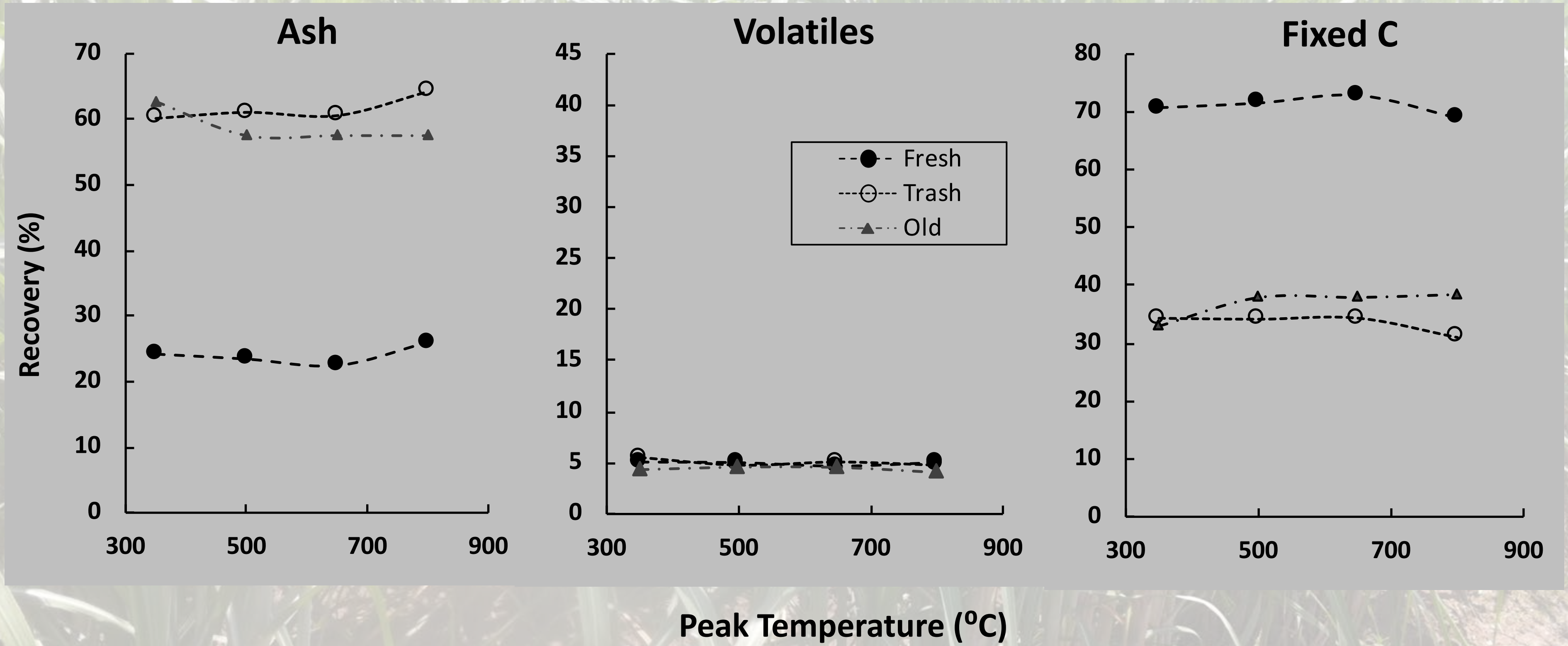


Trash ≈ 'old' >> Fresh

Trash ≈ 'old' ≈ Fresh

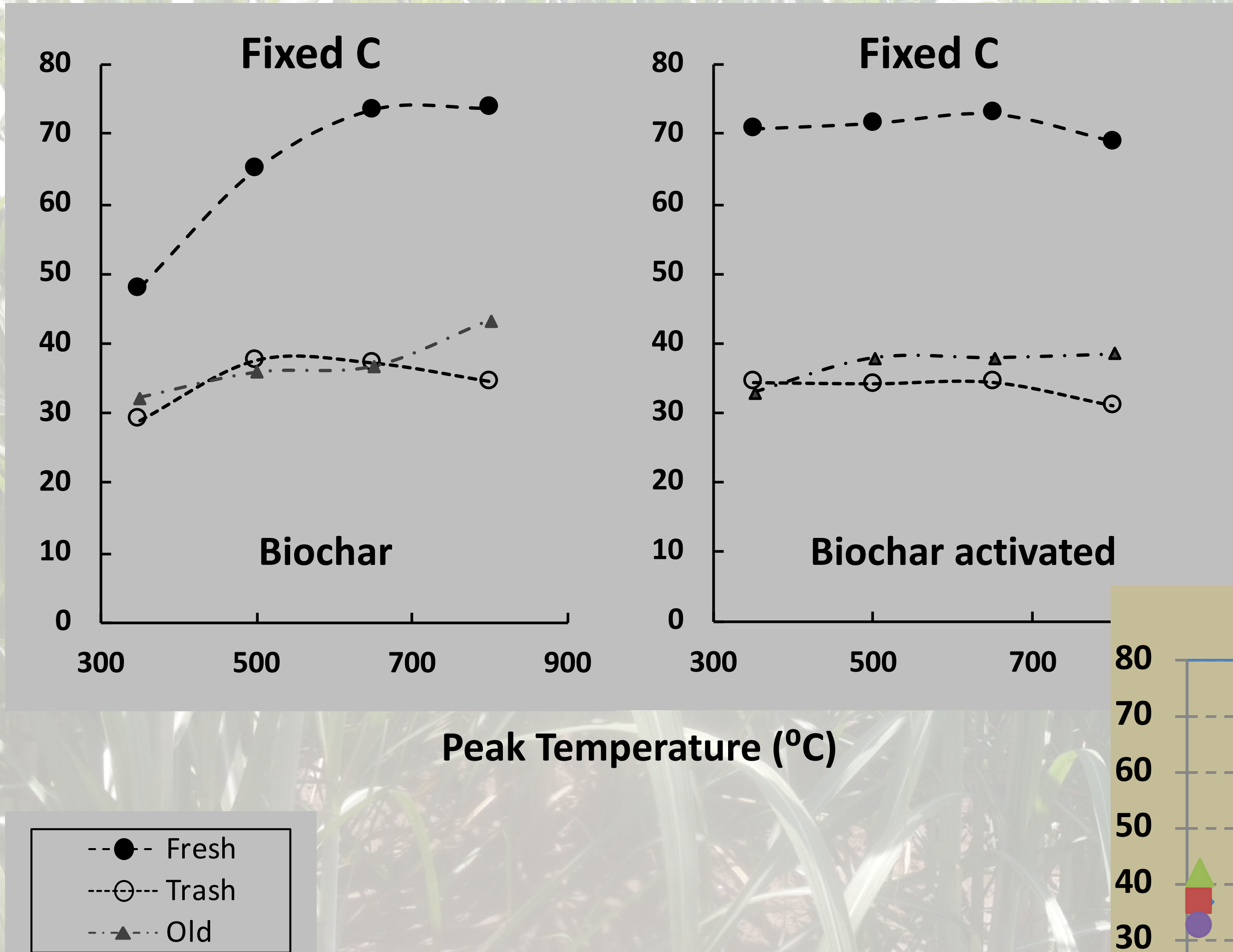
Fresh > Trash ≈ 'old'

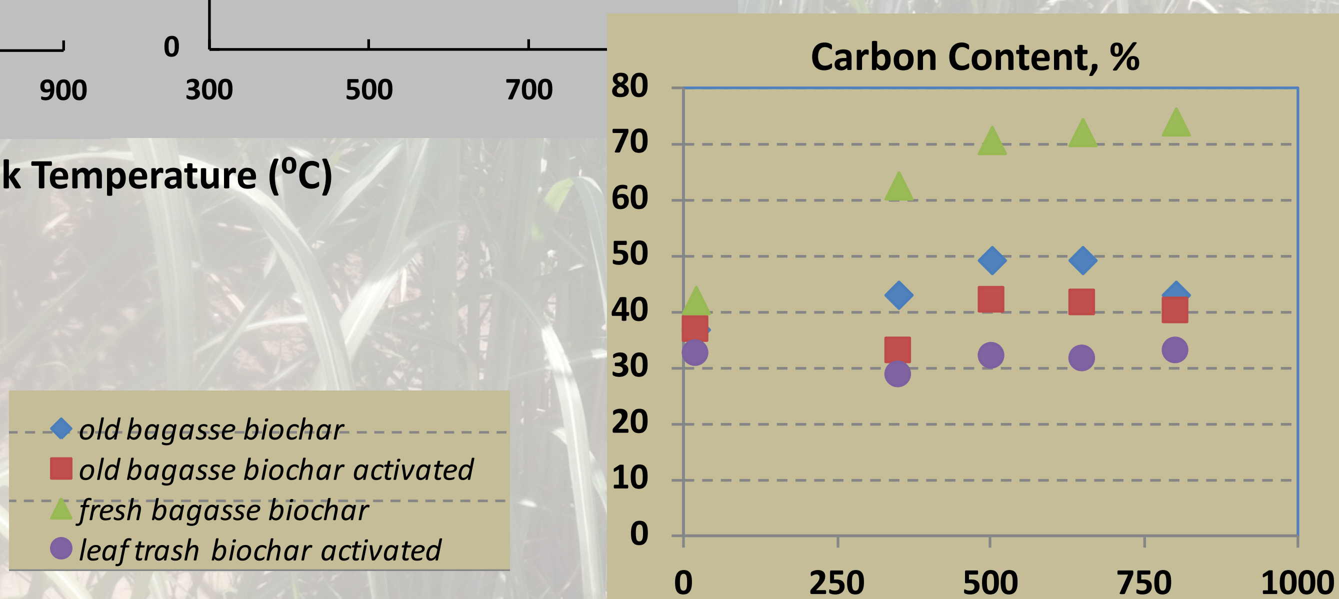
Activated Biochar TGA Analysis



Trash ≈ 'old' >> Fresh | **Trash ≈ 'old' ≈ Fresh** | **Fresh > Trash ≈ 'old'**

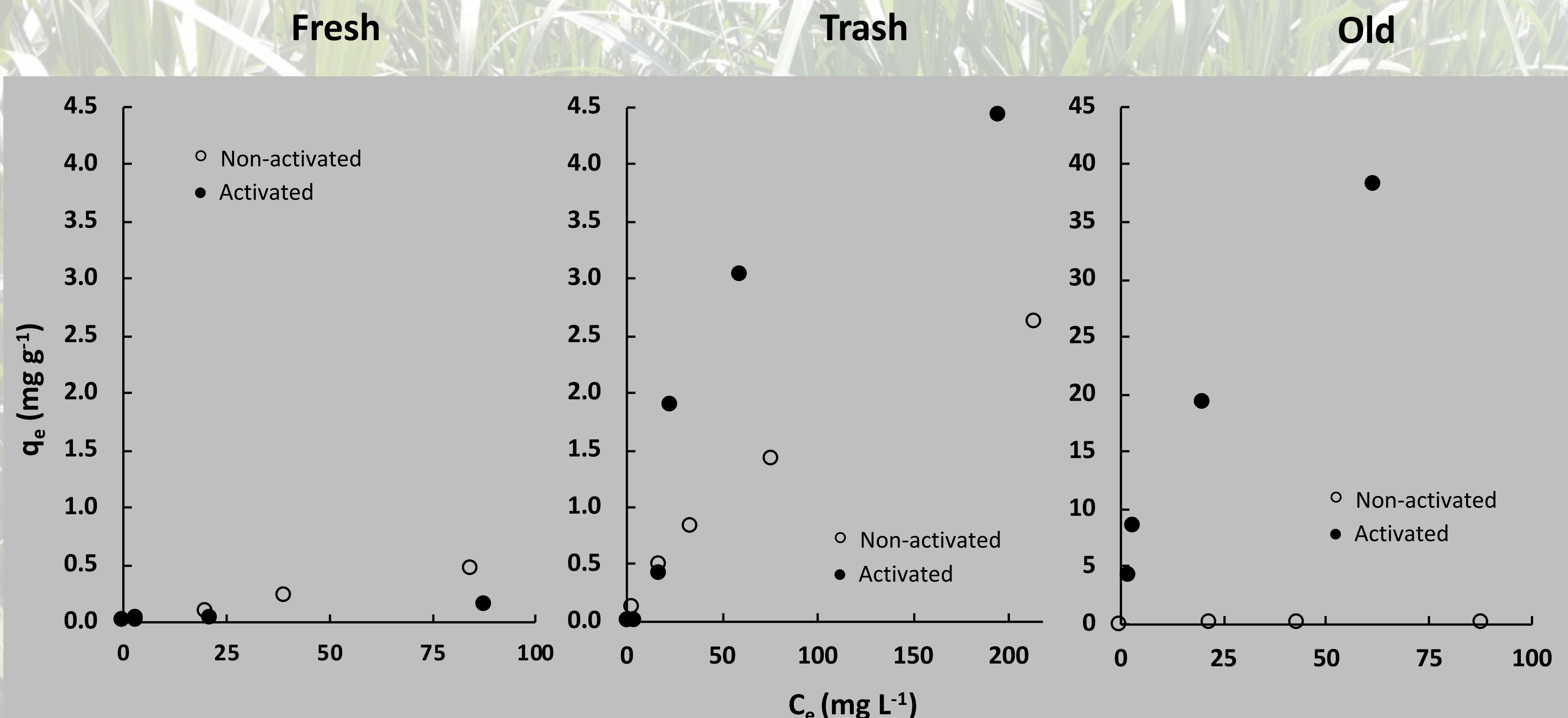
Biochar TGA Analysis





Cd Sorption

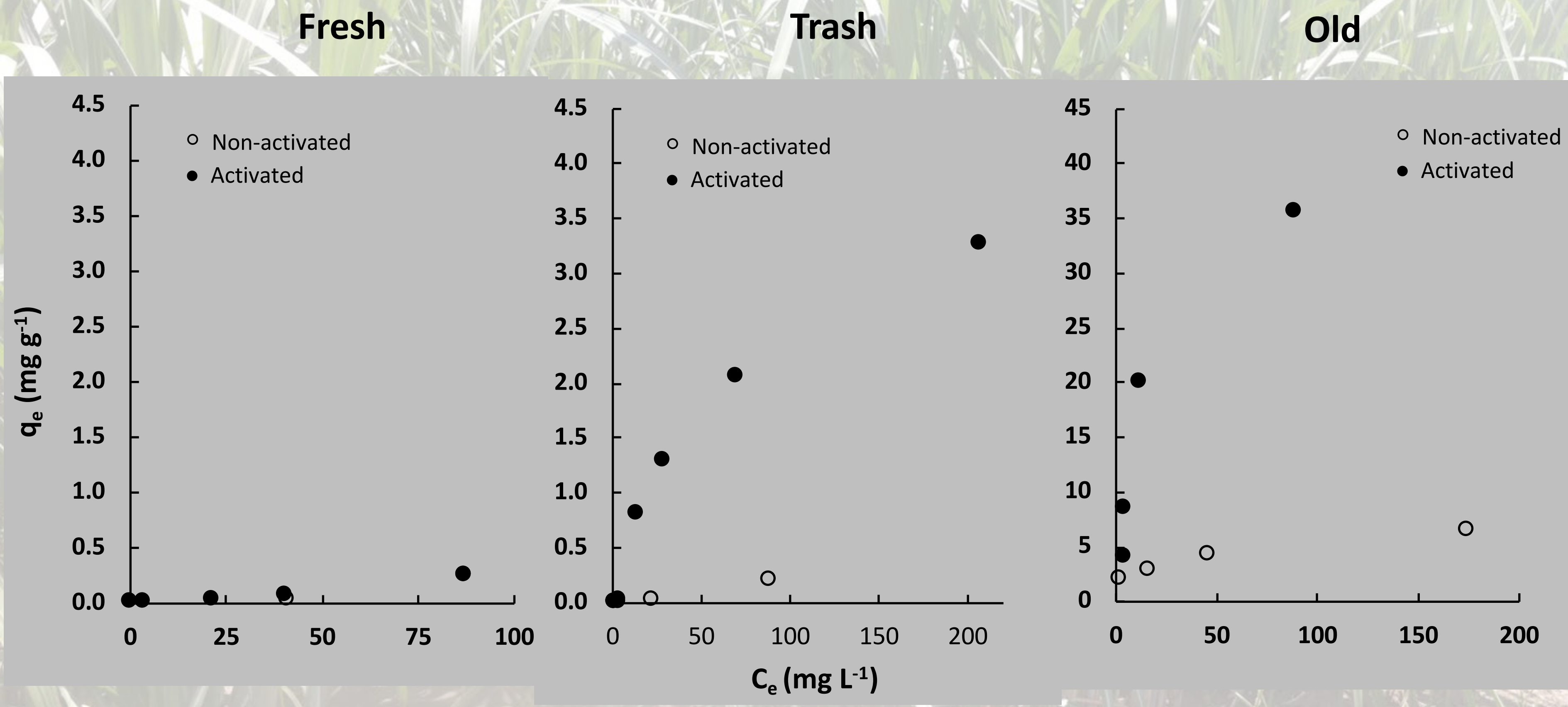
350 °C



Fresh < Trash << ‘old’

Cd Sorption

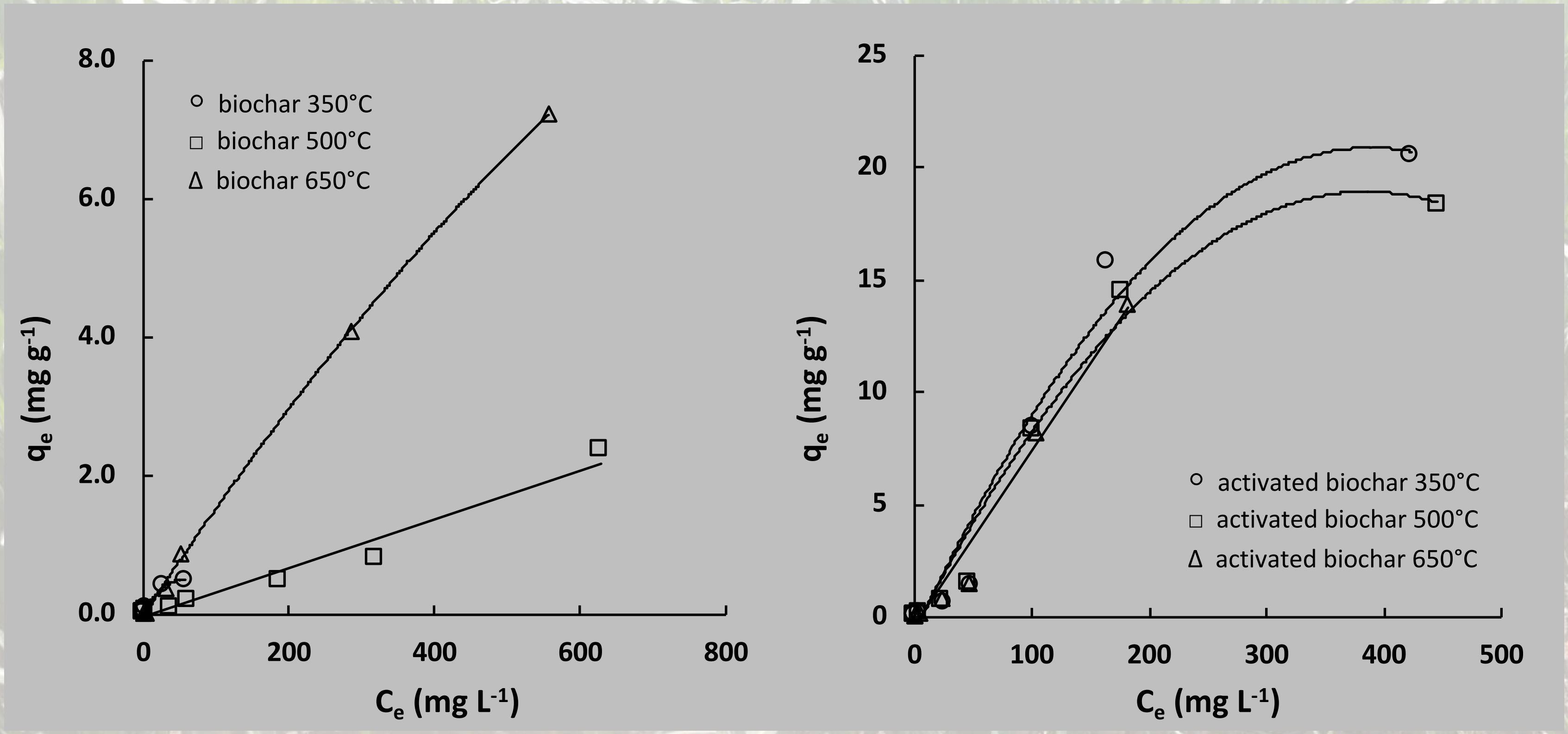
650 ^{o}C



Fresh < Trash << ‘old’

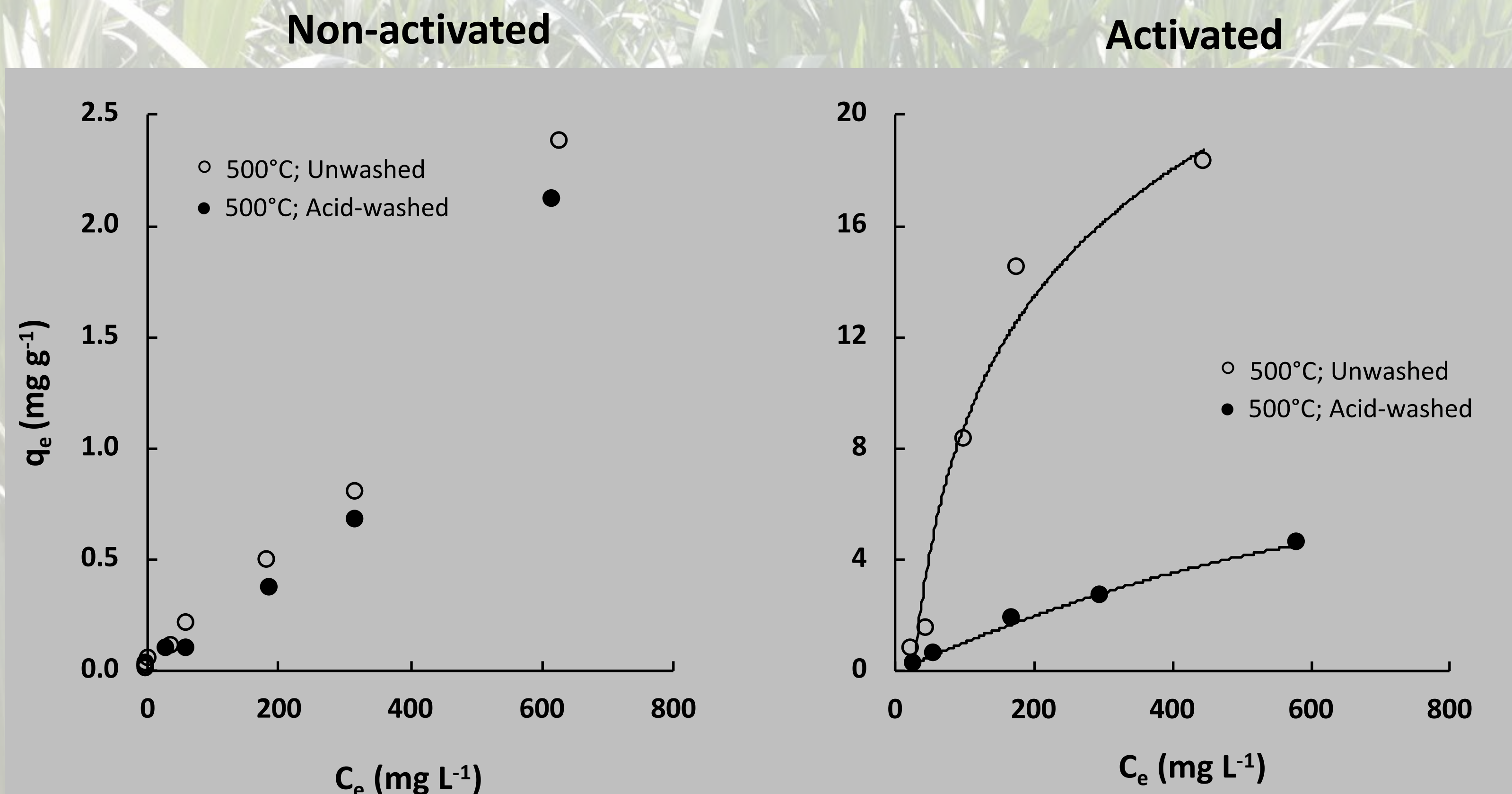
Cu Sorption

'Old' Bagasse Biochar

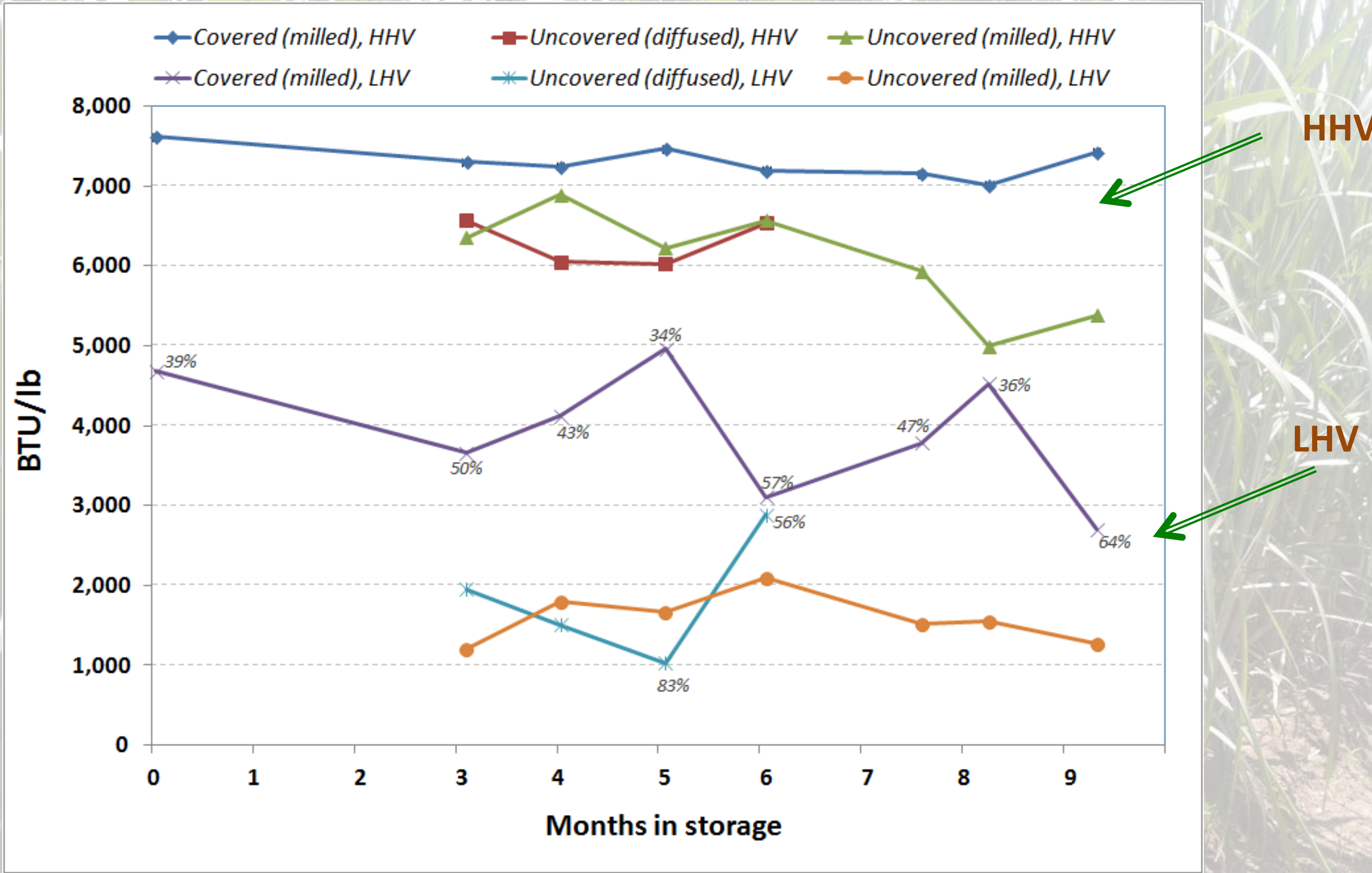


USDA

Effect of Acid-Wash on Cu Sorption by 'Old' Bagasse Biochar



Fuel Value as function of Storage



Uncovered storage of bagasse led to markedly reduced fuel value, increased ash content, and decreased carbon content

HHV: high heating value, BTU/ton; LHV: lower heating value, BTU/ton; Numbers inside graph represent moisture content of bagasse at sampling time

Summary and Conclusions

- Properties of sugarcane biochar are affected by bagasse source and pyrolysis conditions
- Pyrolysis of trash or field-aged bagasse resulted in higher yield of biochar and in biochar of higher ash content compared to that produced from fresh bagasse
- Biochar produced from fresh bagasse had higher levels of fixed carbon and higher surface area
- Biochar produced from field-aged bagasse had higher affinity and sorption capacity for Cd, Cu, and Pb compared to trash or fresh bagasse biochars
- Acid-wash significantly reduced biochar sorption capacity

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