Sustainable And High-functional Materials From Agricultural Waste

Zhaohui Tong Ph.D

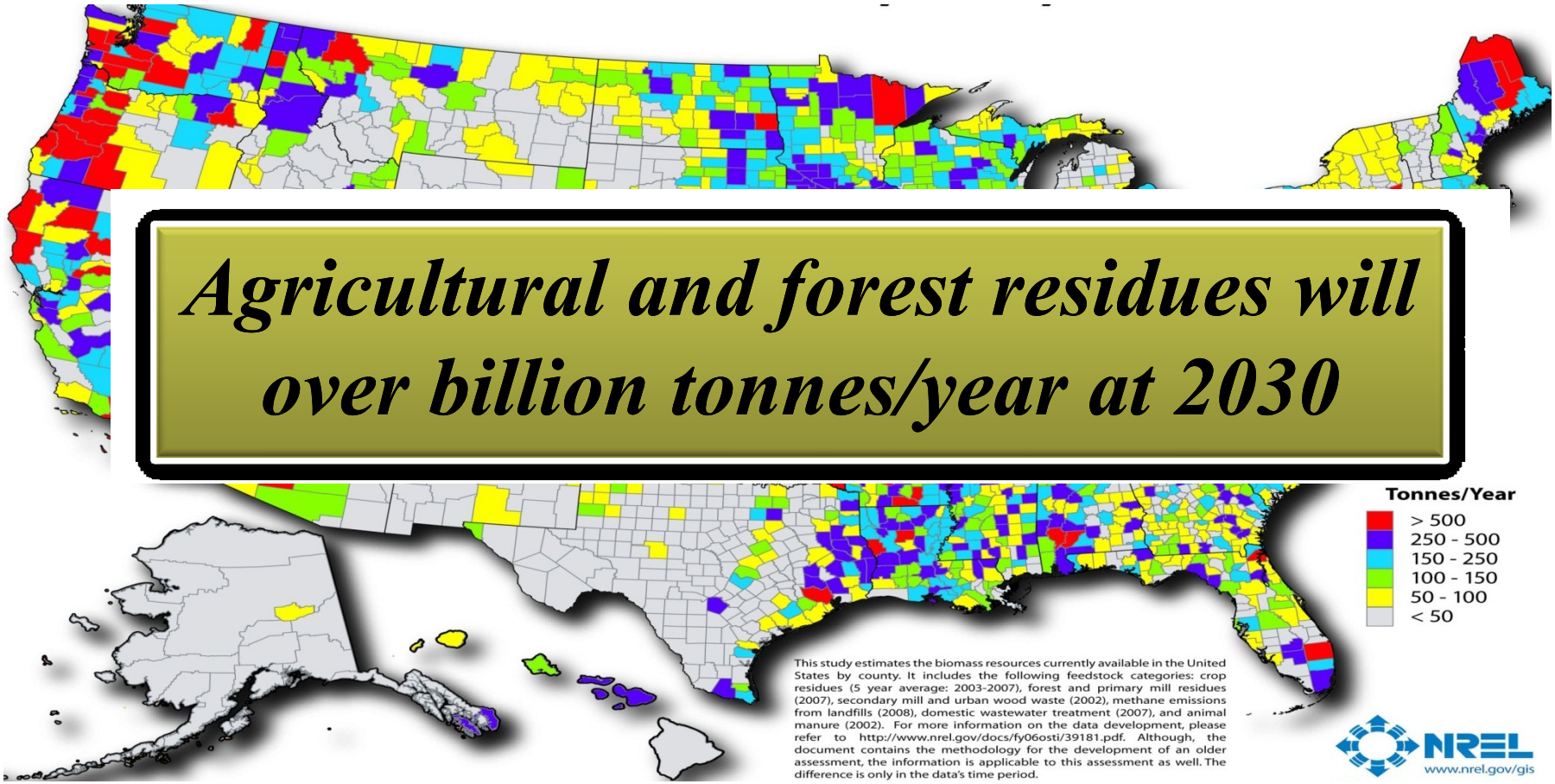
Department of Agricultural and Biological Engineering, IFAS, University of Florida

Presentor: Jijiao Zeng

UF UNIVERSITY of FLORIDA IFAS

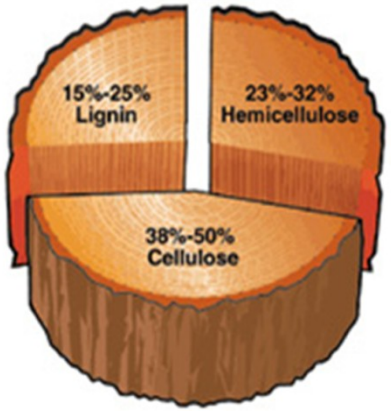
UF UNIVERSITY of FLORIDA

Lignocellulosic Biomass Resource Map of United States



Cellulose Biomass Resources

- Types of Biomass Resources
  - Agricultural residues
  - Forestry residues
  - Oil Crops
  - Major fraction of municipal solid waste
  - Energy Crops (elephant grass)

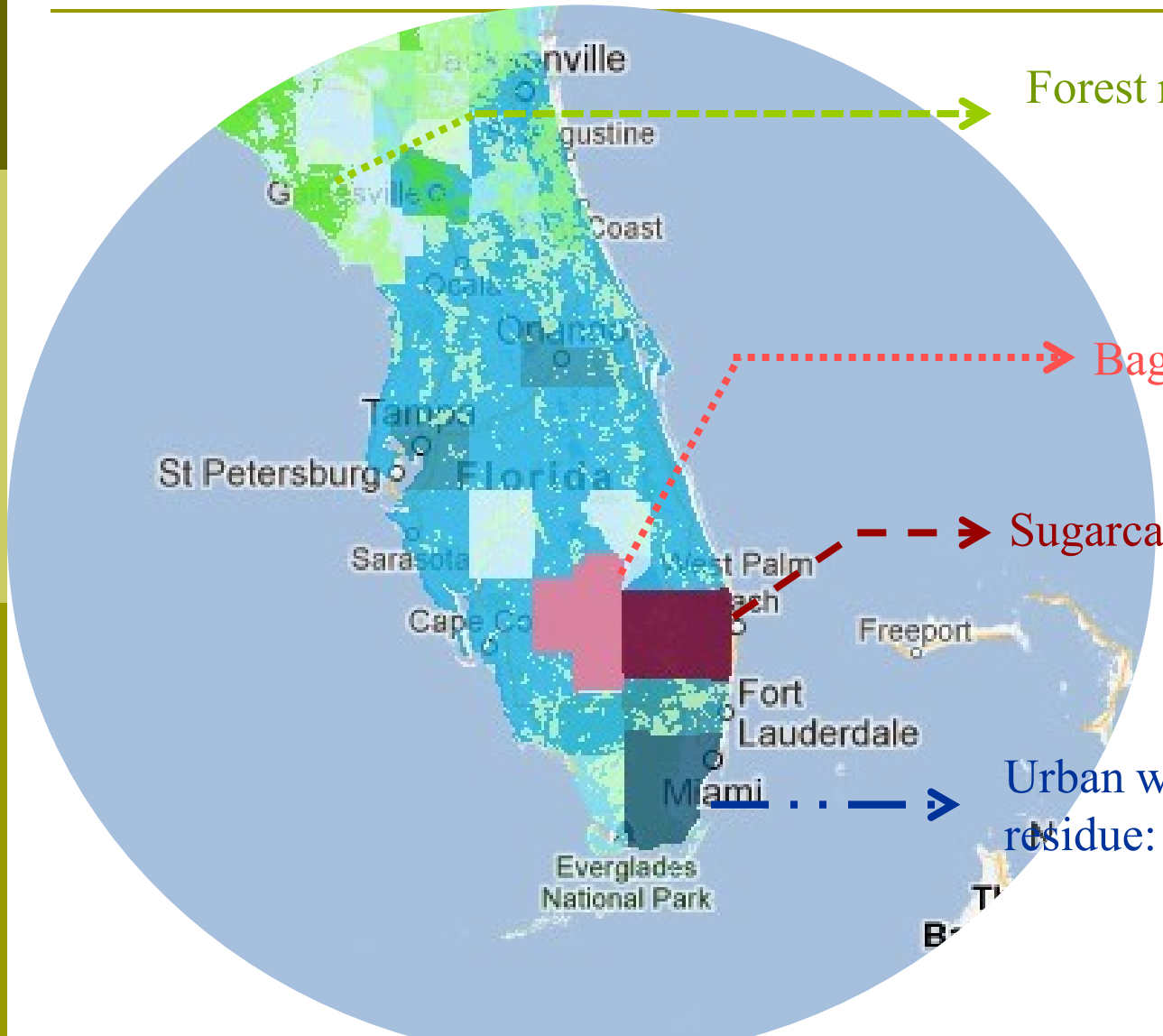


Sugar bagasse

Sweet Sorghum

Wood residues

Availability of lignocellulosic biomass in Florida State



Forest residues: 2,399,000 Tonnes/year

Bagasse 2,591,681 Tonnes/year

Sugarcane: 11,852,000 Tonnes/year

Urban wood and secondary milled residue: 1, 795, 503 Tonnes/year

Sugarcane Bagasse

<u>Bagasse</u> is the fibrous residue of the cane stalk left after crushing and extraction of the juice.

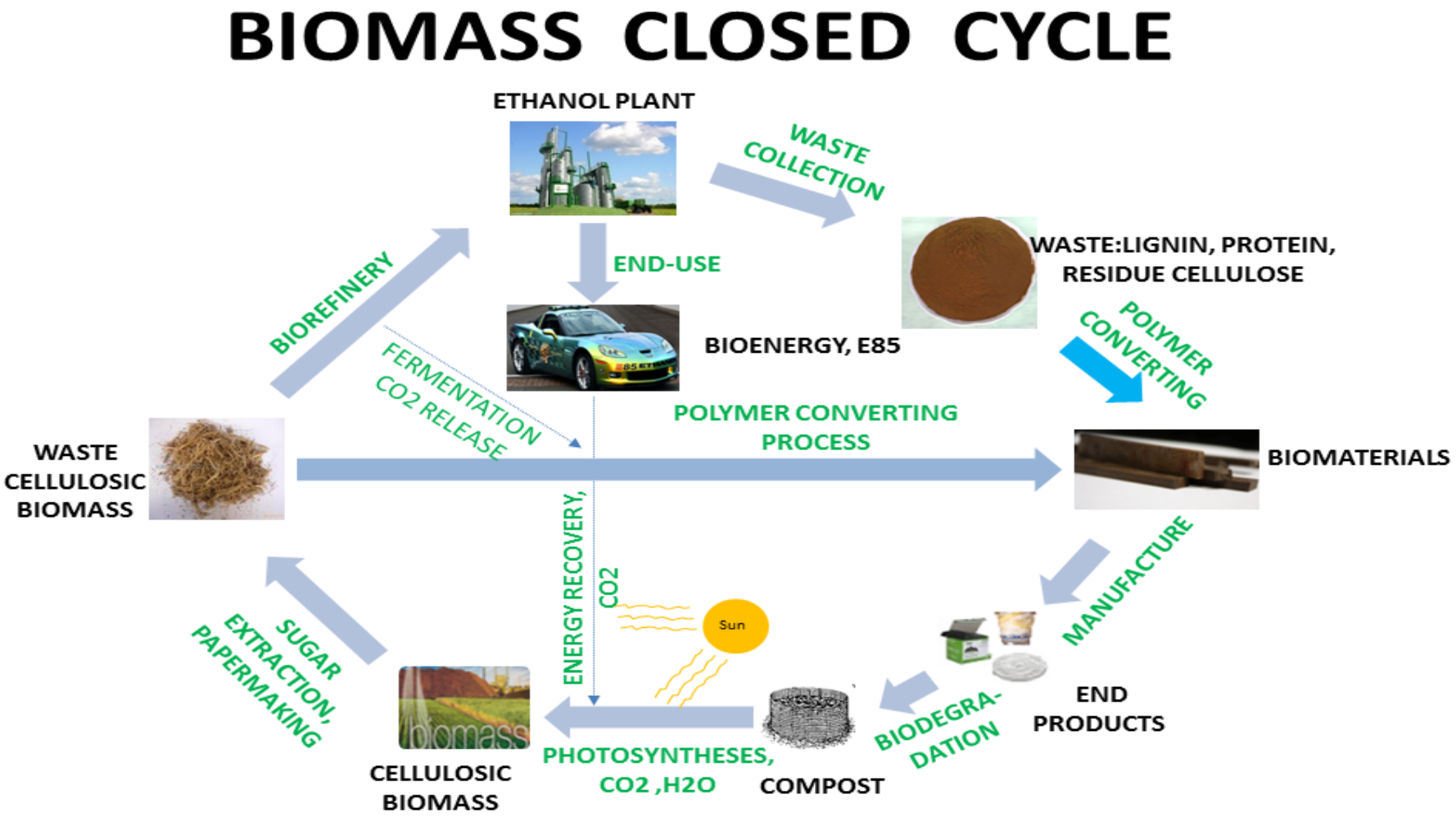
- 60 million tons produced worldwide from sugar industry.
- Mainly used for fuel to generate steam and thus electricity; the rest to produce pulp and board.

Cellulose 45%

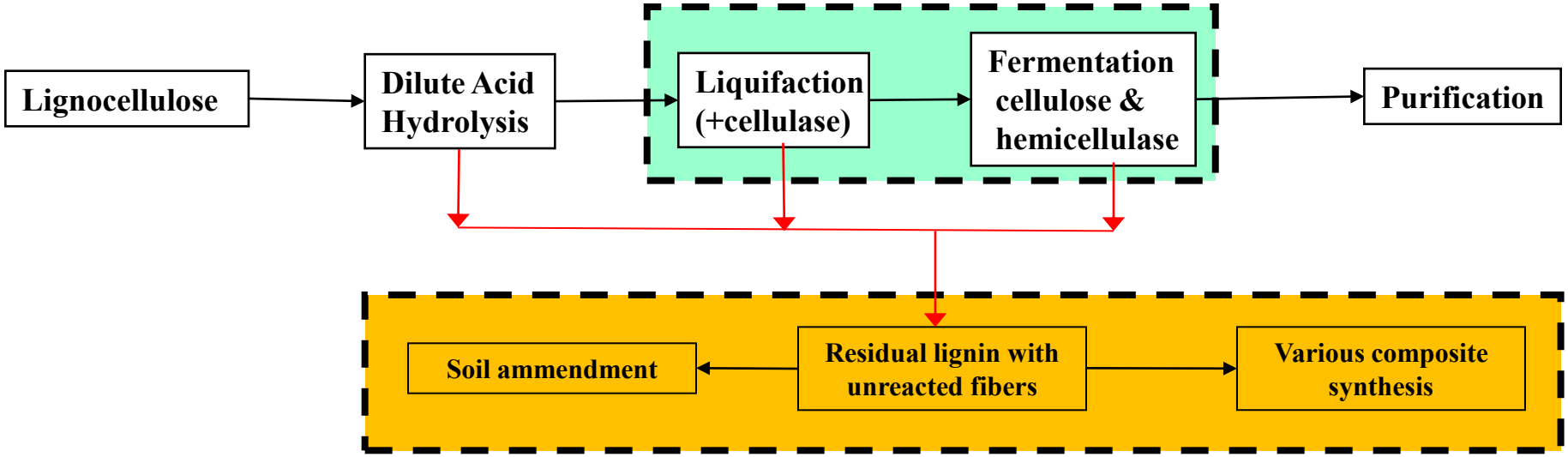
Hemicellulose 25%

Lignin, Ash, other 30%

Bio-based Products Perspective -Integrated Biorefinery



Integrated Biofuel and biocomposites process



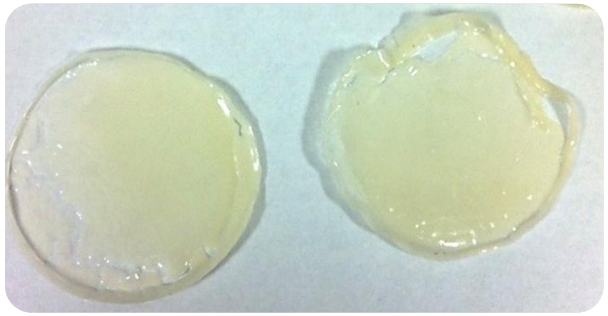
- Integrate into bioethanol process to
  - ✓ Simplify bioethanol process;
  - ✓ Reduce pretreatment cost;
  - ✓ Utilize the hard-to-hydrolysis fibres, residue lignin and protein.

- Lignocellulose reinforced composites
  - ✓ Reduce the cost;
  - ✓ Tailored Properties for specific usage.

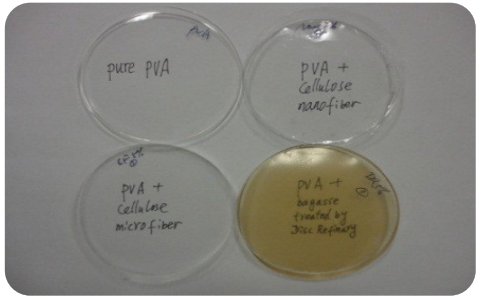
Biobased Materials Made in our lab

Stable latex

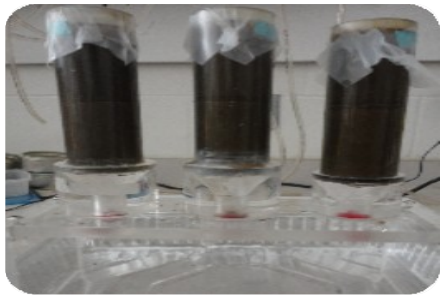
PLA-residue composite



Nanolignin-based Film



PVA-nanoresidue composite film



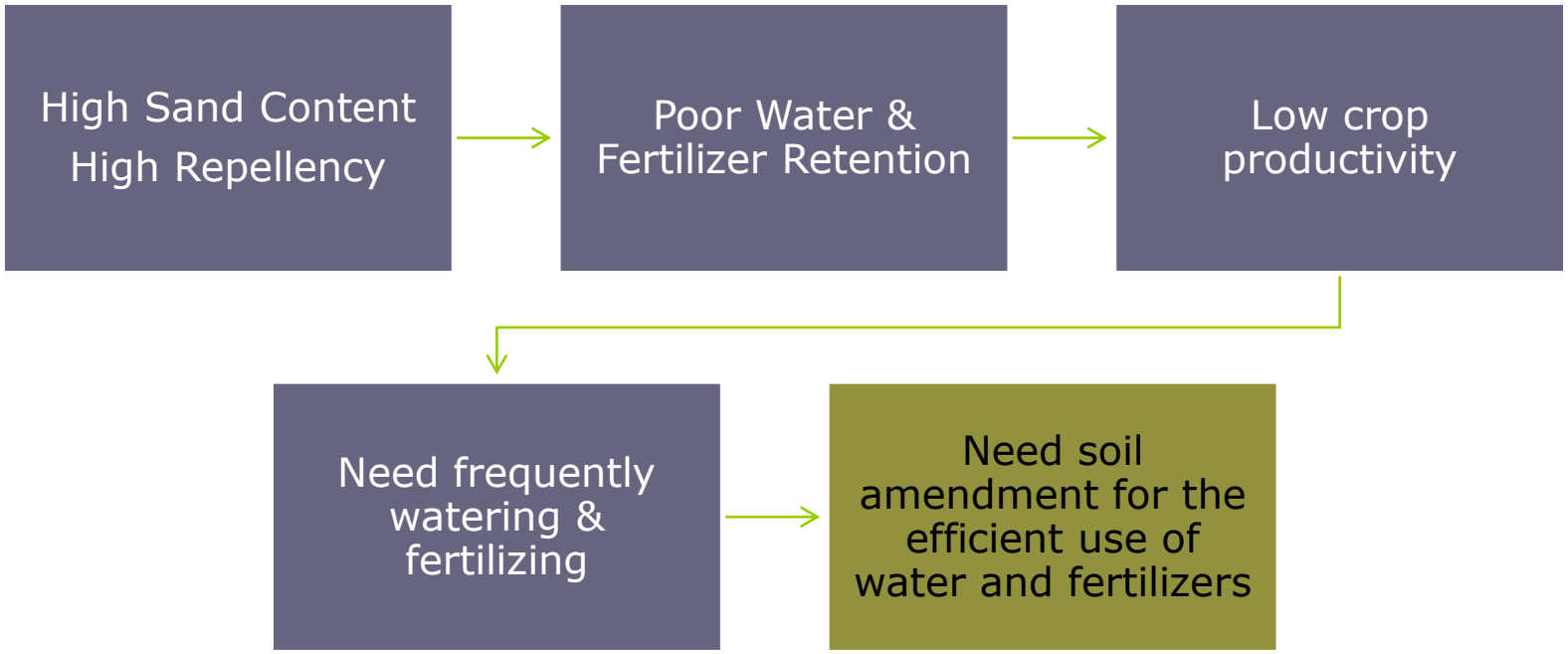
Residue as Soil Amendament

Cellulose Hydrogel

The use of bio-based residue to improve water and fertilizer retention on sandy soil

The use of bio-based residue to improve water and fertilizer retention on sandy soil

Background - Sandy Soil in Florida



The use of bio-based residue to improve water and fertilizer retention on sandy soil

Nonrenewable Soil Amendment Material

- High absorbance polyacrylamide (PAA) and its copolymers

- From natural gas: non-bio-based
- Low salt tolerance (ionic)
- Non- biodegradable
- Toxic residues
- Price $8/kg

The use of bio-based residue to improve water and fertilizer retention on sandy soil

Renewable Soil Amendment Material

- Manures-Low cost but low retention
- Starch-based-expensive and food competitive
- Chitosan-based-expensive
- Cellulose –based
  - Carboxymethylcellulose (CMC)-expensive and sensitive when cationic ions exist
  - Lignocellulosic residues
    - Low cost –Residues from the waste stream of biofuel process and paper mill
    - 100% biodegradable and no toxic to soil

The use of bio-based residue to improve water and fertilizer retention on sandy soil

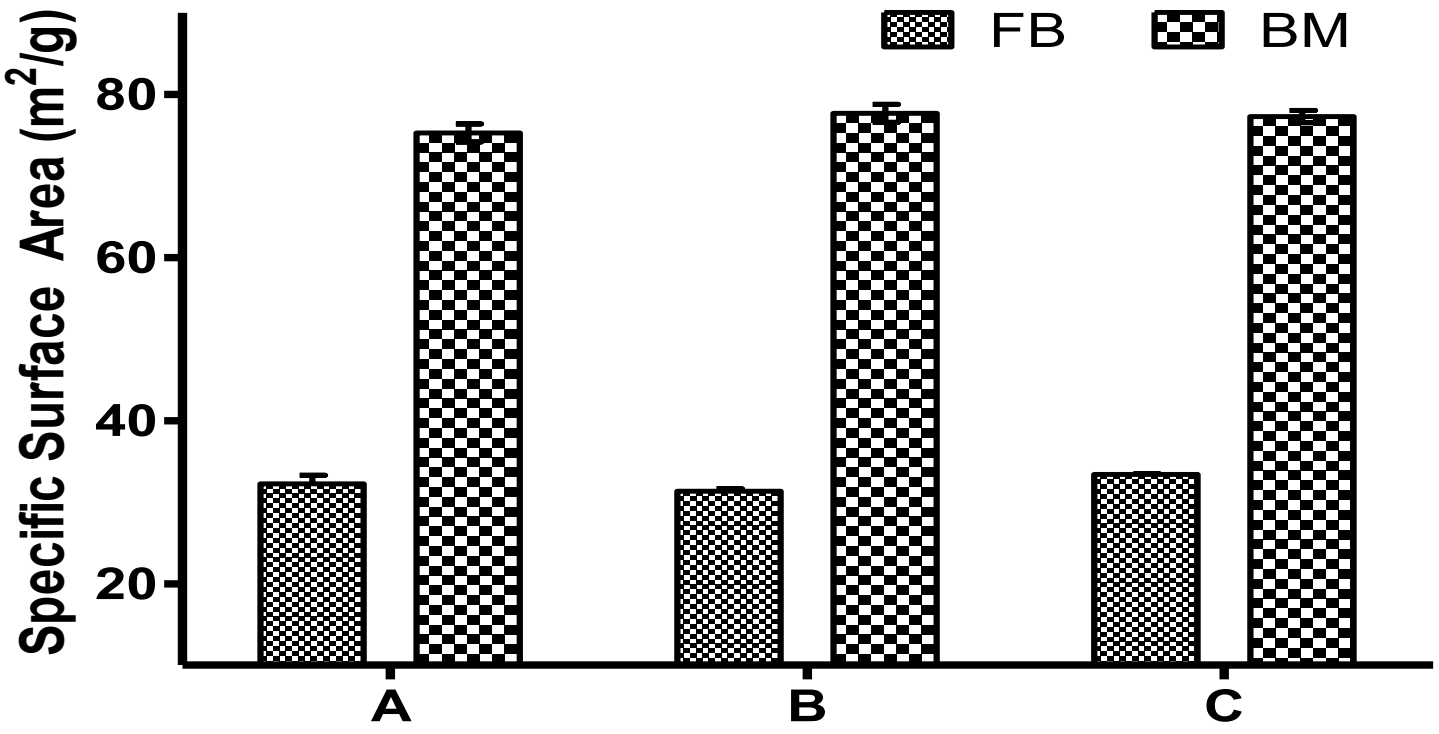
Materials

- Sandy Soil
- Fermented sugarcane bagasse residue
- Paper Mill Brown Residue (BM)

Materials	Lignin	Cellulose	Hemicellulose
Fermented Bagasse	71.26%	22.30%	6.44%
Brown Mill Residue	0.35%	88.47%	11.18%

The use of bio-based residue to improve water and fertilizer retention on sandy soil

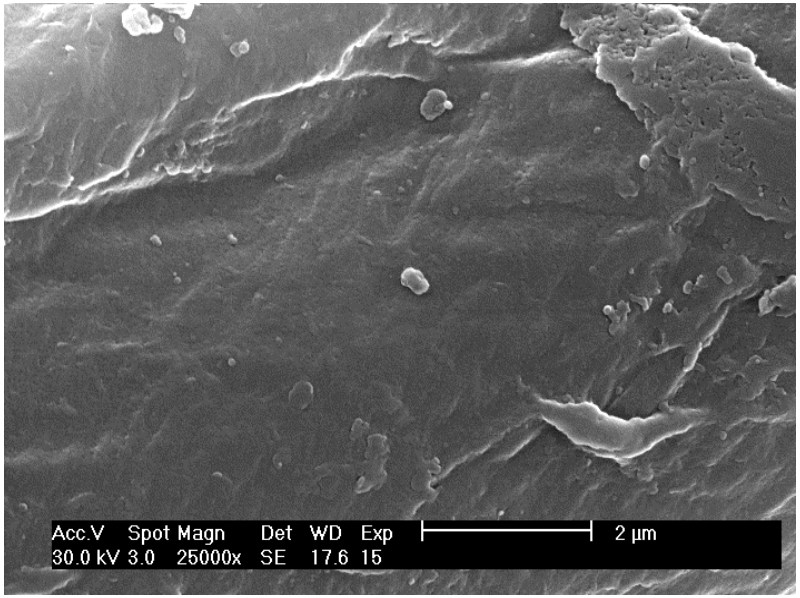
BET specific surface area analysis
of different particle size



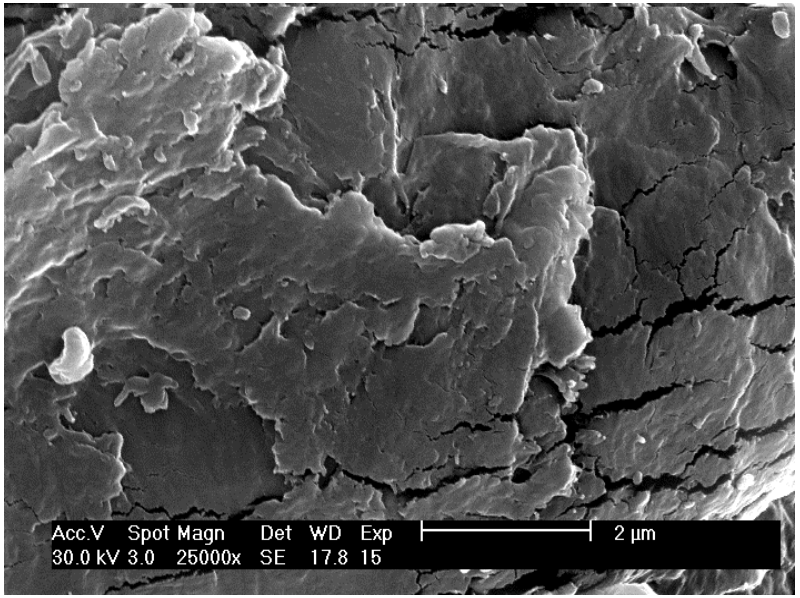
A: 0.297 – 0.5 mm; B: 0.178 – 0.297 mm; C: 0.089 – 0.178 mm

The use of bio-based residue to improve water and fertilizer retention on sandy soil

Scanning Electron Microscopy images of lignocellulosic residue



FB

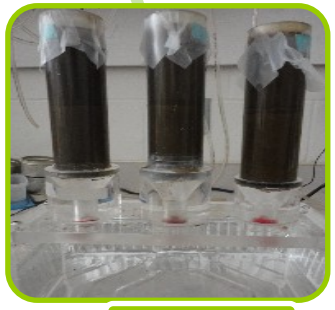


BM

The use of bio-based residue to improve water and fertilizer retention on sandy soil

Residue Soaking

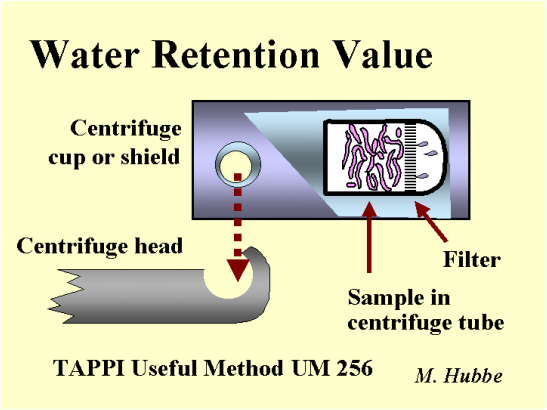
Mixing



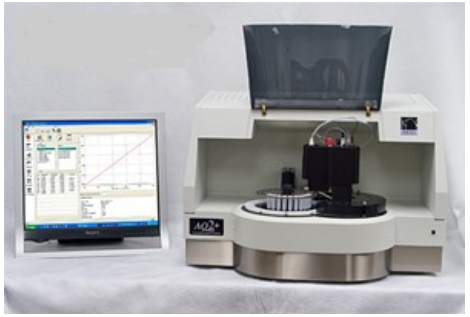
Saturation & Leaching

Centrifuge

Oven Dry

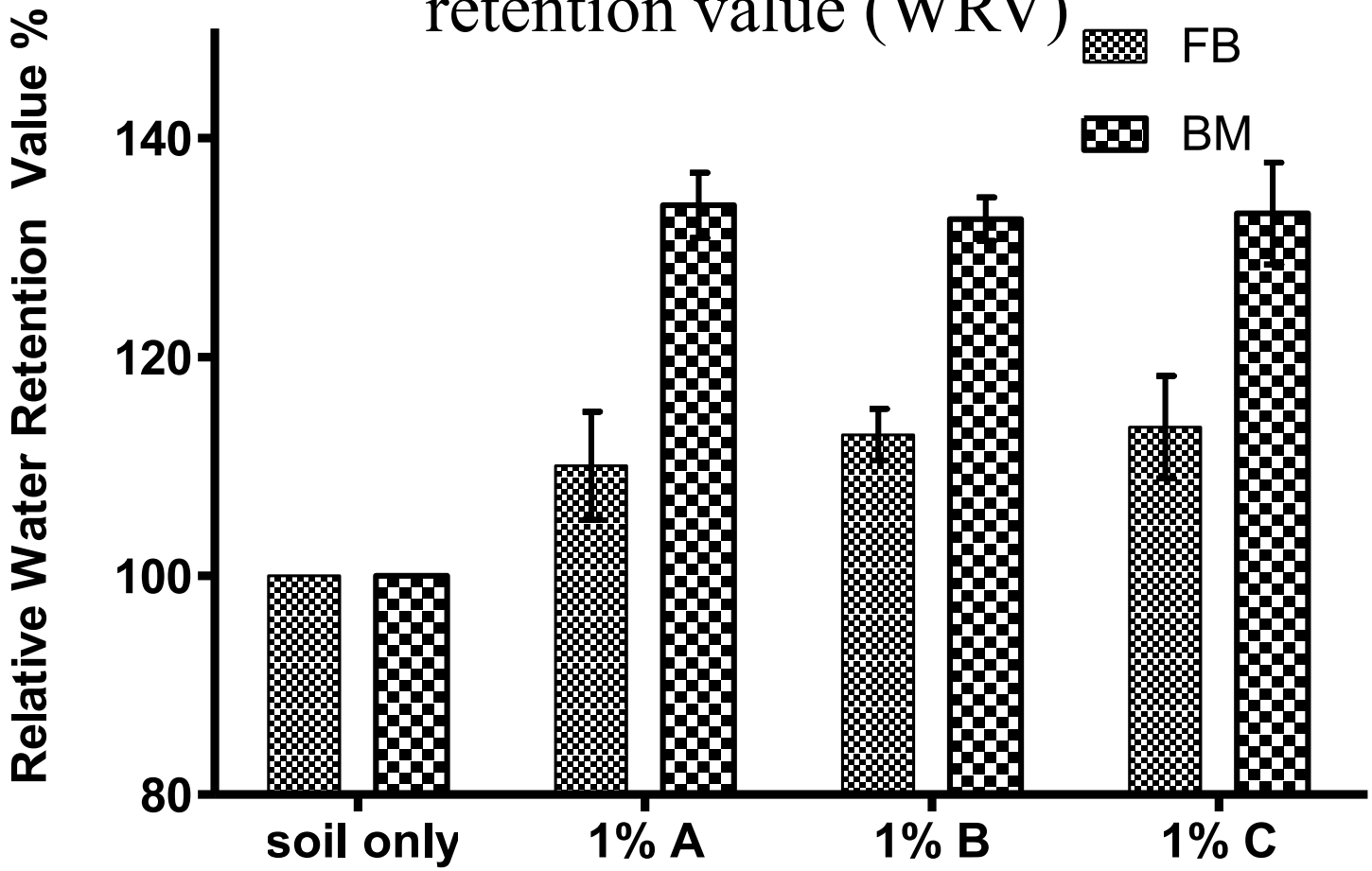


Fertilizer Leachate Concentration Measurement



The use of bio-based residue to improve water and fertilizer retention on sandy soil

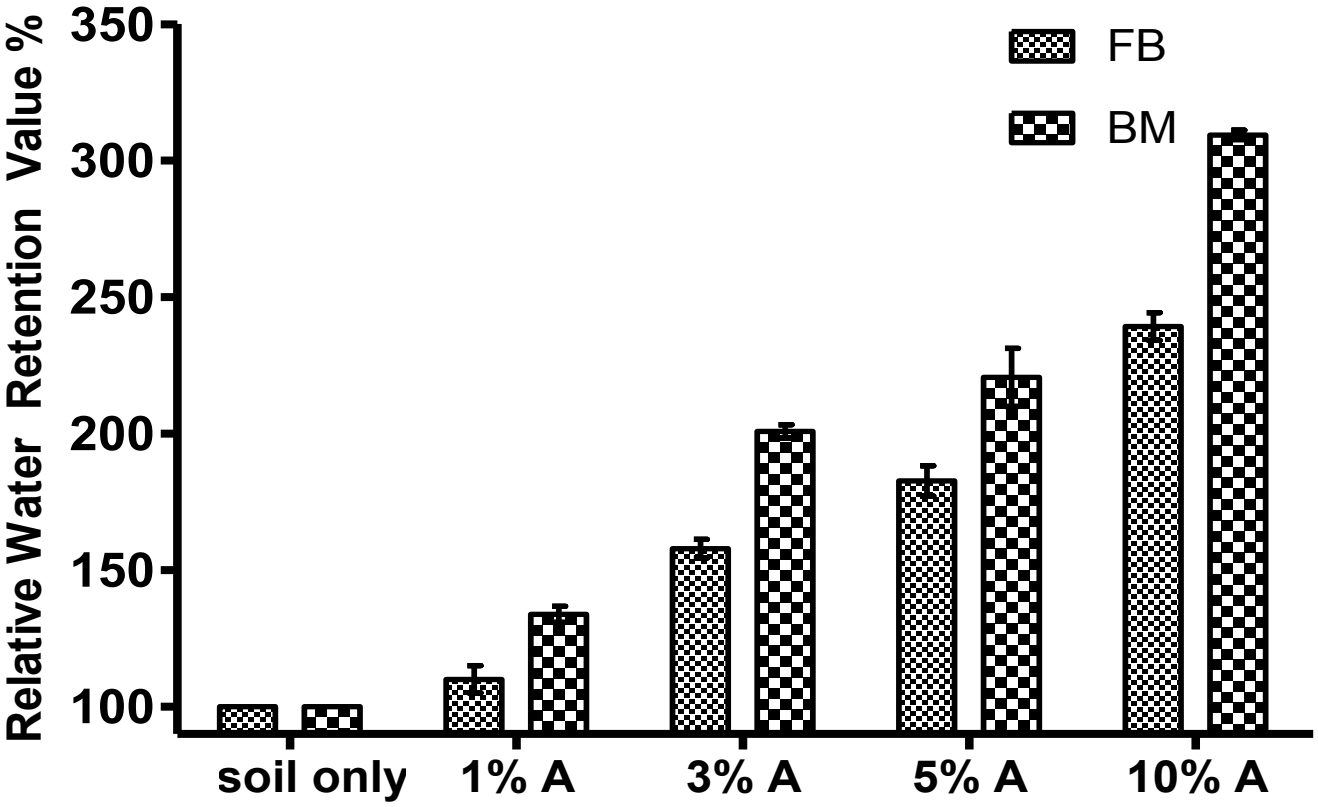
Effect of fiber size on the relative water retention value (WRV)



A: 0.297 – 0.5 mm; B: 0.178 – 0.297 mm; C: 0.089 – 0.178 mm

The use of bio-based residue to improve water and fertilizer retention on sandy soil

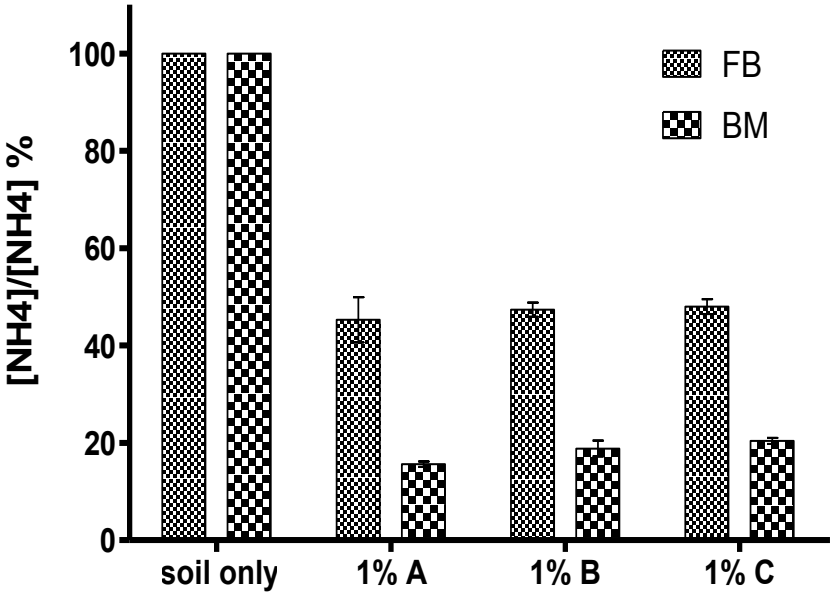
Effect of different fiber loading on the relative water retention value (WRV)

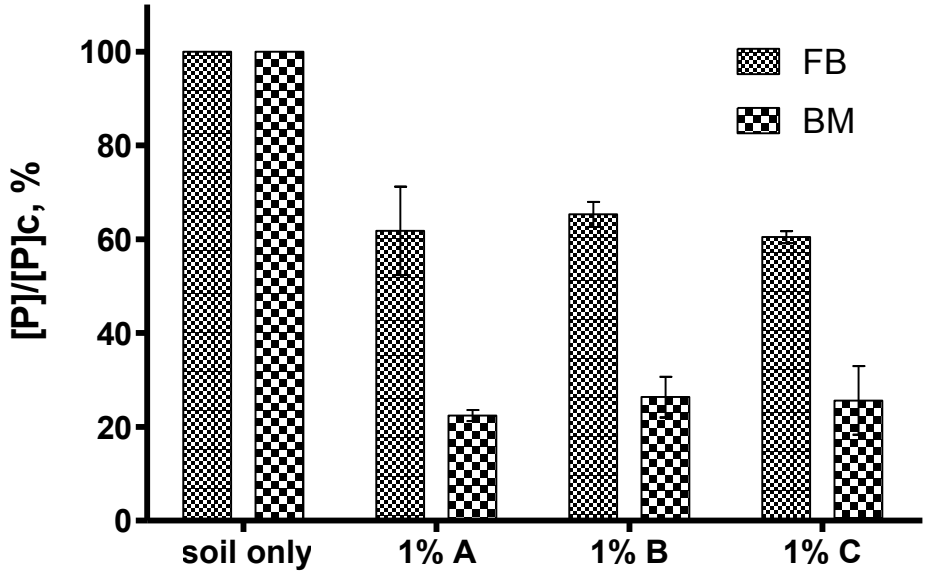


A: 0.297 – 0.5 mm

The use of bio-based residue to improve water and fertilizer retention on sandy soil

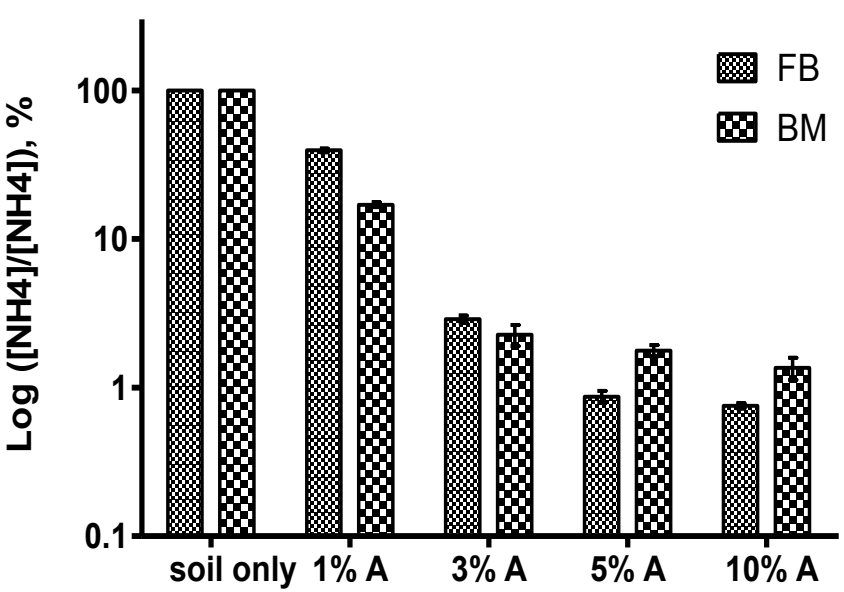
Effect of different fiber size on the relative ammonium and phosphate retention

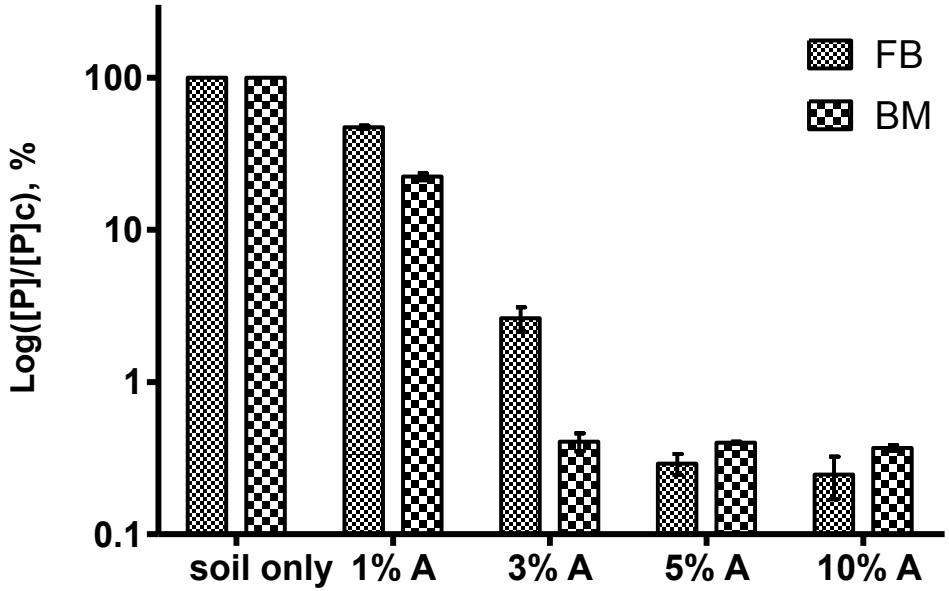




The use of bio-based residue to improve water and fertilizer retention on sandy soil

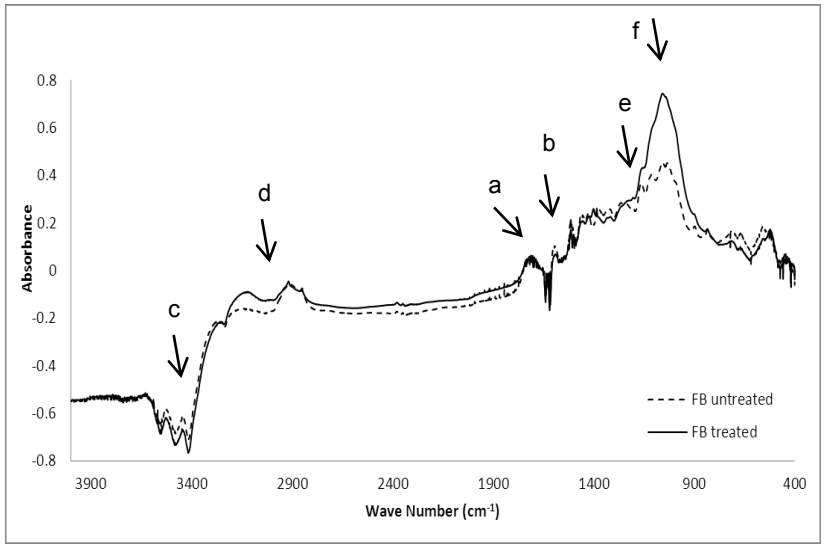
Effect of different fiber loading on the relative ammonium and phosphate concentration in the leachate

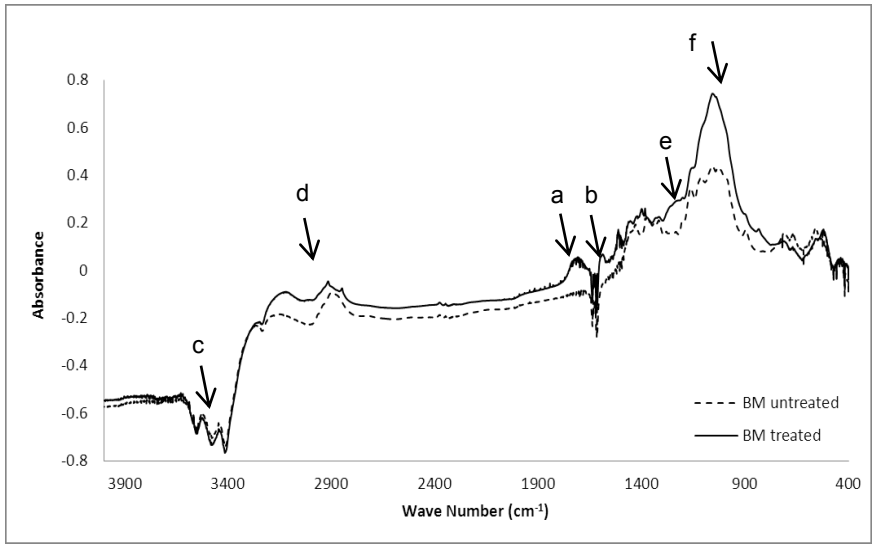




The use of bio-based residue to improve water and fertilizer retention on sandy soil

Fourier Transform Infrared Spectroscopy (FTIR) spectrum





FB BM

Hydrogen bonding between carboxylic acids or their esters and ammonium ions

Conclusions

- Lignocellulosic residue acted as soli amendment can significantly increase water and fertilizer retention
- Utilization of the biofuel production waste streams with almost zero value to high value bio-products
- Improve quality of life of Florida Residents from new sustainable technologies and processes
- Biomaterials: Renewable, Biodegradable, Less environmental impact, Nontoxic, Recyclable…

Acknowledgements

- Collaborators: Wilfred Vermerris, Lonnie Ingram, Pratap Pullammanappallil, Guodong Liu, Yuncong Li.
- Graduate Students :Letian Wang, Suguna Jairam and Nusheng Chen
- Post Doctors: George Cheng, Jijiao Zeng and Fei Wang
- Visiting Scholar: Qifa Zhou
- Funding Support:

  ✓USDA-BRDI grant number: 00094786
  ✓DOE-India Joint Project
  ✓IFAS Start Fund, University of Florida