Bio-based Residues to improve the efficient use of water on Florida Sandy Soil

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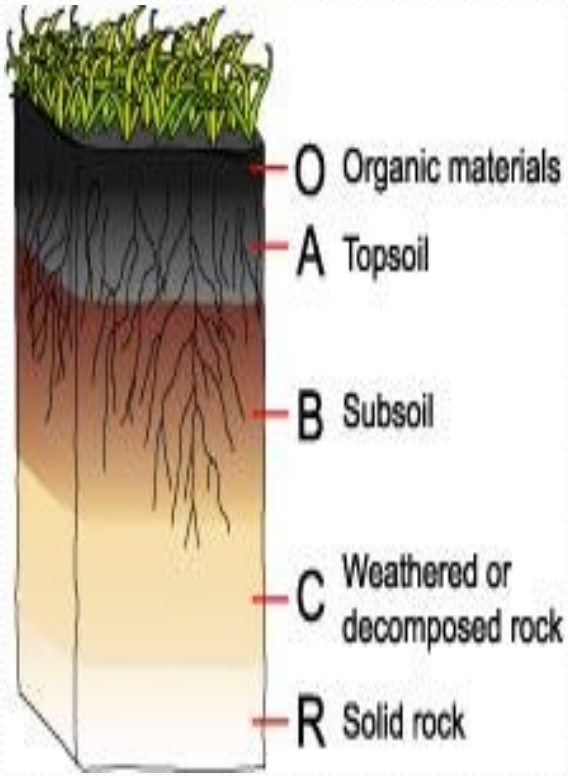
Soil



Soil is a natural body consisting of layers (soil horizons) of primarily mineral constituents of variable thicknesses.

O) Organic matter: Litter layer of plant residues in relatively un-decomposed form.

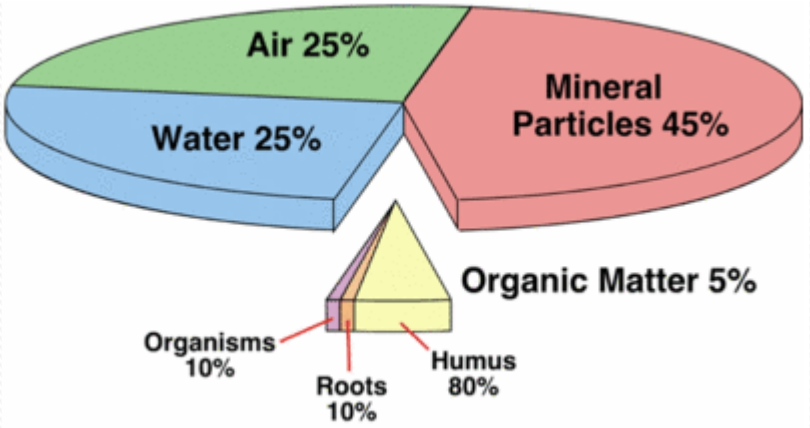
A) Surface soil: Layer of mineral soil with most organic matter accumulation and soil life.

B) Subsoil: This layer accumulates iron, clay, aluminum and organic compounds, a process referred to as illuviation.

C) Solid rock: Layer of large unbroken rocks. This layer may accumulate the more soluble compounds .

Source:
http://www.westone.wa.gov.au/toolbox6/hort6/html/resources/visitor_centre/fact_sheets/sc2.htm

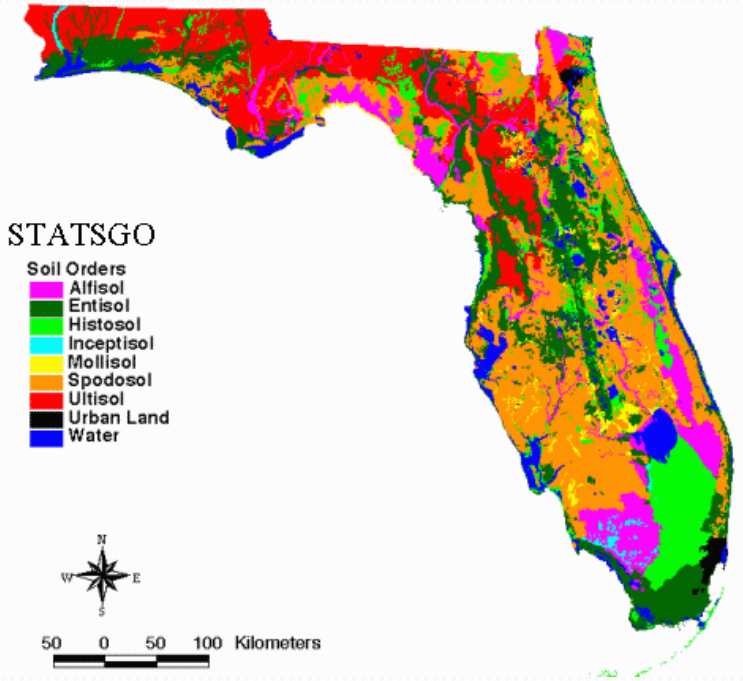
Soil Components



- Permeability
- Water Infiltration
- Structure
- Aeration
- Water Retention

(Source: PhysicalGeography.net)

Florida Soil Conditions



Source:
http://soils.ifas.ufl.edu/faculty/grunwald/research/projects/NRC_2001/NRC.shtml

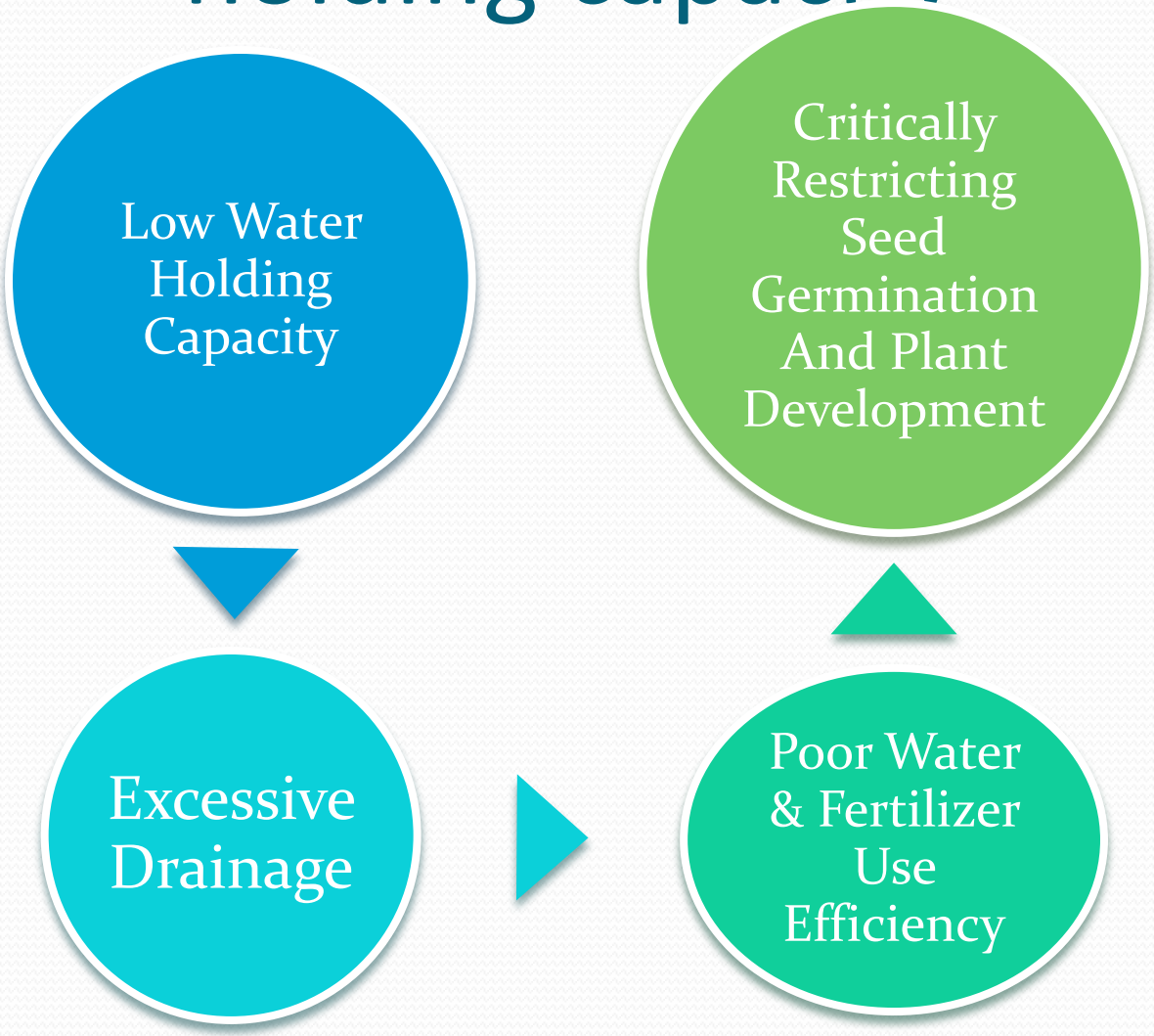
http://www.fnps.org/pages/plants/soil.php

Florida Soil Conditions

- High sand content: more than 50% of sand
- Large air pockets or gaps, which results in quick water drains
- High nutrient lost
- Frequently watering
- Sometimes high salinity (near ocean or well)

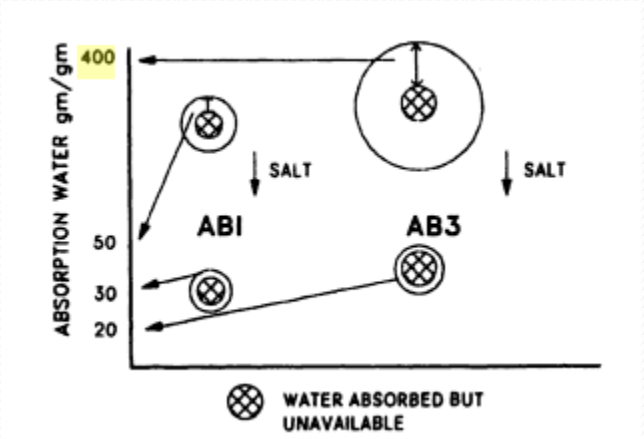
Need soil amendment for the efficient use of water and fertilizer

Soil Amendment with high water holding capacity



Current Soil Amendments

- High absorbance Polyacrylamide (PAM) and its copolymers
  - From natural gas: non-bio-based
  - Price $8/kg
  - Low salt tolerance (ionic)
  - Non- biodegradable
  - Toxic unreacted residues (AMD)
- Bio-based soil amendment
  - Starch-based
  - Chitason-based
  - Cellulose –based
    - Carboxymethylcelluloses (CMC)
    - Lignocellulosic residues



Why lignocellulosic Residues?

- **Motivations**
  - Bio-based next generation biomaterials
  - Low cost –Residues from biofuel process and paper mill
  - 100% biodegradable and No toxic to soil

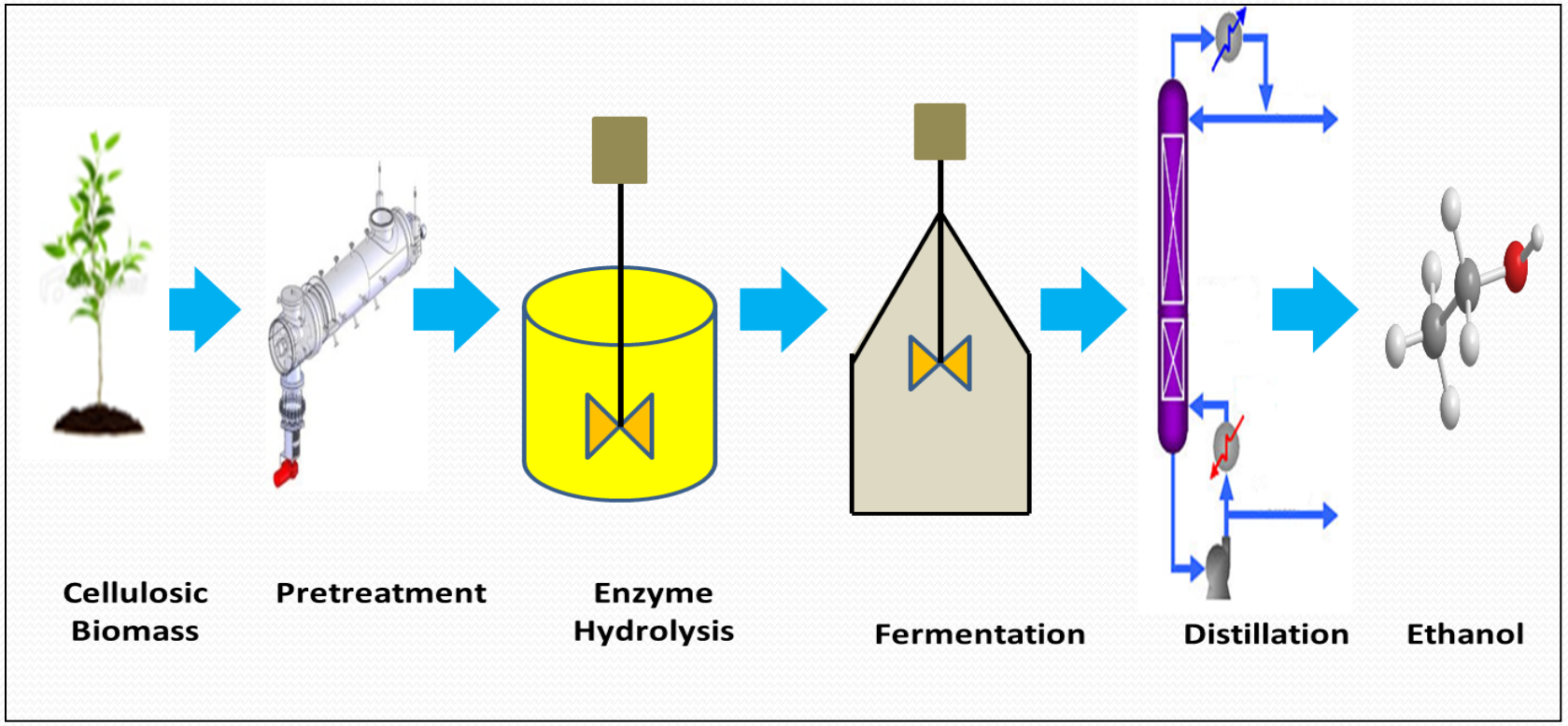
- **Objectives:** Evaluate the function of Bio-based Residues as a soil amendment to improve water holding capability and fertilizer efficiency of Florida sandy soils

Materials

- Florida Top Sandy Soil
- Fermented sugarcane bagasse residue from UF biofuel plant (FB)
- Paper Mill Brown Residue from Pine Tree (BM)

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

Bioethanol Production Process



- Primary Process: Convert cellulose and hemicellulose to ethanol
- Residues: Lignin plus residue fibers

Buckeye Technologies

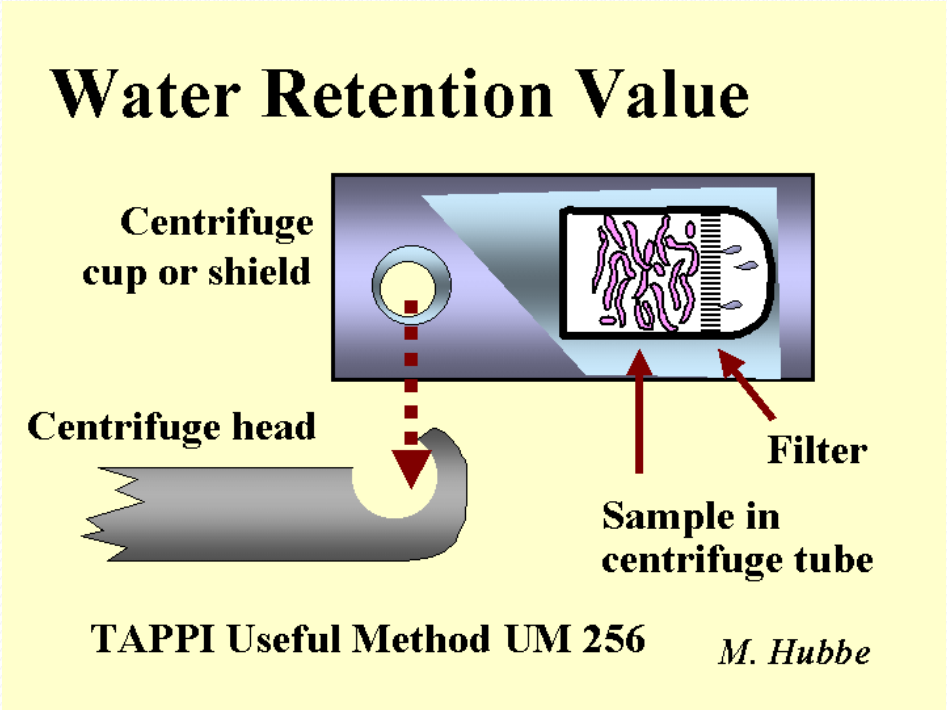
- Buckeye Technologies is a global specialty cellulose business operating in a $7 billion market
- High purity cellulose-Chemical Cellulose, customized fibers, pluff pulp and non-woven materials
- Hemicellulose stream- combined into bioethanol process to produce ethanol
- Lignocellulosic Residues after screening- including 85% cellulose

Experimental Methods

- Measure Water Retention Value (WRV) and Moisture Content of fiber residues and Residue/soil mixture by using modified Tappi UM256 Method;
- Investigate the effects of varied factors including fiber type, size, dosage, and sonication duration on water holding capabilities;
- Investigate the effect of fiber residues on the fertilizer leaching-working on the data-future work

Experimental Methods

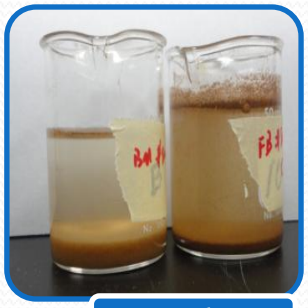
Water Retention Value (WRV): A material's ability to take up water.



$$\mathrm{WRV} = \frac{W_{Water}}{W_{\mathrm{Sample}}} \times 100\%$$

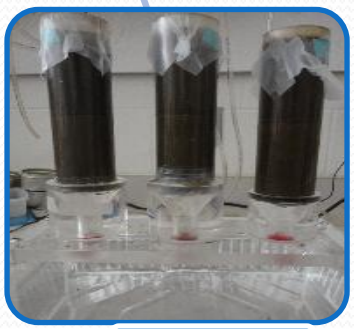
where W_{Water} is the weight of water in the sample after centrifugation, and W_{Sample} is the dry weight of the sample

Experimental Procedure



Residue Soaking

Mixing

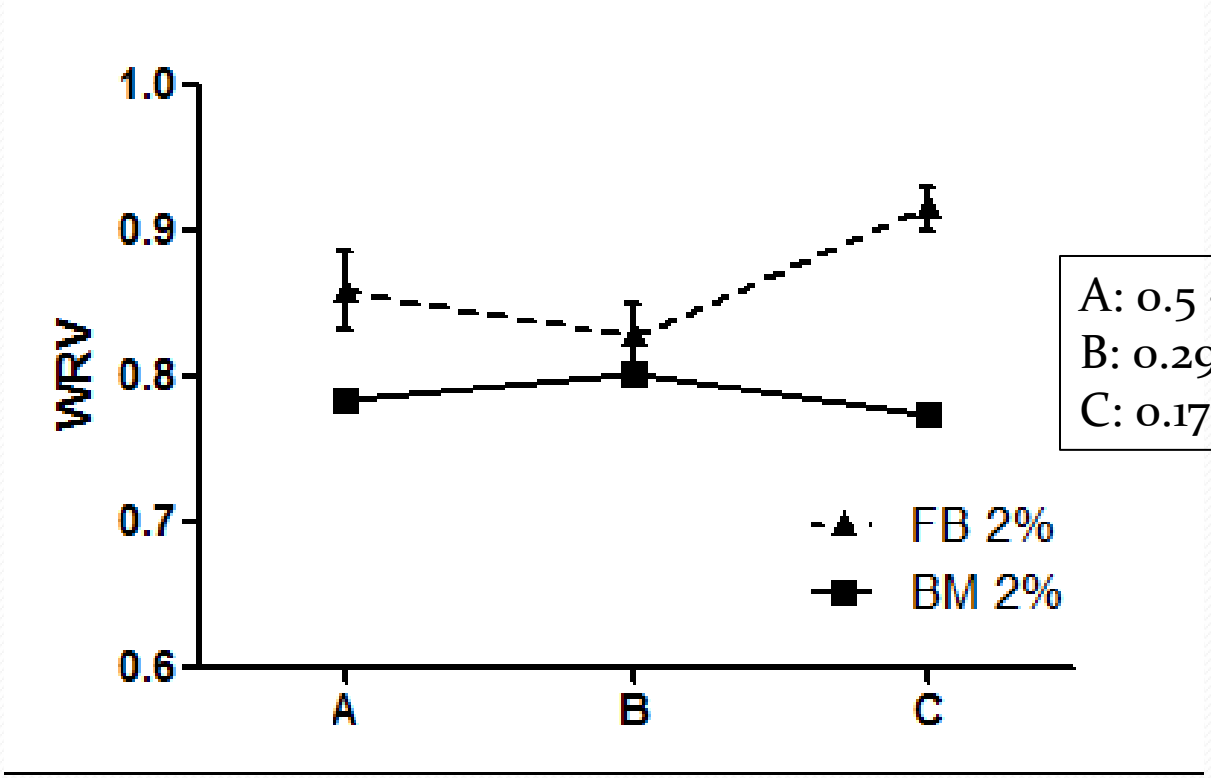


Saturation & Leaching

Centrifuge

Oven Dry

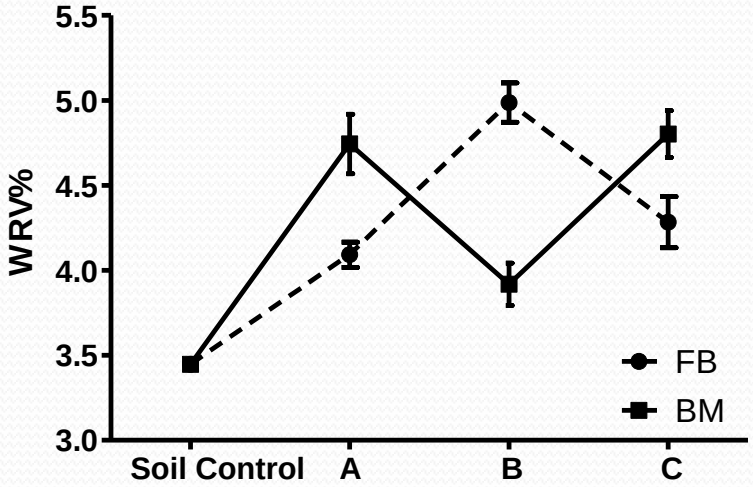
Effect of fiber size on the water retention value of fiber residues



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

Note: Both Fermented Bagasse Residue and Paper Mill Residue were milled and sieved to three size classes

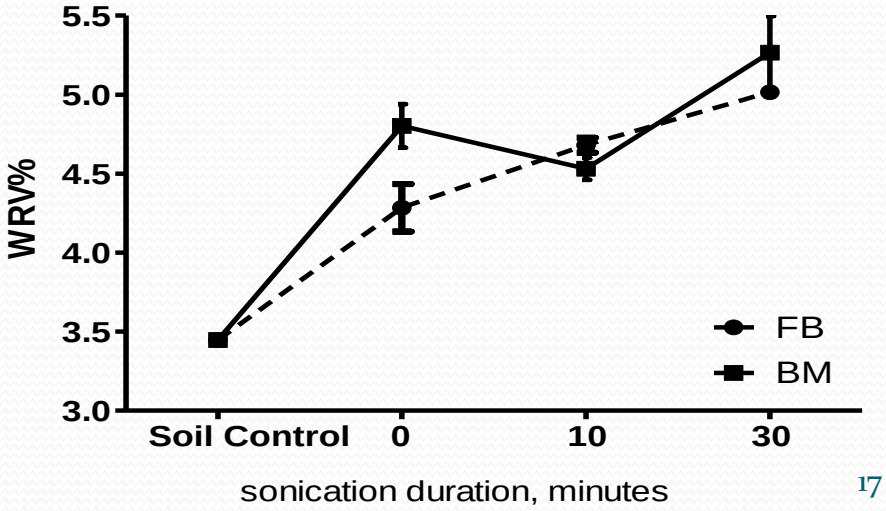
Results – Fiber / Soil Mixture



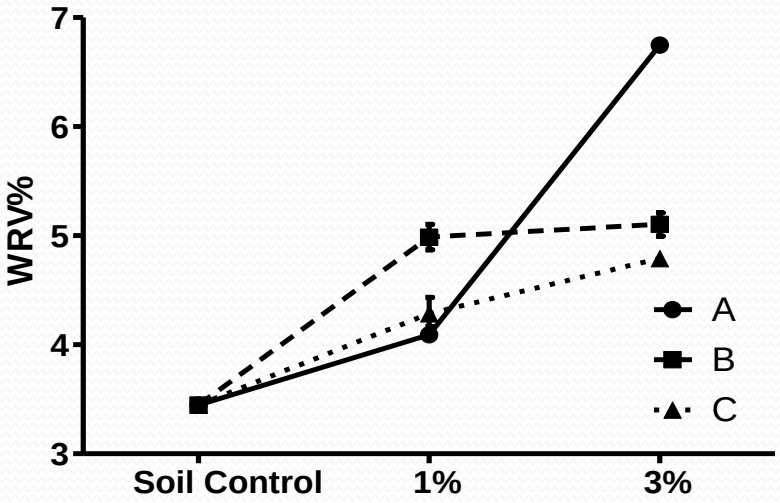
Effect of fiber size on the water retention value of 1% fiber/soil mixture

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

Effect of sonication on the water retention value of 1% fiber (C)/soil mixture



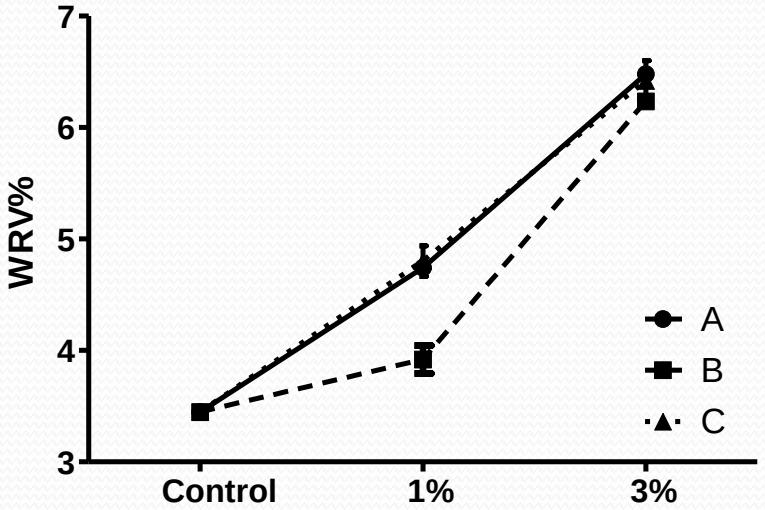
Results – Fiber / Soil Mixture



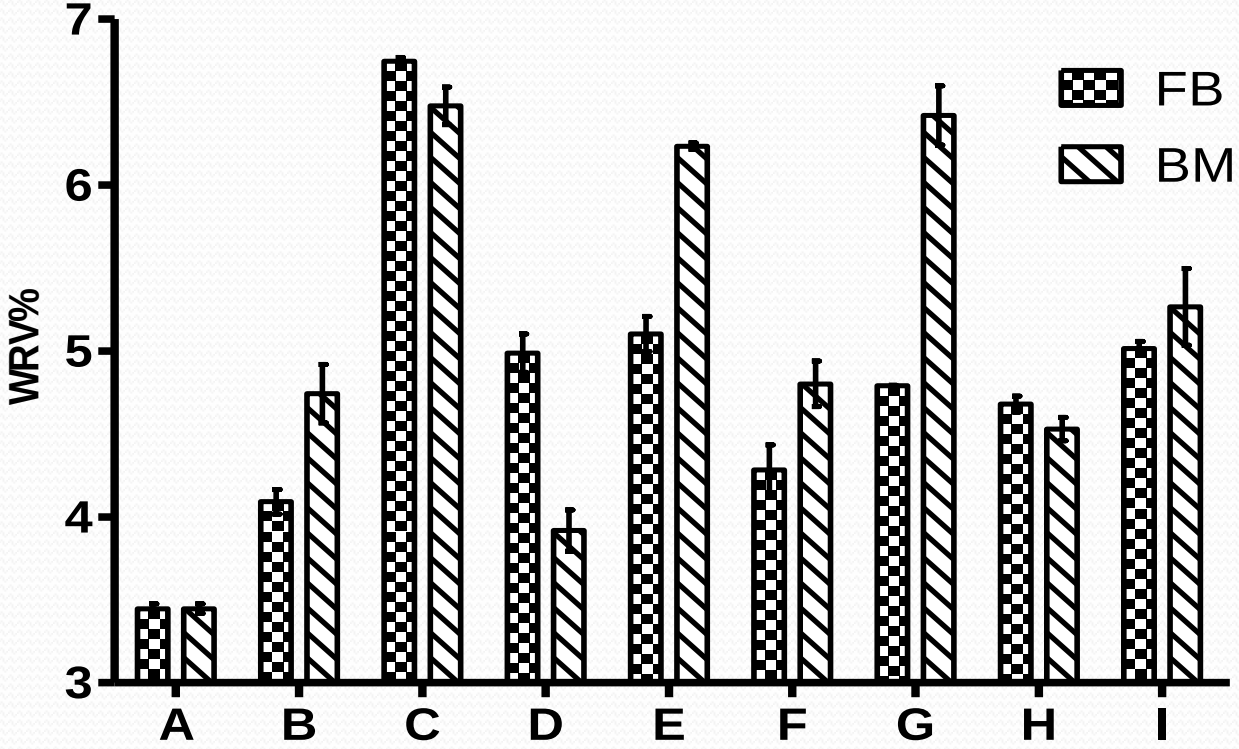
Effect of fiber dosage on the water retention value of fermentation residue (FB)/soil mixture

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

Effect of fiber dosage on the water retention value of brown paper mill residue (BM)/soil mixture



Results – Fiber / Soil Mixture



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

A: Soil Control, B: 1% A, C: 3% A, D: 1% B, E: 3% B, F: 1% C, G: 3% C,
H: 1% C with 10 minutes sonication, I: 1% C with 30 minutes sonication

Conclusions

- Soil's WRV can be increased with the addition of fiber residues as much as ***90 %*** (FB - 3% A)
- Adding only 1% of FB and BM improved WRV of soil by ***40%*** and ***38%*** respectively
- Smaller fiber size – better WRV for FB residues and FB/Soil mixture for 1% fiber dosage
- 10 minutes sonication treatment improved WRV of soil by about 10% (1%, particle size distribution: 0.178 – 0.089 mm), whereas samples with 30 minutes of sonication showed 20% increase of WRV.

Questions?

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