Next-generation sorghums for sustainable production of fuels and chemicals

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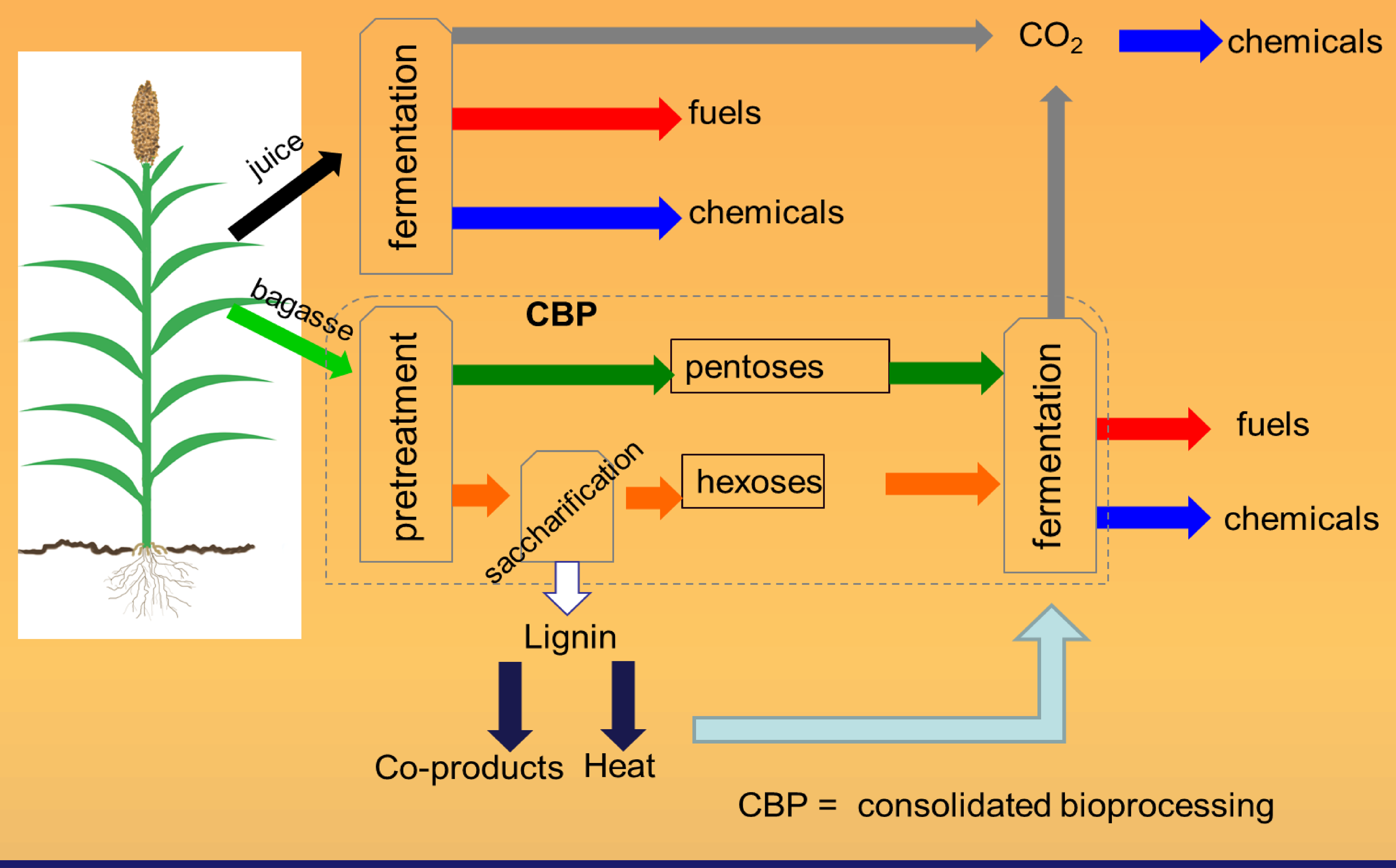
Project objectives

I Breed sorghums with:

- Efficient use of water - root system and photosynthesis
- High sugar yields - genetic basis of sugar accumulation
- Optimal composition of the biomass
  - Easy to process for cellulosic biofuels
  - Good agronomic characteristics

II Enhance bioprocessing

- Novel microbial biocatalysts
- Maximum use of waste streams
  - High-value co-products - Biodegradable plastics and novel biomaterials
  - Economic and environmental benefits of producing co-products from the waste stream vs. burning

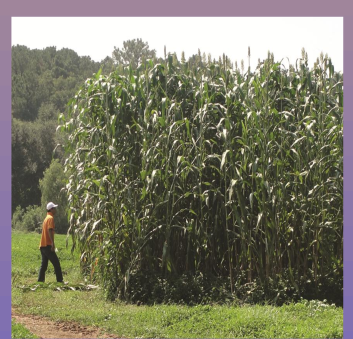


Technical Area 1: Feedstock Development

Manipulation of the cell wall composition to enhance enzymatic conversion and processing characteristics of the biomass for the different end products.

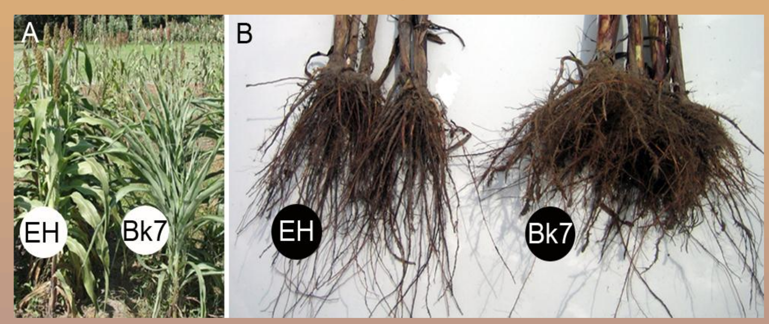
Brown midrib sorghum with enhanced saccharification yields.

High-yielding sweet sorghums

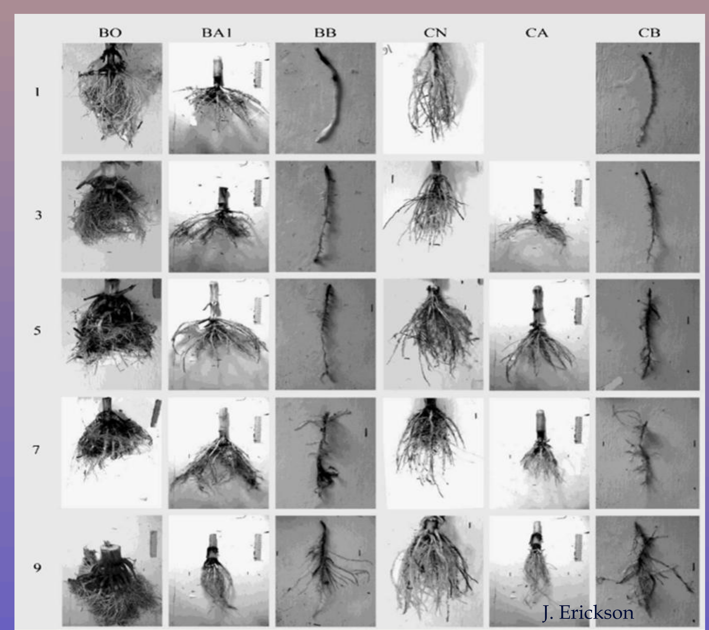


Development of high-biomass, high-sugar sweet sorghums with good agronomic performance that can be processed efficiently

Root architecture-based drought tolerance: dissection of its genetic control via QTL studies.

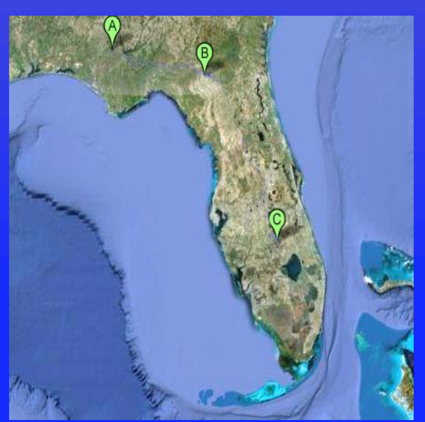


Two genotypes with contrasting response to water limitation. The differences in root architecture are likely to play a role in the response.

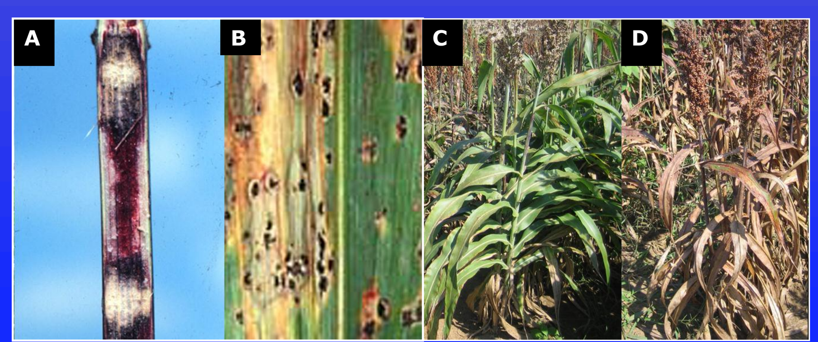


High throughput root phenotyping : 'shovelomics'. Brace/crown roots: number, angle, branching.

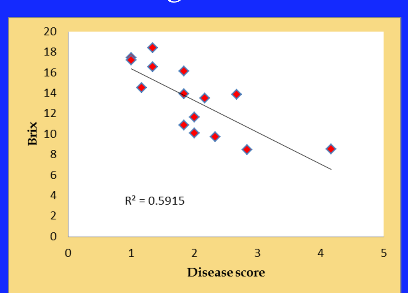
Adaptability to wide array of environments with divergent biotic and abiotic stresses



Initial sites for sweet sorghum yield trials in the estate . A. Marianna, B. Live Oak, C. Highlands.



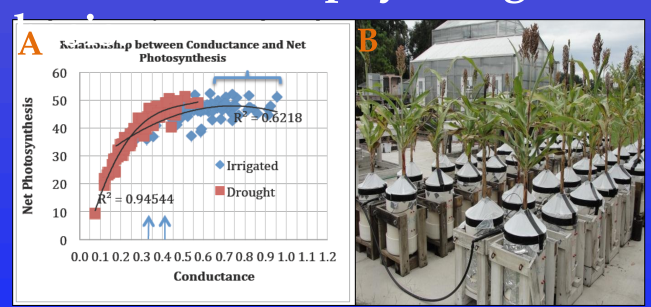
Split sorghum stem showing anthracnose infection . B. Foliar lesions. C. Resistant. D. Susceptible cultivar' at the same maturity and location.



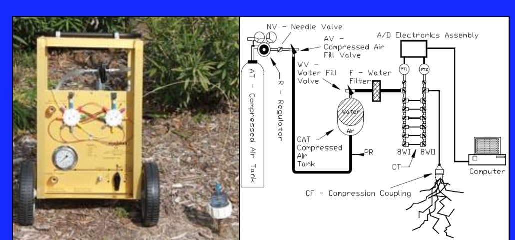
Relarionship between brix and disease score

UF bred Bioenergy cultivar with introgressed anthracnose resistance (left), and anthracnose susceptible commercial hybrid (right).

High "efficient use of water" traits and their physiological basis



A. Photosynthesis and conductance relationship in a field grown panel of sorghum genotypes. Arrows indicate the most efficient conductance level. Bracket indicates wasteful water use. **B.** Setup for the study of the physiological response to water stress



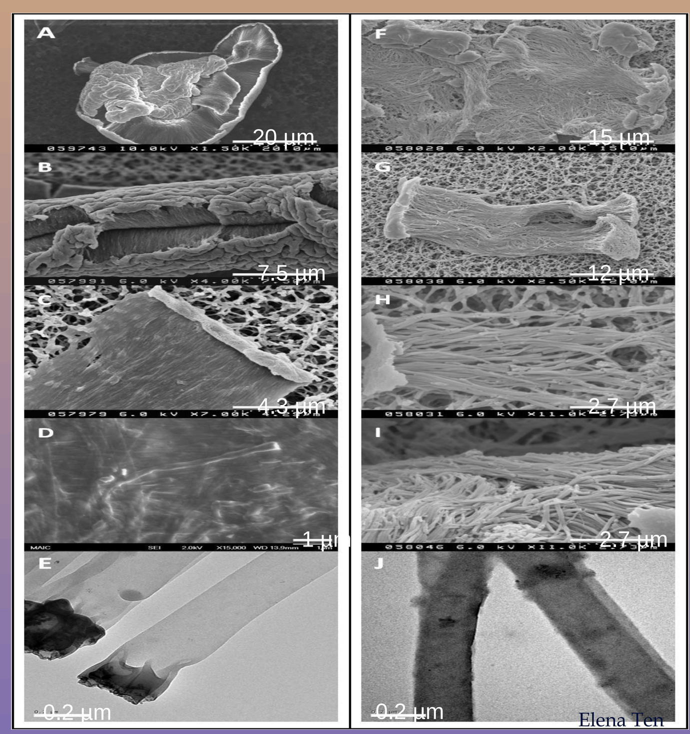
Pressure-flow curves to assess in situ: Root conductance, root stress analysis, root water status, soil to root conductance. Cultivar comparison and segregant population analysis.

Technical Area 2: Biofuels and Biobased Products Development

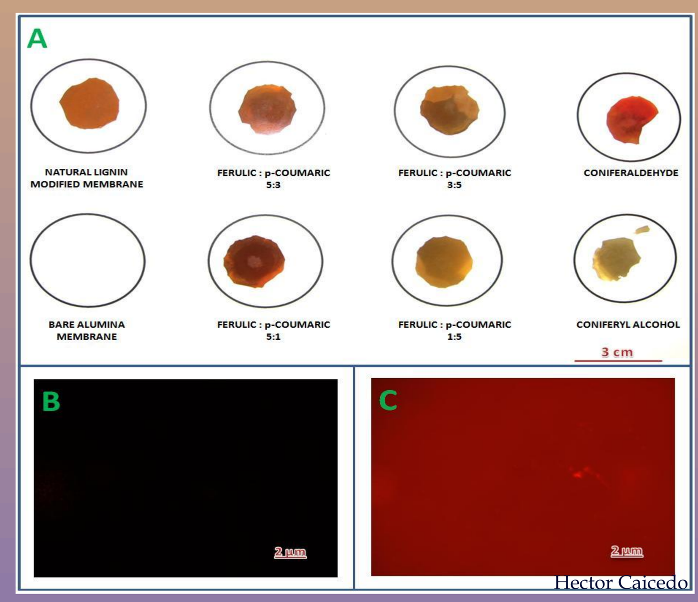
- Determination of nutritional suitability of juice for fermentative microbes.

Optimization of sweet sorghum bagasse pretreatment and fermentation with novel organisms able to utilize hemicellulose-derived sugars .

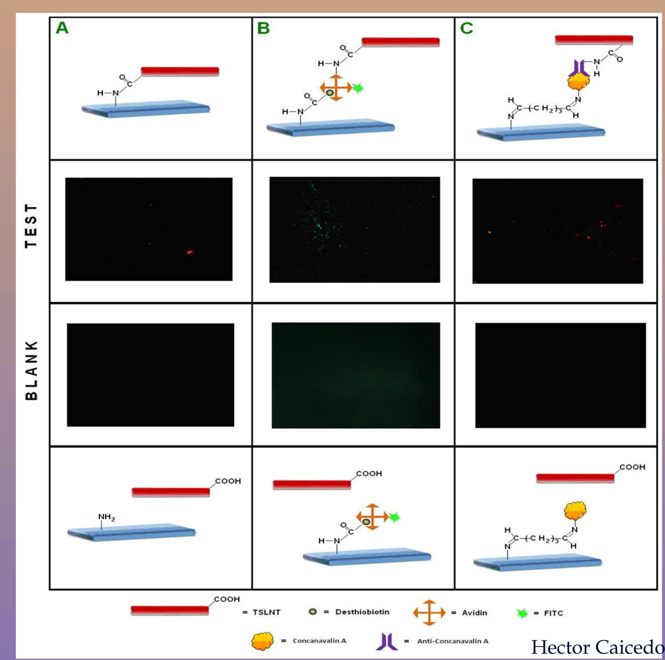
- Production of poly-lactic acid (PLA) composites reinforced with lignin and associated carbohydrates to expand the use and utility of PLA-derived polymers.
- Determination of the impact of lignin subunit composition on physico-chemical properties of lignin-based carbon nanotubes derived from the waste stream generated by bagasse processing.



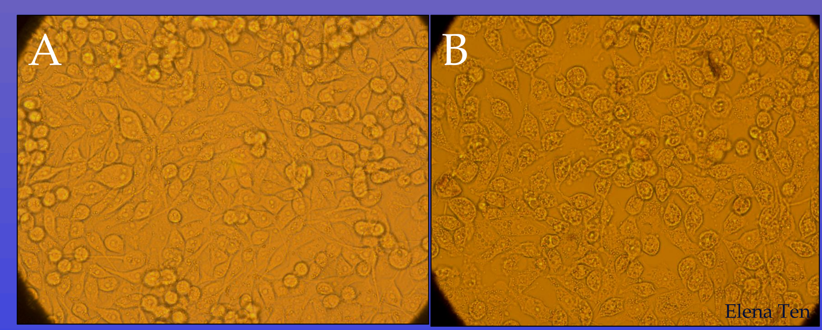
SEM (**a-d** and **f-i**) and TEM (**e, j**) lignin nanotubes synthesized with 5:1 (**a–e**) and 1:5 (**f–j**) molar ratios of ferulic acid and *p*-coumaric acid.



Photographs and fluorescence microscopy images of alumina templates before and after lignin nanotube synthesis. **(a)** membranes before dissolution showing variation in color resulting from lignin nanotubes synthesized with different types of monomers; **(b)** bare alumina membrane under UV light; (**c**) after synthesis of lignin nanotubes.



UV-fluorescence images (labeled 'test') of bio-functionalized-lignin nanotubes immobilized and visualized on an amino-derivatized glass platform.



Optical microscopy micrographs of (a) normal untreated HeLa (cancer) cells and (b) HeLa cells incubated for 72 hours with nanotubes derived from pine lignin by sulfuric acid treatment.

Technical Area 3: Biofuels Development Analysis

- Testing on a commercial scale the best performing sweet sorghums developed and generate production statistics (input/output)
- Perform a life cycle analysis to assess the changes in environmental impact associated with the use of water-use efficient sweet sorghums and the production of biofuels derived from bagasse.
- Perform an economic analysis to estimate the employment opportunities and market potential of implementing a bagasse-to-fuel process and generation of high-value co-products based on water-use efficient sweet sorghums.

Acknowledgements

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