Sugarcane biotechnology and production of fermentable sugars from biomass

Mark Harrison
Centre for Tropical Crops and Biocommodities
Queensland University of Technology

October 2012
Leading Australian university
- 42,500 students

Emphasis on applied research

Needs of industry and community

Brisbane based – global outlook
Enhanced levels of micronutrients

Fungal and viral disease resistance

Crops for Future Environments
Centre for Tropical Crops and Biocommodities
Brisbane, Australia

Fuel chemicals and bioproducts

Syngenta Centre for Sugarcane Biofuels Development

Extreme protein expression in plants
Bio-products (including ethanol) are critically dependent upon low cost, fermentable sugars.
Biomass to fermentable sugars

- Many bio-products (including ethanol) are critically dependent upon low cost fermentable sugars
Sugarcane... the best bioenergy crop?

Five reasons why sugarcane is the best bioenergy crop in Australia (and perhaps even the world...)

<table>
<thead>
<tr>
<th></th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Highly efficient photosynthetic crop</td>
</tr>
<tr>
<td>2</td>
<td>Huge resource - global</td>
</tr>
<tr>
<td>3</td>
<td>Established industrial crop</td>
</tr>
<tr>
<td>4</td>
<td>Resource - vastly under-utilised</td>
</tr>
<tr>
<td>5</td>
<td>Crop residue already at factory</td>
</tr>
</tbody>
</table>
Biomass to fermentable sugars

- Bio-products (including ethanol) are critically dependent upon low cost fermentable sugars
- The Syngenta Centre for Sugarcane Biofuels Development was established in 2008

Efficient, sustainable crop + Efficient harvesting & transport + Effective processing technologies + Ready access to sugars

In planta enzyme expression + Effective processing technologies + Low cost fermentable sugars
Plant made enzymes

- Major hurdle: cost of enzymes to convert biomass into fermentable sugars
- Production of tonnes of enzyme per day required
- Innovation: plant-made enzymes
- Production of fibrolytic enzymes in transgenic sugarcane brings together *in planta* expression with the best biomass crop
- Higher embedded value in sugarcane
- Significant and commercially-focused global partner
Plant made enzymes

- Innovation across 4 major areas required to deliver success:
  - efficient genetic transformation of sugarcane
  - a transgene expression “tool-kit” for sugarcane
  - biochemistry/enzymology of fibrolytic enzymes
  - complementary processing and pretreatment technologies
Plant made enzymes

- Innovation across 4 major areas required to deliver success:
  - efficient genetic transformation of sugarcane
  - a transgene expression “tool-kit” for sugarcane
  - biochemistry/enzymology of fibroloytic enzymes
  - complementary processing and pretreatment technologies
Plant made enzymes

- Innovation across 4 major areas required to deliver success:
- efficient genetic transformation of sugarcane
- a transgene expression “tool-kit” for sugarcane
- biochemistry/enzymology of fibrolytic enzymes
- complementary processing and pretreatment technologies
Plant made enzymes

- Innovation across 4 major areas required to deliver success:
  - efficient genetic transformation of sugarcane
  - a transgene expression “tool-kit” for sugarcane
  - biochemistry/enzymology of fibrolytic enzymes
  - complementary processing and pretreatment technologies
Plant made enzymes

- Innovation across 4 major areas required to deliver success:
  - efficient genetic transformation of sugarcane
  - a transgene expression “tool-kit” for sugarcane
  - biochemistry/enzymology of fibrolytic enzymes
  - complementary processing and pretreatment technologies
QUT Mackay Renewable Biocommodities Pilot Plant

- Pilot-scale research and development integrated biorefinery
- The facility links innovations in plant biotechnology and process development with assessment of commercial viability
- Funding for the facility was contingent on providing access to both academia and industry
Pilot scale and demonstration

- Reduce the risk associated with new technology
- Reduce investment risk
- Understand the process at a pre-commercial scale (lower cost)
- Produce product for market testing
- Provide data for commercial plant design
Biomass feed and pretreatment

Biomass preparation
- Biomass storage, size reduction
- Weighing machine

Andritz steam-ex pretreatment reactor
- Two-stage Hastelloy reactor with
- Integral hydraulic press
- Steam explosion vertical reactor
- Acid, alkali, solvent based processes
Hydrolysis and fermentation

- Hydrolysis reactors

- Fermentation equipment
  - Stirred fermenters – 10, 100, 1,000, 10,000 L
  - Airlift fermenters – 10, 100, 1,000 L
  - DO, pH, Temp, flow control
  - Aerobic, anaerobic
  - Batch, fed-batch, continuous
Bio-separation and product recovery

- Bio-separations equipment
- Centrifuges
- Rotary drum vacuum filtration
- Membrane filtration
- Distillation column
- Spray drier
- Fluidised bed dryer
- Autoclave
- Steriliser, CIP unit
- Assorted tanks and pumps
Acknowledgements

- Staff and students in the Centre for Tropical Crops and Biocommodities
- The staff of the Syngenta Centre for Sugarcane Biofuels Development
- Our colleagues at Syngenta Biotechnology Inc
- The funding bodies and organisations that have supported our work
Further information:  www.ctcb.qut.edu.au