Multiple Uses for *Eucalyptus grandis* Cultivars in Florida

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*Eucalyptus grandis* cultivars grown in Florida can be utilized in many ways:

- Landscape mulch
- Windbreaks
- Electrical power plants
- Biorefineries
- Synthesis gas
- Potting soil
- Medium density fiberboard
- Fence posts/ Lumber
Commercial E. grandis Cultivars

E.nergy™ Series Eucalyptus grandis Cultivars: G1, G2, G3, G4, G5
(US Patents PP21,582, PP21,571, PP21,569, PP21,570, and PPAF, respectively)

13.3-yr-old G4

2-yr-old G1, G2, G3
b) EG growing region

Uses of E. grandis

Mulchwood
Windbreaks
29.5 year power purchase agreement for 100% of the electricity

$200 million Generating Facility will begin construction in 2014 and start operating in 2016.

Bubbling fluidized bed boiler using a dry cooling system that minimizes the amount of water processed (50,000 gallons per day vs. 1.5 million processed by other facilities), resulting in less impact on local water supplies and other resources

$11 million annual local boost as phosphate mining leaves

350 construction jobs,
35 permanent jobs (@ $50K/yr) in the plant,
85 jobs (@ ~$40K/yr) associated with growing eucalyptus, thus bolstering local agriculture with another crop

Double Ft Meade's tax base
Ft. Meade Project Details

Facility on 25 acres within 1,148 acres of former phosphate land where some of the trees will be grown. Other feedstock will come from land leased from local farmers.

Dedicated eucalyptus plantations
- 100% of the necessary fuel.
- Establish 44 million trees over the next four years.
- Grown, harvested and coppiced on a 2- to 4-year rotation.
- ~650,000 tons/year transported to the facility and chipped on-site.

Ft Meade is the first of four biomass facilities US EcoGen plans following the same model, including eucalyptus as the feedstock.
Energywood
Phosphoric Lignocellulosic Biorefinery
To Decrease Ethanol Costs, Improve Environmental Aspects, and Produce High-Value Coproducts.

Research Advances Required for Process Simplification:

1. Develop biocatalysts with improved resistance to hemi toxins.

2. Replace Sulfuric with less aggressive acid – Phosphoric
   Gypsum piles replaced with crop fertilizer (borrowed)
   Eliminate Zirconium
   Lower the level of inhibitors

3. Solve mixing and pumping issues with high fiber solids 10-20% dw
   (Liquefaction tank; 6 h residence)

4. Develop process using only fertilizer chemicals
   (N,P,K,Mg,S,trace metals) Coproduct → New crops

   → Eliminates fiber washing, detox, separate fermentations, & develop co-product value for all process materials.

UF Stan Mayfield Biorefinery Pilot Plant
Woody Biomass

Dilute Acid Impregnation → High Temp Steam

Liquefaction

Fermentation (C5+C6) → Enzymatic

Distillation Purification

Ethanol & other chemicals

Fiber for boiler

No substrate fractionation
No liquid/solid separation
No toxin cleanup
No purification of sugars
No Zirconium or exotic metal
Fermentation broth = fertilizer
## Compositional Analysis (%) of E. grandis Cultivars

<table>
<thead>
<tr>
<th></th>
<th>Cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1</td>
</tr>
<tr>
<td>Glucan</td>
<td>38.8</td>
</tr>
<tr>
<td>Xylan</td>
<td>9.7</td>
</tr>
<tr>
<td>Galactan</td>
<td>1.8</td>
</tr>
<tr>
<td>Arabinan</td>
<td>5.0</td>
</tr>
<tr>
<td>Total Sugars</td>
<td>55.3</td>
</tr>
<tr>
<td>Lignin</td>
<td>33.2</td>
</tr>
</tbody>
</table>

Slight variability in characteristics
Phosphoric Acid Pretreatment: 200ºC, 0.8%, 5 minutes

Releases (g/kg) of E. grandis Cultivars

<table>
<thead>
<tr>
<th>Sugars</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellobiose</td>
<td>8.49</td>
<td>9.44</td>
<td>9.58</td>
<td>10.08</td>
</tr>
<tr>
<td>Glucose</td>
<td>15.17</td>
<td>18.66</td>
<td>18.77</td>
<td>20.42</td>
</tr>
<tr>
<td>Xylose</td>
<td>78.49</td>
<td>70.24</td>
<td>74.44</td>
<td>85.08</td>
</tr>
<tr>
<td>Galactose</td>
<td>15.24</td>
<td>17.53</td>
<td>16.49</td>
<td>15.66</td>
</tr>
<tr>
<td>Arabinose</td>
<td>14.18</td>
<td>11.15</td>
<td>15.35</td>
<td>15.26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inhibitors</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HMF</td>
<td>0.99</td>
<td>0.63</td>
<td>1.08</td>
<td>0.58</td>
</tr>
<tr>
<td>Furfural</td>
<td>3.94</td>
<td>3.73</td>
<td>4.14</td>
<td>4.71</td>
</tr>
<tr>
<td>Acetic Acid</td>
<td>16.90</td>
<td>17.44</td>
<td>16.20</td>
<td>18.20</td>
</tr>
</tbody>
</table>

Total Sugars | 131.57 | 127.01 | 134.93 | 146.48 |
Total Inhibitors | 21.82 | 21.81 | 21.42 | 23.49 |
Predicted Ethanol Yields

Up to 240g/kg biomass = 304L/tonne = 73 gal/ton
(vs 156 – 280g/kg of sugarcane)
### US Forest Service Synthesis Gas in a Down-Draft Biomass Gasifier

#### E. grandis Cultivar Gasification Suitability

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1</td>
</tr>
<tr>
<td><strong>Proximate Analysis</strong></td>
<td></td>
</tr>
<tr>
<td>Volatile Matter (%, dry)</td>
<td>83.1</td>
</tr>
<tr>
<td>Fixed Carbon (%, dry)</td>
<td>15.8</td>
</tr>
<tr>
<td>Ash Content (%, dry)</td>
<td>1.06</td>
</tr>
<tr>
<td>Moisture Content (%, dry)</td>
<td>10.5</td>
</tr>
<tr>
<td>Extractive Content (%, dry)</td>
<td>4.3</td>
</tr>
<tr>
<td>Higher Heat Value (BTU/lb)</td>
<td>7,572</td>
</tr>
</tbody>
</table>

Slight variability in characteristics but generally have the high volatile matter and heating values and low ash and moisture necessary for gasification.
Gasification Applications/Products

Planet Green Solutions

PGS-20kW, PGS-60kW, PGS-120kW

Methanol and Hydrogen

Synthetic Fuel

Biochar
Potting Soil Substitute for Peat Moss

Chipped Euc Stems

Industrial Hammermill

Ready for Mixing

G1 G2 G3
### Substrates in Study

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Peat (%)</th>
<th>Perlite (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peat (75%)</td>
<td>Perlite (25%)</td>
<td></td>
</tr>
<tr>
<td>G1 (75%)</td>
<td>Peat (25%)</td>
<td></td>
</tr>
<tr>
<td>G2 (75%)</td>
<td>Peat (25%)</td>
<td></td>
</tr>
<tr>
<td>G3 (75%)</td>
<td>Peat (25%)</td>
<td></td>
</tr>
<tr>
<td>Pine bark (50%)</td>
<td>Peat (33%)</td>
<td>Perlite (17%)</td>
</tr>
<tr>
<td>G1 (50%)</td>
<td>Peat (50%)</td>
<td></td>
</tr>
<tr>
<td>G2 (50%)</td>
<td>Peat (50%)</td>
<td></td>
</tr>
<tr>
<td>G3 (50%)</td>
<td>Peat (50%)</td>
<td></td>
</tr>
</tbody>
</table>

![Image of substrates and plants](image-url)
End of Study

38 days after planting

43 days after planting
Significance to Horticulture Industry

- Eucalyptus as a replacement/supplement for peatmoss and pine bark
  - Peatmoss (used for greenhouse crops)
    - from Canada, much of the cost associated with shipping
  - Pine bark (used for greenhouse & nursery crops)
    - less available and reduced quality: more burned for energy, fewer paper mills and sawmills
- Wood-based substrates (eucalyptus, whole pine tree, etc.) estimated to be similarly priced to peatmoss and pine bark
  - Greenhouse crops: finer texture required, must process with a Hammermill
  - Nursery crops: coarser material used, process using tub or horizontal grinder
Eucalyptus Substrates

• Benefits
  – Grown close to large segment of horticulture industry (FL, TX, and Gulf coast)
  – Sustainable/short rotation cropping systems

• Concerns
  – Nutrient and water availability
  – Economics and commercial availability
Composite Products:

Medium Density Fiberboard
OSB
Cement Board

Solid Wood Products:

Fence Posts
Lumber
Dendroremediation

b) EG growing region

Uses of E. grandis
Comparison of G2, G3, G4, and G5

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Cultivar</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth</td>
<td></td>
<td>Fast</td>
<td>Fast</td>
<td>Fast</td>
<td>Fast</td>
</tr>
<tr>
<td>Freeze-resilience</td>
<td></td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Average</td>
</tr>
<tr>
<td>Windfirmness</td>
<td></td>
<td>Average</td>
<td>Average</td>
<td>Resistant</td>
<td>Average</td>
</tr>
<tr>
<td>Coppice</td>
<td></td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>TC Propagation</td>
<td></td>
<td>Readily</td>
<td>Readily</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Pedigree (gen.)</td>
<td></td>
<td>4th</td>
<td>2nd</td>
<td>2nd</td>
<td>2nd</td>
</tr>
<tr>
<td>Wood density (kg/m$^3$)</td>
<td></td>
<td>522</td>
<td>470</td>
<td>640</td>
<td></td>
</tr>
<tr>
<td>Wood MC (dry wt)</td>
<td></td>
<td>104%</td>
<td>129%</td>
<td>89%</td>
<td></td>
</tr>
<tr>
<td>Chalcid</td>
<td></td>
<td>Resistant</td>
<td>Resistant</td>
<td>Resistant</td>
<td>Resistant</td>
</tr>
</tbody>
</table>

As short rotation woody crops, these cultivars may produce 16 dry tons/acre/year in 2.5 years.
Productive *Eucalyptus grandis* cultivars can be utilized for:

- Mulch
- Windbreaks
- Electricity
- Ethanol and coproducts
- Synthesis gas
- Potting soil
- MDF
- Fence posts/Lumber