Potential of *Eichhornia Crassipes* for Biomass Refining

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Introduction

• Department of Energy goal:
  • 60 Bgal/yr ethanol by 2030¹

• Current production
  • 5.4 Bgal/yr blended into gasoline for 2006²
  • 129 Ethanol plants, and growing

• The need for diverse feedstocks
  • Corn grain can only meet 15% of transportation needs¹
  • Cellulosic ethanol can fill remainder
  • Greater energy output/input ratio³

Feedstock Evaluation

• Ideal Attributes
  • Wide availability
  • Ease of cultivation
  • Frequent harvest cycles
  • No / low competition with food crops
  • Easy to process
  • Inexpensive

• Water hyacinth
  • Global invasive nuisance weed
  • Growth can exceed 200 tons DM / ha / yr
  • 2 week harvest cycle
  • Aquatic plant
  • Low-tech processing
  • Millions of dollars spent each year to remove / dispose
Process Description

- Cultivation
- Harvest & Collection
- Pressing
- Pretreatment / Storage
- Hydrolysis / Fermentation
Cultivation

• Infested waterways
  • Removal credit
  • Developing countries

• Hyacinth cultivation (farms)
  • Unused commercial ponds / lakes
Harvest & Collection

A Floating Island Shredder
Photo by J. Schiess
SHJ/Florida D.E.P.

Removing Floating Islands of vegetation with a Harvester
Photo by J. Schiess
SHJ/Florida D.E.P.

Harvester attempting to remove water hyacinth and water lettuce jam in Moore Haven Canal
Lake Okeechobee 1986
Photo by J. Schiess
2002 Florida D.E.P.
Harvest & Collection

- Novel cutter design
  - Simply slice mats
    - *Mat width design variable*
    - *Length dependent on connectivity*
  - Use less energy than traditional harvesters
  - Tow swaths of mats to shore
- **Cut pattern to allow re-growth**
Pressing

- Can remove approximately 97 wt% of the water
- Will decrease volume for silage
- Water will be processed (if necessary) and returned to lake
Pretreatment / Storage

- Partial Anaerobic digestion
  - Approximately 14 days
  - Less energy intensive
- Remove loose water
- Combine with storage to reduce costs
Process Cost Estimation

- Estimation allowed for multiple inputs to affect overall cost per ton to produce
- Referenced current biomass-to-ethanol evaluations
- Manufacturing cost estimation for chemical process industry adapted for agribusiness plan\(^1\)
- Key design parameters taken from literature, manufacturers, and best guesses

Key Design Parameters

- **Cultivation**
  - Lake covered in 300 acres of hyacinth
  - Located in United States
  - 100 ton dry matter / ha / yr

- **Harvest / Collection**
  - Cut width of 3.5 m
  - Cut speed of 45 m / min
  - Harvested 8 hours / day

- **Pressing**
  - 97 wt% water removal
  - Power usage: 18HP/ton fiber/hr

- **Pretreatment / Storage**
  - 14 days to digest

- **Misc.**
  - Labor ($10 / hr + benefits)
  - Overheads
  - Taxes, insurance
  - Depreciation
Total Cost: $28 / ton of dry matter
Sensitivity Analysis

- Lowest possible cost
  - 1 harvester & 1 transport boat
  - Cut width greater than 7m
  - Cut speed greater than 45 m/min
- Operation most likely at 3.5 m and 45 m/min
Future Work

- Investigation of digestion process
  - Temperature
  - pH
  - Residence time
- Hydrolysis methods
  - Acid
  - Enzymatic
- Fermentation yields
  - Quality of biomass produced
- Application to other aquatic nuisance weeds

Summary

- **Water hyacinth as a feedstock**
  - Rapid growth rate
  - Wide availability
  - Low cost

- **Exportable low-technology process**

- **Cost Estimation / Sensitivity Analysis**
  - *E. Crassipes* is an economically viable biomass feedstock
    - *A blight on an ecosystem can be used as an economic benefit*
    - *Cost competitive with other feedstocks (less than $40 per dry ton)*
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