Can sweet sorghum and sweet potato contribute to self-sufficiency of small farms?

Michael Bomford

5th Annual Small Farms Conference
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US Ethanol Mandates

Billion gallons vs. Exajoules

- Advanced biofuel
- Cellulosic biofuel
- Conventional biofuel

Energy Independence and Security Act of 2007, Section 202
Conventional Biofuel = Ethanol made from corn starch
US Ethanol Mandates

Cellulosic Biofuel = Renewable fuel made from cellulose, hemicellulose, or lignin, with lifecycle greenhouse gas emissions >60% below gasoline baseline.
US Ethanol Mandates

Advanced Biofuel = Renewable fuel not made from corn starch, with lifecycle greenhouse gas emissions >50% below gasoline baseline
US Energy Consumption by Source, 1775-2006

Exajoules

- Coal
- Natural gas
- Petroleum
- Nuclear
- Hydro
- Geothermal
- Solar
- Wind
- Biomass

DOE-EIA. 2007.
US Energy Consumption, 1950-2025
Renewable energy production

DOE-EIA. 2009. Energy Perspectives
U.S. Corn Use, 1990 - 2008

Bushels in Billions


Ethanol
FSI less ethanol
Exports
Feed & Residual

FSI = Food, seed, and industrial less ethanol.
Direct and indirect energy use by US farms, 1965-2002

Energy Consumption in Agriculture in Agriculture as a Producer and Consumer of Energy

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will biofuels offset a substantial portion (&gt;5%) of current US energy consumption?</td>
<td>No!</td>
</tr>
<tr>
<td>Can biofuels play a major role in advancing US farm and food system self-sufficiency?</td>
<td>Yes! (We won’t starve)</td>
</tr>
<tr>
<td>Large-scale agrofuels</td>
<td>Small-scale biofuels</td>
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<tr>
<td>----------------------</td>
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</tr>
<tr>
<td>Promote homogeneity</td>
<td>Promote biodiversity</td>
</tr>
<tr>
<td>Long-distance hauling, centralized processing, extensive distribution</td>
<td>Local or on-farm production and use</td>
</tr>
<tr>
<td>Resource consuming, waste generating</td>
<td>Resource cycling</td>
</tr>
</tbody>
</table>
Biofuels

Benefits

Liabilities

Fossil fuel & greenhouse gas offsets

Environmental & human well-being

Biofuels extent

Sustainable biofuels

• Feedstock
  – Low input
  – Diverse
  – Regionally adapted
  – Grown sustainably
  – Avoids land use conversion, waste

• Processing / distribution
  – Decentralized
  – Uses renewable energy
Small, organic, sustainable

• Smaller farms
  – Use land more efficiently
  – Promote biodiversity

• Organic farms
  – Use energy more efficiently
    (Synthetic fertilizers and pesticides use 30-50% of energy involved in grain production)
  – Promote biodiversity
“Because of its reduced energy inputs, organic agriculture is the ideal production method for biofuels.

[...] Organic agriculture offers a favourable energy balance because of its lower energy requirements.

As the aim of biofuels is to reduce dependency on nonrenewable energy sources and to mitigate environmental damage of fossil fuel emissions, organic production of biofuels furthers these goals in a way that conventional agriculture does not.”
Objectives

• Compare organic sweet sorghum and sweet potato to corn in terms of
  – Potential ethanol yield (land use efficiency)
  – Energy use efficiency
  – Labor use efficiency

• Compare efficiencies at three small organic farm scales
  – Biointensive
  – Market garden
  – Small farm
<table>
<thead>
<tr>
<th>Common name</th>
<th>Soybean</th>
<th>Corn</th>
<th>Sweet potato</th>
<th>Sweet sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Image</strong></td>
<td><img src="image1.png" alt="Soybean Image" /></td>
<td><img src="image2.png" alt="Corn Image" /></td>
<td><img src="image3.png" alt="Sweet potato Image" /></td>
<td><img src="image4.png" alt="Sweet sorghum Image" /></td>
</tr>
<tr>
<td><strong>Latin name</strong></td>
<td><em>Glycine max</em></td>
<td><em>Zea mays</em></td>
<td><em>Ipomoea batatas</em></td>
<td><em>Sorghum bicolor</em></td>
</tr>
<tr>
<td><strong>Food</strong></td>
<td>Edamame, soy-based products</td>
<td>Sweet corn, grain, syrup, etc.</td>
<td>Tubers, leaves</td>
<td>Syrup, grain</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Biodiesel from lipids in bean</td>
<td>Ethanol from starch (grain)</td>
<td>Ethanol from starch (tuber)</td>
<td>Ethanol from sugars (stalk) and starch (grain)</td>
</tr>
</tbody>
</table>
Small Farm Scales

• Biointensive
  – Human-powered; no fossil fuels
  – Smallest scale

• Market garden
  – Walk-behind tractor is largest fossil fuel powered machine

• Small farm
  – Conventional 4-wheeled tractors
Theoretical ethanol yield, 2008

Sweet sorghum
Preliminary Conclusions (Year 1 of 4)

- Yields under low input, small-scale organic production systems
  - Field corn about 33% below average
  - Sweet potato about average
  - Sweet sorghum about 50% higher than average

- Field corn and sweet sorghum yields lower in Biointensive-scale system; sweet potato yields similar across scales

- Biointensive scale gives highest energy efficiency; small farm gives highest land and labor use efficiency

- Sweet sorghum and sweet potato more compatible with low-input small farm systems than corn
Observations (year 2 of 4)

- All crops look better in 2009 (wet year) than in 2008 (dry year)
- Biointensive plots performing much better in 2009
Microfueler

- Manufacturer claims to be “more power-efficient than US commercial ethanol plants due to its advanced membrane filtration technology and a non-combustion fermentation and distillation process”
- Starting on-farm tests this fall
By Michael Bomford

At the beginning of July 2008 I posted pictures of the farm scale study at Kentucky State University. Here are some pictures of the same study, repeated in 2009. The plot diagram that I posted in 2008 is identical for 2009, except that we have rotated the crops:

- Last year’s soybean rows are this year’s corn.
- Last year’s corn is this year’s sweet potato.
Thanks to

- Tony Silvernail
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- John Bell
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