Organic Sweet Sorghum & Edamame Soybean

Michael Bomford, PhD
Kentucky State University
Outline

1. Sweet sorghum production & processing
2. Intermission – How do organic sweet sorghum and soybean relate to big picture issues regarding farm and food system energy?
3. Edamame soybean production & processing
Sweet sorghum & Edamame soybean

- Lesser-grown varieties of major crops
- Niche markets
- High value... suitable for small farms
- Labor intensive
  - Fairly easy to grow, but lots of work between harvest and sale
- Low input... soybeans fix their own N; sweet sorghum needs little N and is drought tolerant
Sorghum

- *Sorghum bicolor* (L.) Moench
- Native to Africa
  - Domesticated 5,000-8,000 years ago
  - First crop sown on newly cultivated land in 18th century Ethiopia
  - Drought tolerant
  - Breaks up soil, scavenges nutrients, roots build fertility through decomposition
  - Allelopathic
- Introduced to America in 1757

## Types of Sorghum

<table>
<thead>
<tr>
<th></th>
<th>Grain sorghum (Milo)</th>
<th>Forage sorghum</th>
<th>Sweet sorghum (Sorgo, Cane)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height</strong></td>
<td>2-4’</td>
<td>6-12’</td>
<td>8-12’</td>
</tr>
<tr>
<td><strong>Bred for</strong></td>
<td>High grain:stalk ratio (dwarfing genes)</td>
<td>High dry matter content</td>
<td>High sugar content (15-20%) in juice</td>
</tr>
<tr>
<td><strong>Uses</strong></td>
<td>Livestock feed, biofuel, pet food, human food</td>
<td>Silage</td>
<td>Syrup, molasses, sugar, ethanol</td>
</tr>
<tr>
<td><strong>US Acres</strong></td>
<td>4.4 million</td>
<td>273,000</td>
<td>30,000</td>
</tr>
</tbody>
</table>
Sweet Sorghum:
Site selection

- Performs well on a wide range of soils
  - Prefers good drainage
- Sensitive to acidity (lime to pH >5.8)
- Low N requirement (~40 lb/ac)
  - No N necessary after legumes
  - Don’t plant after poultry litter application
- Out-competes many weeds
  - Tall, allelopathic
  - Plan for 1-2 cultivations between rows when plants are <12” tall
Planting

• Warm season crop
  – Drought tolerant
  – Heat tolerant
  – Grows slowly in cold
  – Frost sensitive

• Early-mid May planting is best; no later than early June (100-130 days to harvest)

• Direct seed, or transplant 2-3 week old seedlings for earlier harvest

• 3’ rows; 4-6” between plants
Harvest

• Hand
  – Tobacco knives, machetes, sharpened hoes

• Small machinery
  – Sickle bar mower, hedge trimmer

• Large machinery
  – Corn binder, forage chopper, in field juicer
Juice

- Juice extraction
  - Old roller mills extract 50-60% of stalk weight as juice
  - Short shelf life
Syrup

• Boil down to 78% sugar
• Batch or continuous flow pan
• Energy intensive, time consuming
<table>
<thead>
<tr>
<th>Location and Variety</th>
<th>Stripped stalks</th>
<th>Syrup/ton of stalks</th>
<th>Syrup/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tons/acre</td>
<td>Gallons</td>
<td>Gallons</td>
</tr>
<tr>
<td>Blairsville, GA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brandes</td>
<td>18.7</td>
<td>11.7</td>
<td>219</td>
</tr>
<tr>
<td>Dale</td>
<td>18.6</td>
<td>13.1</td>
<td>243</td>
</tr>
<tr>
<td>Theis</td>
<td>17.9</td>
<td>11.6</td>
<td>208</td>
</tr>
<tr>
<td>Williams</td>
<td>19.9</td>
<td>16.6</td>
<td>328</td>
</tr>
<tr>
<td>Quicksand, KY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brandes</td>
<td>19.0</td>
<td>11.7</td>
<td>222</td>
</tr>
<tr>
<td>Dale</td>
<td>20.0</td>
<td>13.9</td>
<td>278</td>
</tr>
<tr>
<td>Theis</td>
<td>20.1</td>
<td>13.1</td>
<td>262</td>
</tr>
<tr>
<td>Williams</td>
<td>13.4</td>
<td>10.9</td>
<td>146</td>
</tr>
</tbody>
</table>

\(^1\text{Freeman et al., 1986. USDA Agr. Handbook No. 611.}\)
Economics

- Fixed & variable costs: $800-$1000/acre
- Labor accounts for more than half of cost
- Break even yield is 66 gallons per acre at $15 per gallon
- Average yield is 175 gallons per acre
- 200-300 gallons per acre
- $20-$25 per gallon (conservative)
- $2,500 per acre return

Much higher prices available, according to audience.
Sweet, Sweet Sorghum: Kentucky’s Golden Wonder

• “I wrote *Sweet Sweet Sorghum* to encourage more people to eat this luscious, nutritious food I have loved as long as I can remember. Sorghum is that rare food that is good, good for us, good for small farms and farm families, good for communities, and good for the earth…”

• “Eco-friendly, anti-oxidant-rich, cash producing sorghum cane, which growers around the world use for food, fiber, and fuel, can support our farms and small communities. Those of us who love the small farms and farmers of Kentucky and the rest of Sorghum Nation have the future in our sticky hands.”

• “If we eat it, growers will grow it.”
  – Rona Roberts, 2011
National Sweet Sorghum Producers and Processors Association

• Annual meeting:
  February 16-18, 2012
  Pigeon Forge, Tennessee
• $20/year membership
• Newsletter, classifieds
Ethanol
Biggest Crops in USA

Harvested area (Million ac)

- Corn
- Soybean
- Hay
- Wheat
- Sorghum

Slide skipped in oral presentation due to time constraints.
U.S. Sorghum Acres

Million acres

Slide skipped in oral presentation due to time constraints
Slide skipped in oral presentation due to time constraints.
Direct and indirect energy use by US farms, 1965-2002

- Fertilizers and pesticides
- Natural Gas
- Propane
- Electricity
- Diesel
- Gasoline

Slide skipped in oral presentation due to time constraints
US Food System
Energy Use, 2002

Non-food 85.6%
Food 14.4%

Transportation 0.6%
Wholesale & retail 2.2%
Food service 1.7%
Households 4.1%
Agriculture 2.0%
Processing 2.8%
Packaging 0.9%

Low input farming techniques

• Organic
• Cover cropping
• Conservation tillage
• Integrated Pest Management

• Even more important:
  – low input processing, distribution, storage, preparation

Slide skipped in oral presentation due to time constraints
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.”
Why On-Farm Production?

- Farms can be energy producers
- Resilience
  - Local production keeps resources (nutrients, dollars) cycling locally
  - Local production gives autonomy/security
  - Decentralized, distributed generation reduces opportunities for supply shocks
  - Distributed generation spreads wealth, risks

Slide skipped in oral presentation due to time constraints
<table>
<thead>
<tr>
<th>Large-scale agrofuels</th>
<th>Small-scale biofuels</th>
</tr>
</thead>
<tbody>
<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

Terrestrial N Cycle

Flows measured in millions of metric tons (Tg) of nitrogen.

- Lightning, 5
- Fossil fuel use, 25
- Industry, 130
- Bacteria & algae, 140
- Fixed, 300
- Recycled
- Atmosphere, 110
- Ocean, via atmosphere, 55
- Rivers & lakes, 60
- Ground-water, 15
- Biosphere, 10

Annual nitrogen flow to and from terrestrial ecosystems

- Anthropogenic
- Pre-industrial
- Combined

Bomford, 2011. *Agriculture and Natural Gas.*

Slide skipped in oral presentation due to time constraints.
Soybean

• *Glycine max* (L.) Merr.
• Native to East Asia
  – Widely grown in China for past 5,000 years
  – Introduced to Japan and Korea before written records
  – Considered sacred for its ability to fix nitrogen
  – Used in fermented food products (soy sauce, natto, miso, tempeh)
• Introduced to America in 1765
  – Not used for food in US until 1920s
  – Promoted by Henry Ford, who spent $1.25 million on soybean research
  – Used to build soil after dustbowl
Nodules on Soybean Roots
Soybean makes a good summer cover crop… (if you don’t harvest the beans)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Seeding rate (lb/ac)</th>
<th>Aboveground biomass (lb/ac)</th>
<th>C:N</th>
<th>Nitrogen (lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Legume</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cowpea</td>
<td>70</td>
<td>3529</td>
<td>21</td>
<td>75</td>
</tr>
<tr>
<td>Sesbania</td>
<td>20</td>
<td>4278</td>
<td>23</td>
<td>86</td>
</tr>
<tr>
<td>Soybean</td>
<td>90</td>
<td>3505</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>Velvetbean</td>
<td>40</td>
<td>1263</td>
<td>21</td>
<td>28</td>
</tr>
<tr>
<td><strong>Non-Legume</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum-sudangrass</td>
<td>35</td>
<td>7825</td>
<td>53</td>
<td>78</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>30</td>
<td>5936</td>
<td>50</td>
<td>57</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>60</td>
<td>3157</td>
<td>34</td>
<td>43</td>
</tr>
</tbody>
</table>

Edamame: Immature Soybean

- Green vegetable soybean
- Bred for large bean, and sweet, nutty flavor, similar to boiled peanuts
- Boiled as green bean, or in pod
- Eaten in Japan since at least 1275
- Nutritious:
  - rich in carbohydrates, protein, dietary fiber, omega-3 fatty acids and micronutrients (folic acid, manganese, vitamin K)
McDonald's premium salads

US Edamame Imports (tons)

A harmonious blend of crisp greens, warm orange-glazed chicken (grilled or crispy), snow peas, edamame, mandarin oranges, and toasted almonds. Add the Newman’s Own® Low-Fat Sesame Ginger dressing, and we’re talking pure inspiration.
Edamame soybean: Site selection

• Same as oilseed soybean
• Grows on a wide range of soils, but performs best on deep, well-drained soil
• Low weed pressure
• Avoid areas known to be infested with soybean cyst nematode (stunted ovals in field with cysts on plant roots)

Cysts from soybean cyst nematode are much smaller than root nodules.

Edamame varieties suited to all latitudes in US
Planting Edamame Soybean

- Organic seed available for several varieties
- Don’t pre-soak seed
- Inoculate with soybean inoculant if land is new to soybean (Take care to avoid GMO inoculants on organic land… check OMRI)
- Seed is larger than oilseed soybean… need bigger seeder plate
- Plant after soil reaches 60 °F (early June). Poor germination in cool soil. 60-90 days to harvest.
- Seed every 3” in rows 1.5’ - 3’ apart
## Budget Snapshot: 1 Acre Green Edible Soybeans

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>6,000-10,000 pounds</td>
</tr>
<tr>
<td>Wholesale Price</td>
<td>$1.50/pound</td>
</tr>
<tr>
<td>Preharvest Variable Costs</td>
<td>$500-$1,000</td>
</tr>
<tr>
<td>Harvesting and Handling (boxes, picking, cooling)</td>
<td>$5,500-$9,500</td>
</tr>
<tr>
<td>Total Costs (including fixed costs)</td>
<td>$6,750-$11,250</td>
</tr>
<tr>
<td><strong>Projected Net Return</strong></td>
<td><strong>$400-$2,500</strong></td>
</tr>
</tbody>
</table>

*From Matthew Ernst. [Edamame](#). University of Kentucky Ag Economics.*

*Much higher prices available, according to audience.*
Edamame stripper

- Strip 250 plants/hr instead of 30-40 plants/hr
• Top: Combine Harvester
• Left: Pod sorter
• Right: Pod sheller

S. Shanmugasundara. 1990. *Mechanization of Vegetable Soybean Production in Taiwan*. AVRDC.
Post harvest

- Cool to improve shelf life (1-2 weeks fresh)
  - Harvest in early morning
  - Strip beans in shade, or in cool room
  - Store in cooler
- Beans freeze well
Beans can be sold on the stem

- Common in Japan
- Keeps beans alive and fresh
- Works at some farmers’ markets; not accepted by wholesalers

Photo by Todd Pfeiffer, University of Kentucky (Source)
Questions?

- Michael Bomford
- 502-597-5752
- Michael.Bomford@KYSU.edu
- http://Organic.KYSU.edu