Industrial Hemp as a Modern U.S. Commodity Crop

D.W. Williams
UK Department of Plant and Soil Sciences
UK Robinson Center for Appalachian Resource Sustainability

University of Kentucky
College of Agriculture, Food and Environment

Cannabis sativa L.

Photo: Matt Barton

Photo: Matt Barton
History of industrial hemp

• Native to central Asia; propagated for 1000s of years.

• Was one of the main textile fibers of the world until the mid/late-19th century.

• After the federal Marihuana Tax Act was enacted in 1938, nearly all hemp production ceased (except for a brief revival during WWII). Not illegal until 1970.

Hemp Botany

- Summer annual
- Can be dioecious or monoecious
- Exhibits strong photoperiodic flowering
- Huge phenotypical and biochemical differences among genotypes
Why grow hemp today?

Three major harvestable components:

- Fiber
- Grain
- Cannabinoids

Bast and hurd fibers

- Industrial applications (injected, molded)
- Composite materials (green plastic)
- Building materials
- Fabrics
- Animal bedding
- Energy/carbon sequestration?
- Carbonaceous materials?

Grown for fiber...

- Goal is strong vegetative growth
  - Variety selection is key relative to latitude and climate
  - Planting date is key relative to variety
- Not too much fertilizer
- Harvest is at the onset of reproductive growth
  - BPs and new engineering for harvest equipment are under investigation
  - Rotting is key to success in high-quality fiber production regardless of other factors
Sunstrand’s Value

Hemp for Food... Human or animal food; depends on where you are. Or... for propagation (certified seed).
Hemp for grain...

- Mostly very different varieties than those bred primarily for fiber (latitude of origin?).
  - Shorter stature much easier to harvest with conventional equipment.
  - Again, variety selection relative to latitude and climate is paramount.
- More fertilizer; pretty much like corn.
- Harvest at 75% maturity, but must be dried immediately.
- Dual-purpose crops are harvested for grain initially and fiber subsequently.

Hemp for cannabinoids

"As noted, until now, Epidiolex has been a schedule I controlled substance. By virtue of this order, Epidiolex (and any generic versions of the same formulation that might be approved by the FDA in the future) will be a schedule V controlled substance. Thus, all persons in the distribution chain who handle Epidiolex in the United States (importers, manufacturers, distributors, and practitioners) must comply with the requirements of the CSA and DEA regulations relating to schedule V controlled substances."

"As further indicated, any material, compound, mixture, or preparation other than Epidiolex that falls within the CSA definition of marijuana set forth in 21 U.S.C. 802(16), including any non-FDA-approved CBD extract that falls within such definition, remains a schedule I controlled substance under the CSA."
2018 Hemp Farming Act/Farm Bill

Conforming changes to Controlled Substances Act
(a) In general
Section 102(16) of the Controlled Substances Act (21 U.S.C. 802(16)) is amended—
(1) by striking (16) The and inserting (16)(A) Subject to subparagraph (B), the; and
(2) by striking Such term does not include the and inserting the following:
   (B) The term marijuana does not include—
      (i) hemp, as defined in section 297A of the Agricultural Marketing Act of 1946; or
      (ii) the

Additionally, cannabinoid production models are derived from other Cannabis systems where the harvestable component has been dried/cured buds, and broad acre production has never been utilized.
Hemp for cannabinoids...

• For optimal production, could essentially be the same exact system as other current Cannabis production systems.
  • Mainly interested in female flower buds, no male or pollinated (fertilized) flowers.

• BP's for field-scale production of cannabinoids are completely unknown.
  • Variety selection?
  • Planting methods?
  • Fertility?
  • Harvest methods?
  • Cutting?
  • Chopped/dried/ensiled/dual-purpose models could very likely be competitive.
  • European model (dual purpose with grain)?

---

### Production Report Data*

<table>
<thead>
<tr>
<th></th>
<th>Grain</th>
<th>Fiber</th>
<th>Floral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower</td>
<td>20</td>
<td>14</td>
<td>112</td>
</tr>
<tr>
<td>Acres Planted</td>
<td>1,237</td>
<td>1,898</td>
<td>1,983</td>
</tr>
<tr>
<td>Acres Harvested</td>
<td>808</td>
<td>820</td>
<td>1,371</td>
</tr>
<tr>
<td>Avg. Yield lb/acre</td>
<td>516</td>
<td>2,956</td>
<td>1,024</td>
</tr>
<tr>
<td>Avg. Price per lb</td>
<td>$1.70</td>
<td>$0.94</td>
<td>$7.20</td>
</tr>
</tbody>
</table>

*Production analysis of 2017 production report data is not complete. Average Yield was calculated only from plots with reported yield above zero (Does not include dual purpose Grain & Floral).
Kentucky Program Highlights

2019 KY Hemp Program Data-Growers

- 1,075 – Grower Applications (371 Postmarked, 704 Walking)
- 323 – Previous Participants
- 853 – New Applicants
- 45,250+ – Requested Acres
- 1,455 – Different Growing Addresses
- 98 – Different Counties Represented

- 1,099 – Applicants planning to grow for Floral Material
- 330 – Applicants planning to grow for Fiber (often dual-purpose)
- 248 – Applicants planning to grow for Grain (often dual-purpose)

From: KDA hemp program

2019 KY Hemp Program Data-Processors, etc.

- 113 – Total Potential Processor/Handlers
- 41 – New Processor Applications
- 72 – Returning Multi-year Processors

- 60 – Processors of Floral Material (CBD Extractors)
- 22 – Fiber Processors
- 29 – Grain Processors
- 17 – Handlers (Labs, Brokers, etc.)

From: KDA hemp program
Maturity of global hemp industry efforts

• Europe: 12 March 1998

• EU: Not precise (never banned in Finland, Sweden, 1995, France, 1996, etc. France hemp support: Federation of Agricultural R&D Institute, 2015.

• China: Not precise, never banned in China's countrywide regulation, 1998. EU: 1993; Germany, 1996, etc.


General Statistics

Global hemp compared to standard U.S. commodities

• Preliminary information for 2017 indicate that hemp acreage increased and the European Union (EU) estimates reached record levels which could put global acreage at more than 300,000 acres.” From: Hemp as an Agricultural Commodity. Renée Johnson, Specialist in Agricultural Policy. June 22, 2018. Congressional Research Service.

• U.S. 2017 Acreage (values)
  • Corn = 90.9 million A ($41 billion/522B)
  • Soybeans = 89.5 million A ($41 billion/548B)
  • Wheat = 12.1 million A ($7.75 billion/599B)
  • Cotton = 12.1 million A ($7.75 billion/599B)

• Canada = 3.29 million ($532 million/526B)
• Sunflower = 2.15 million ($390 million/527B)

Source: USDA NASS

Photo: Matt Barton
### Potential Returns

#### Hemp Returns/Acre (does not include land cost) Seed Production Only

<table>
<thead>
<tr>
<th>Seed Price/lb</th>
<th>Low Prod (100 bu corn)</th>
<th>Medium—Low Prod (125 bu corn)</th>
<th>Medium—High Prod (150 bu corn)</th>
<th>High Prod (175 bu corn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.50</td>
<td>$66</td>
<td>$134</td>
<td>$202</td>
<td>$260</td>
</tr>
<tr>
<td>$0.60</td>
<td>$56</td>
<td>$118</td>
<td>$186</td>
<td>$244</td>
</tr>
<tr>
<td>$0.70</td>
<td>$45</td>
<td>$108</td>
<td>$176</td>
<td>$234</td>
</tr>
<tr>
<td>$0.80</td>
<td>$35</td>
<td>$98</td>
<td>$164</td>
<td>$222</td>
</tr>
</tbody>
</table>

#### Seed Production Only

- Low Prod (100 bu corn) = $66
- Medium—Low Prod (125 bu corn) = $134
- Medium—High Prod (150 bu corn) = $202
- High Prod (175 bu corn) = $260

#### Corn—Soybean Rotation

- $121 (5/bu Corn/$11.25/bu Soybeans) = ($3.66/$8.76)

### Notes

- Costs include labor and depreciation/overhead but not land costs.
- $3.50/gal fuel; N, P, and K at $.50/unit; 50 miles one-way trucking to market.

### Economic Considerations for Growing Industrial Hemp: Implications for Kentucky’s Farmers and Agricultural Economy

- Assumes 650#/A hemp grain yields

- What about certified seed production?

- Fibers especially are equally simple—just need yield!

- Cannabinoid economics are EXTREMELY complex and not well defined—today unsustainable and ludicrous.

### UK Industrial Hemp Research—Overview

- Research efforts have expanded at UK both in scope and scale each year 2014–2018.

- Includes efforts in multiple departments/units within UK:
  - Agronomy
  - Plant biochemistry/physiology
  - Plant molecular biology
  - Ecosystems and agricultural engineering
  - Horticulture
  - Agricultural economics
  - Plant pathology
  - Animal and Veterinary/Equine Sciences
UK Agronomic Hemp Data-Fiber

• Until 2018, 3.8 ton/A; 5.1 ton/A this year

• Effects of plant populations on yield, stem morphology, and uniformity of physical characteristics
  • Seeding rates
  • Row spacing

• Seed production from fiber lines
  • Planting dates

UK Agronomic Hemp Data-Grain

• ~1000#/A since 2015

• Still very excited about the potential for certified seed

• Quantity and quality of oil from hemp grain
  • Significant differences in both among varieties

• Dual-purpose trials
  • Grain yields okay
  • Straw ~1.5 ton/A
  • Grain/cannabinoids?
UK Agronomic Hemp Data-Cannabinoids

- Economics are undefinable today
- Production models totally up in the air
- Significant differences in pollinated vs. un-pollinated buds
  - Greenhouse
  - Field confounded by location, theoretically by other means as well.
- Need work on production models, perhaps dual-purpose cannabinoid crops if the molecule is the harvestable component of interest
  - Grain vs. fiber versus
    - Baling?

- Need work on production models, perhaps dual-purpose cannabinoid crops if the molecule is the harvestable component of interest

<table>
<thead>
<tr>
<th>Pollinated</th>
<th>Not Pollinated</th>
<th>Pollinated</th>
<th>Not Pollinated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom</td>
<td>3.97 1.32 1.79</td>
<td>4.52 2.06 1.66</td>
<td>7.87 3.43 1.69</td>
</tr>
<tr>
<td>Top</td>
<td>6.62 2.81 2.04</td>
<td>6.71 3.24 2.14</td>
<td>6.10 3.56 2.13</td>
</tr>
</tbody>
</table>

Total CBD Concentrations as a Function of Pollination and Bud Location on Plants Grown in the Greenhouse or in the Field
Direct Acknowledgements

- Kentucky Department of Agriculture: Commissioners Comer and Quarles, Brent Burchett, Doris Hamilton, et al.
- UK CAFE administration
- UK Dept. of Plant and Soil Sciences
- Kentucky Tobacco Research and Development Center
- Several corporate supporters
Agronomic Industrial Hemp Research
Uk-Robinson Sub-station

Photo: Matt Barton

david.williams@uky.edu
hemp.ca.uky.edu