UNIVERSITY OF KENTUCKY College of Agriculture, Food and Environment

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY COLLEGE OF AGRICULTURE, FOOD AND ENVIRONMENT
Center for Crop Diversification Crop Profile

Industrial Hemp Production

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Introduction

Industrial hemp (*Cannabis sativa* L.) is a versatile plant that can be grown for its fiber, seed, or oil. Hemp fields were once a common sight in Kentucky during the state's prominence as the leading hemp producer in the U.S. Although commercial hemp production ceased throughout North America in the late 1950s, there is currently renewed interest in growing this crop. While hemp faces significant legal obstacles due to its close relationship to the marijuana plant, there are a number of states, including Kentucky, working toward reviving the hemp industry. Section 7606 of the Agricultural Act of 2014 (the federal farm bill) authorized state departments of agriculture in states that have legalized hemp, including Kentucky, to develop pilot programs for industrial hemp research. The Kentucky Department of Agriculture has been working with universities, farmers and processors around the state since 2014 to implement pilot programs.

This profile is intended to provide an overview of hemp cultivation and economics; this information will be updated as data becomes available from the pilot programs. For more information on the current situation of industrial hemp, refer to the companion profile "Industrial Hemp — Legal Issues."

Marketing

Hemp fibers have been used to manufacture hundreds of products that include fiber for injected/molded composite materials, twine, paper, construction materials, carpeting, clothing, and animal bedding. Seeds have been used in making industrial oils, cosmetics and other personal care products, and medicines. Hemp seed or oil can be found in cooking oil, salad dressings, pasta, and snack products. This crop has also generated great interest among pharmaceutical and medical researchers.

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Currently all hemp products sold in the U.S. are imported or manufactured from imported hemp. American food processors

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and product manufacturers using imported hemp seed oil and hemp fiber could be interested in a domestic product. Because of the need for processing plants to process hemp from field production, and the apparent lack of such industry in the U.S., substantial infrastructure development would be required for profitable U.S. farm production. Substantial research would also be required for new uses of hemp, such as in the pharmaceutical industry.

Market Outlook

The fact that the commercial production of hemp has been legally prohibited in the United States has not deterred substantial interest in the feasibility of U.S.-grown industrial hemp. Both federal and state research institutions have conducted many production and market feasibility studies. A number of these studies are listed and summarized in a 2015 Congressional Research Service report, "Hemp as an Agricultural Commodity." This study, like others, notes that potential U.S. producers face not only existing regulatory prohibitions on industrial hemp, but also substantial international competition, particularly from Canadian, European, and Chinese producers. This is due to industry infrastructure development (Canada and Europe) and labor cost savings (China).

There is significant interest in using natural fibers such as hemp instead of synthetic fibers for a number of industrial applications. Examples include manufacturing composite parts for vehicles, as well as construction materials such as hempcrete and hemp ceiling tiles. There are corporate entities in Kentucky investing in infrastructure to purchase hemp fiber from producers and process it into a useable product.

Other market segments for hemp products may include hemp food and body care products. Notably, hemp and hemp seed oil are ingredients in some certified organic foods, which have been gaining greater popularity in recent years. Certified organic hemp could be a possible growth market in North America.

Potential industrial hemp commodity production in the United States would need to be accompanied by marketing plans that address advantages held by existing international producers. Adequate hemp processing facilities would also likely need to be in close proximity to potential new producers, with site-specific market and processing feasibility analysis required.

Production Considerations

Despite Kentucky's prior history of production, industrial hemp is basically an untested crop in this state. Agriculture as a whole has changed considerably since hemp's heyday, so past production information cannot be relied upon to determine how the crop should be grown and harvested today. Local research will be needed to provide specific data on cultural requirements, such as plant spacing and nutritional needs, as well as harvest and processing methods. Meanwhile, the following information has been gleaned from other countries, such as Canada, that are currently growing hemp, as well as research that began in Kentucky in 2014.

Cultivar selection

Industrial hemp and marijuana are genetically different cultivars of the same plant species and are distinguished from one another based on their intended use and tetrahydrocannabinol (THC) levels. THC is the main chemical that gives marijuana users their "high." While marijuana cultivars typically contain more than 3% to 15% THC by weight, hemp cultivars are bred to contain only trace amounts (less than or equal to 0.3%).

Another cannibinoid that can be harvested from hemp is cannabidiol or CBD. CDB has shown promise in treating epilepsy, and has been used as an analgesic, an anti-depressant, and as an appetite enhancer. Dozens of additional cannabinoids are present in hemp, but research on their potential as pharmaceuticals has not yet been conducted.

Fiber yields, fiber quality, seed size, oil content,

and oil composition vary among hemp cultivars. Dual-purpose cultivars are suitable for both fiber and seed uses; however, the current industry trend in other countries seems to be toward selecting varieties specific for one use or the other. The University of Kentucky began basic agronomic research in 2015 with varieties grown for each purpose - fiber, grain, and cannabinoids. Should commercial production of industrial hemp return to the Commonwealth, it is anticipated that hemp will be grown under contracts that specify the cultivar.

Industrial hemp production has been legal in Canada since the 1990s. Only varieties included in their List of Approved Cultivars (published by Health Canada) are permitted for production. These varieties contain less than 0.3% THC under normal growing conditions, and most are of European origin. It is unknown at this time which varieties would be most suitable for Kentucky production.

Site selection and planting

Industrial hemp grows best on well-drained soils with high fertility and rich in organic matter. Soil pH should be at or slightly below neutral. Days to maturity and seed quality should be considered when choosing varieties. There are currently no U.S. standards for seed certification. Hemp seed needs moisture to germinate or weeds will take over. An ideal seeding depth is ¼-inch, and it germinates best in a firm bed. Although hemp has been considered to be a low-input crop, yields and quality suffer when plants are grown in poorly drained clay soils, as well as soils low in fertility. The best yields are attained when hemp is grown with inputs similar to corn and wheat.

Seeding can be accomplished with a standard grain drill using either conventional tillage or no-till. In general, hemp seed should be planted in late April or early May in Kentucky. Although seedlings can tolerate some frost in the spring, it is best to seed hemp after the danger of a killing frost has passed and soil temperatures are 46° F or above. Experience in Canada indicates that

Hemp seed

early plantings yield more fiber. Spacing depends on the cultivar and end use. Generally, hemp for fiber is planted in dense stands to promote taller height and discourage branching and flowering, thus maximizing fiber yields. On the other hand, since flowering and branching are desirable for seed production, plants are spaced farther apart. For more information on seeding rate, row spacing and fertilizer requirements, please see the University of Kentucky publication "An Introduction to Industrial Hemp, Hemp Agronomy, and UK Agronomic Hemp Research," (http://hemp.ca.uky.edu/sites/hemp.ca.uky.edu/files/general/2015_hemp_article.pdf).

Pest management

Hemp is the potential host to a number of diseases and insects; however, many of these problems are not widespread or are considered insignificant. Canada indicates Botrytis gray mold, Sclerotinia white mold, European corn borer, and grasshoppers have been observed. No pesticides (herbicides, insecticides, fungicides, nematicides, etc.) are registered for hemp in the U.S, so growers must follow good cultural practices to reduce the impact of pests, especially weeds.

Hemp is very competitive with weeds, and because it grows quickly, densely planted hemp (for fiber) will shade out most weedy growth after about three to four weeks. Weed suppression is

not as effective at the wider spacings required for seed production. Research is underway to evaluate pesticides for hemp production, but at this time, good management regarding soil moisture at planting, seeding dates, seeding rates, and fertility is the best way to reduce the negative impacts of pests, especially weeds. Thus far, significant insect or disease problems have not occurred in field-grown hemp in Kentucky.

Tall growing hemp plants are more prone to wind and hail damage. These and other stresses can result in increased THC levels.

Harvest and storage

Small fields can be harvested by hand, with sickle bar mowers, or with hay swathers. Larger fields necessitate the use of mechanical harvesters, such as combines, forage harvesters, or specialized machinery. Industrial hemp fibers are tough on equipment and can cause plugging, as well as wind around moving parts.

Hemp for Fiber

Hemp is generally harvested for fiber when plants are between early bloom and seed-set, depending on desired quality of fiber and usage. To preserve long fibers for the highest quality products (e.g., hemp fabric), hemp stalks should harvested so that they are not broken or cut up.

Hemp consists of two main types of fibers: bast (outer long fibers) and hurds (inner short fibers). Each type of fiber has its own uses in industry. Once cut, hemp must undergo a process known as retting, which begins breaking the chemical bonds that hold these two types of fibers together. Field or dew retting is the most common and least costly method of accomplishing this. Cut stems are left in the field for up to five weeks and kept moist with dew and rain, which can be supplemented with irrigation water. Stems are monitored and turned for uniform retting. Stalks need to begin rotting so fibers will separate, but without resulting in deterioration of fiber quality. The speed of field retting is dependent on several factors. The weather will have large impacts. Warm, moist weather will significantly speed up retting relative to cool, dry weather. The size of the stems also has a large effect. Small diameter stems will ret much more rapidly than larger diameter stems. Stem diameter is a function of both plant density (seeding rate) and variety.

Water retting is more expensive and labor-intensive than field retting; however, it results in more uniform retting and hence better quality fibers. Stems are submerged in water for seven to 10 days; heat may also be applied during some of this time. Chemical retting (chemicals are used to dissolve the bonds between fibers) and green retting (fibers are separated mechanically) have also been used.

After retting, the stems are dried to less than 15% moisture and then baled. Baled hemp is then transported to the processing plant. If stored, baled hemp must be placed indoors to prevent further retting and deterioration of fibers.

Equipment does not yet exist in the U.S. for optimal cutting and management of hemp during retting. The skills needed for successful field retting are somewhat like the skills needed to produce high-quality hay; as is the case with hay, field retting will depend on weather conditions.

Hemp for Seed

Hemp seeds are combined when 70% of the seed is ripe. Combining grain past the optimal time generally results in lower quality seed, losses due to shattering, and possible bird damage. Grain should be dried to below 12% moisture for storage and at 8 to 10% for long-term storage.

Hemp as a Duel-Purpose Crop

Dual-purpose hemp is cut when seeds have neared maturity. Seeds can be combined first and then stalks re-cut later. It is also possible to modify the combine to harvest both grain and stalks at the same time. Waiting until seeds are harvestable will result in poorer quality fiber, which is acceptable only for lower value uses, such as pulp.

Hemp for Cannabinoids

Optimal harvest methods for cannabinoids have not yet been determined.

Labor requirements

Labor needs per acre, according to production data from Canada, are similar to other specialty grain and oilseed crops, such as small grain production for grain and straw, or specialty soybeans.

Research at the University of Kentucky

Researchers in the University of Kentucky's Plant and Soil Sciences Department and the Kentucky Tobacco Research and Development Center are working to determine agronomic parameters for optimal establishment, production and harvest of industrial hemp for use as fiber, grain, or cannabinoids. UK research in 2015 focused on standard variety trials and germplasm screenings; evaluation of land races (feral or heirloom hemp) for fiber, grain, and cannabinoid production; industrial hemp establishment and management trials for cannabinoid production; and determination of the tolerance of industrial hemp to agricultural herbicides. Research is dependent on receiving financial support from the industrial hemp industry, as there is currently no state or federal funding for hemp research.

Economic Considerations

Potential regulatory costs of commercial hemp production would be a matter of conjecture at this point. Initial start-up production investments would include land preparation and purchase of seed. The installation of an irrigation system is another potential production cost. Specific data on costs and returns are not currently available for U.S. production. The Department of Agricultural Economics at the University of Kentucky developed a preliminary hemp budget summary for the Commonwealth in 2013. This included net returns per acre for hemp fiber, seed, and both fiber and seed for a lower price scenario ($50/ton for fiber and $0.50/lb for seed), and a higher price scenario ($100/ton for fiber and $0.90/lb for seed). The budget did not include land cost, and was developed for four levels of productivity – low, medium-low, medium-high, and high. Returns per acre in the lower price scenario ranged from a negative $314 for fiber only production, to $202 per acre for seed only production at the high productivity level. For the higher price scenario, returns ranged from a low of negative $52 per acre for fiber only, to $622 per acre for seed only production at the high productivity level. However, as of 2015, it appears that profits on hemp grown for fiber will likely equal those of grain for food. Seed for resale (to plant the following year) will be most profitable. For more details on the 2013 budget figures, please see Appendix V in the publication "Economic Considerations for Growing Industrial Hemp: Implications for Kentucky's Farmers and Agricultural Economy" (see URL below).

The economics and profitability of cannabinoid production are very complex and not yet well-defined. There is potential for the cannabinoids to be profitable, but it is unknown how they may be regulated for sale to the public. Until this is determined, it is not possible to define the economics of a cannabinoid production system.

Selected Resources

On the Internet

- UK Industrial Hemp Research (University of Kentucky, 2015) http://hemp.ca.uky.edu
- Industrial Hemp — Legal Issues (University of Kentucky, 2015) http://www.uky.edu/Ag/CCD/introsheets/hemplegal.pdf
- Kentucky Department of Agriculture Industrial Hemp Program http://www.kyagr.com/marketing/hemp-pilot.html
- Economic Considerations for Growing Industrial Hemp: Implications for Kentucky's Farmers and Agricultural Economy http://www2.ca.uky.edu/cmspubsclass/files/EconomicConsiderationsforGrowingIndustrialHemp.pdf
- Growing Industrial Hemp in Ontario (Ontario Ministry of Agriculture, Food and Rural Affairs, 2009) http://www.omafra.gov.on.ca/english/crops/facts/00-067.htm

- Feasibility of Industrial Hemp Production in the United States Pacific Northwest (Oregon State University, 2014) https://catalog.extension.oregonstate.edu/sb681
- Hemp (Farmers Bulletin 1935, USDA, original 1943, slightly revised 1952) http://www.industrialhemp.net/pdf/USDA_Bulletin_1935.pdf
- Hemp: A New Crop with New Uses for North America (Purdue University, 2002) http://www.hort.purdue.edu/newcrop/ncnu02/v5-284.html
- Hemp as an Agricultural Commodity (Congressional Research Service, 2015) http://www.fas.org/sgp/crs/misc/RL32725.pdf
- Industrial Hemp (Agricultural Marketing Resource Center, 2015) http://www.agmrc.org/commodities__products/fiber/industrial_hemp.cfm
- Industrial Hemp (British Columbia Ministry of Agriculture and Food, 1999) http://www.agf.gov.bc.ca/speccrop/publications/documents/hempinfo.pdf
- Industrial Hemp in the United States: Status and Market Potential (USDA, 2015) http://www.ers.usda.gov/publications/ages/ages001e.aspx
- Industrial Hemp Production in Canada (Alberta Agriculture and Rural Development, 2012) http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/econ9631

Books in print

- *A History of the Hemp Industry in Kentucky*. James F. Hopkins. 1998. University Press of Kentucky: Lexington, KY. 244 pp.
- *Report to the Governor's Hemp and Related Fiber Crops Task Force*. Sara McNulty, ed. 1995. Commonwealth of Kentucky. 223 pp.

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Photos courtesy of Stephen Patton (hemp in field, Page 1), and Matt Barton (hemp seed, Page 3), University of Kentucky Agricultural Communications Services **September 2015**