



AGRICULTURAL ALTERNATIVES

Industrial Hemp Production

Industrial hemp (*Cannabis sativa* L.) has a long history with human civilization and was often found near early nomadic settlements close to streams in well-manured areas. Hemp was traditionally cultivated as a fiber source and most genotypes in temperate climates had very low tetrahydrocannabinol (THC) content. Hemp came to North America in the early 1600s, played an important role in Pennsylvania agriculture during the 1700s and 1800s, and was widely grown in many parts of the state. At one time there were over 100 water-powered mills for processing hemp fiber in Lancaster County alone (www.pahic.org/ten-things-you-never-knew-about-pa-hemp-history). There were also many hemp seed oil mills that pressed the excess hemp seed into oil, which was used in paints, ink, varnishes, and lamp oil. Hemp was used in the production of rope, grain bags, Conestoga wagon covers, and clothing. In the mid-1800s the introduction of cotton as a fiber crop and tobacco led to a decline in hemp production. Hemp production continued into the twentieth century on a limited basis.

Also evolving over time were higher THC content “marijuana” hemp types from southern Asia that were used in the drug trade. The story of industrial hemp became linked with its high-THC cousin in the 1930s with the introduction of legislation both at the state and federal levels banning their cultivation. Concern over using the plants for drug purposes led to the Marihuana Tax Act of 1938, which made both hemp and marijuana controlled substances and effectively eliminated production of industrial hemp (with a few exceptions when fiber was needed during WWII). It wasn’t until the 1960s that THC was determined to be the psychoactive component that gets a person “high,” so there was no way at the time to distinguish low-THC industrial hemp from high-THC varieties like those used for medical marijuana.

The changing legal status of hemp since 2014 has enabled states to begin to allow hemp cultivation. In 2017 hemp cul-



Alyssa A. Collins

tivation was allowed in Pennsylvania on a research basis under the supervision of the Pennsylvania Department of Agriculture. This has created some interest in the commercial production of hemp for seed and fiber purposes in the state. Industrial hemp can be grown for seed, fiber, or cannabidiols (CBDs) extracted from the plant tissue. This publication focuses on growing industrial hemp for either seed or fiber on an agronomic crop farm with a typical complement of tillage, planting, and harvest equipment. In most cases industrial hemp is grown specifically for one use (i.e., hemp or fiber), but it is possible to grow a dual-purpose crop as well. Doing this, however, requires investment in more specialized management and harvesting machinery. Growing industrial hemp for CBD extraction is a much more involved process and the legal status of CBDs is currently unclear.

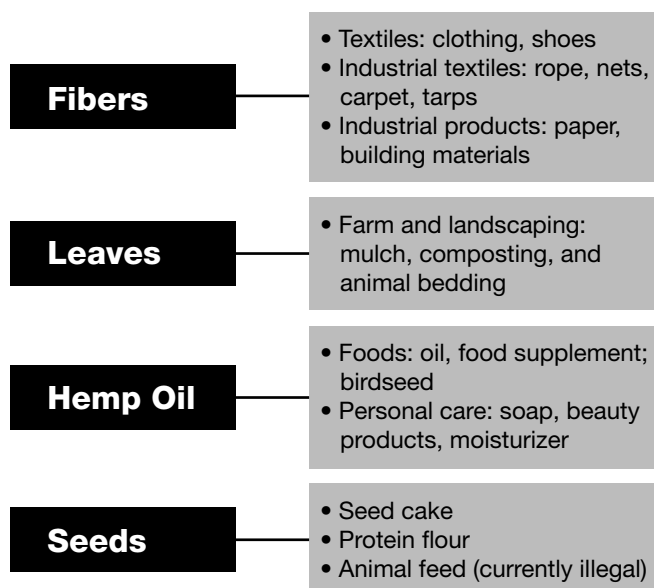
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Policies Affecting the Market for Industrial Hemp

Since 1937 *Cannabis sativa* has been a federally regulated Schedule I drug under the Controlled Substance Act, regulated by the Drug Enforcement Agency (DEA) (www.dea.gov/druginfo/ds.shtml). A distinction between use of *Cannabis sativa* for medical, recreational, and industrial purposes was made only recently when Section 7606 of the Agricultural Act of 2014 (the “Farm Bill”) was created. This cleared a legal path for industrial hemp to be grown in three limited circumstances: by researchers at an institute of higher education, by state Departments of Agriculture, or by farmers participating in a research program permitted and overseen by a state Department of Agriculture (nifa.usda.gov/industrial-hemp). In 2016 the DEA, U.S. Department of Agriculture, and the Food and Drug Administration (FDA) issued a joint statement detailing the guidelines for growth of industrial hemp as part of state-sanctioned research programs. Those guidelines state that hemp can only be sold in states with pilot programs, plants and seeds can only cross state lines as part of permitted state research programs, and seeds can only be imported by individuals registered with the DEA (www.federalregister.gov/documents/2016/08/12/2016-19146/statement-of-principles-on-industrial-hemp).

Governor Tom Wolf signed the Pennsylvania Hemp Law, House Bill 967, in July 2016. This allowed the Pennsylvania Department of Agriculture (PDA) to begin an industrial hemp pilot program in 2017. Currently, farmers and institutions of higher education are participating in this program, which requires an application and permits and growing industrial hemp in accordance with research goals (www.governor.pa.gov/governor-wolf-signs-fifteen-bills-into-law-including-ica-ethics-reform-and-industrial-hemp-regulation).

Figure 1: Industrial Hemp Plant Uses



Industrial Hemp Uses and Products

Industrial hemp and marijuana are different cultivars bred from the same species, *Cannabis sativa*. While biologically related, the plant has been bred for different purposes, and the traits exhibited in cultivars grown for industrial hemp and marijuana are distinct. Industrial hemp is grown for its fiber and seeds, while marijuana cultivars are grown for high levels of THC. Industrial hemp is a plant with many uses, including food, fiber, fuel, industrial, and personal care products. A partial list of potential uses of industrial hemp can be found in Figure 1.

For much of the last century, U.S. domestic markets for industrial hemp products have been primarily supplied by Canada and China. The sales value of hemp-based products was over \$688 million in the United States in 2016 (www.hempbizjournal.com/market-size-hemp-industry-sales-grow-to-688-million-in-2016). Industrial hemp is produced commercially in over 30 countries worldwide, with France being the largest producer of industrial hemp in the world.

Industrial Hemp Market Challenges

Industrial hemp is a very versatile product with many potential uses for the plant fiber and seeds. Industrial hemp producers should carefully identify which industrial hemp product(s) and sales channels are available before starting production, secure any necessary permits prior to production, and ensure that production is done in accordance with state and federal laws. The policy situation is fluid and expected to change at the state and federal levels over the coming years. The difficulty in finding current market information on sale prices and demand makes any projections of the long-term profitability of industrial hemp a real challenge for potential growers.

There is domestic and global competition in the industrial hemp marketplace. Domestically, several states have already researched the economic impact of industrial hemp and have examined the resources required to develop supply chains for industrial hemp, creating a foothold in the marketplace ahead of Pennsylvania. For example, the State of New York incentivized industrial hemp production in 2017 by creating a multiyear \$5 million fund to kickstart the industry (esd.ny.gov/sites/default/files/Hemp_Fact_Sheet_Final.pdf). Other states with industrial hemp programs include Kentucky, Oregon, and Colorado. Canada and China have long-established networks of producers, supply chains, and manufacturing facilities in place to deliver products from field to market.

Due to the longstanding federal policies that made the cultivation of industrial hemp illegal, the supply chains and processing and manufacturing facilities necessary to create market-ready products need to be established in the United

States. Industrial hemp producers in Pennsylvania will need to carefully consider the cost of transporting fiber or grain when evaluating the potential profitability of industrial hemp. The creation of supply chains and processing facilities is closely tied to policy and the current low level of domestic production. As with any business, a potential industrial hemp producer should carefully research the markets, costs, laws, and necessary supply chain partners before beginning production.

Hemp Production

Hemp is best adapted to well-drained soil with a pH between 6.0 and 7.0. Hemp does not grow well on wet soils or those with a heavy clay content. Hemp is sensitive to soil crusting and soil compaction, which can occur on these soils. Ideally, hemp should be planted in May to early June in most areas of Pennsylvania. Some Canadian varieties are short season and could be planted through mid- to late June and still mature before frost. Hemp is a short-day plant and will only begin to mature when day length is less than 12 hours of sunlight.

Hemp grown for seed is generally grown with medium to shorter varieties. Under current law, varieties must be sourced from other countries since shipment of seed between states is not permitted. Varieties that have low THC levels must be selected. In Pennsylvania and many other states, the level of THC in industrial hemp must be under 0.3 percent. Most industrial hemp seed sources have tested their varieties to meet this requirement. Varieties come in various heights, including those that are medium height (6–7 feet tall), semi-dwarf (4–5 feet tall), and dwarf (3–4 feet tall). In the United States, medium to taller varieties are preferred because there are no herbicides labeled for hemp.

Hemp for seed can be planted in rows, like corn, or with a grain drill, like a small grain. Because there are no herbicides currently labeled for use on hemp, hemp grown in rows will require some mechanical weed control. Hemp can also be grown in a tilled seedbed similar to that prepared for forage crop establishment: firm, level, and relatively fine. It can also be established with no-till methods using burndown herbicides to control existing weeds. Planting rates for industrial hemp depends on the variety, but in general rates from 25 to 35 pounds per acre are recommended. Planting depth should be $\frac{1}{2}$ to $\frac{3}{4}$ inch. A dense, drilled stand should provide some control of weeds.

Fertilizer requirements are best determined by a soil test. The Agricultural Analytical Services Lab at Penn State has developed fertilizer recommendations for hemp. In a soil with optimum levels of phosphorus (P) and potassium (K), recommendations for a crop with a 1,500-pound yield potential would be 150 pounds of nitrogen (N), 30 pounds of phosphate (P_2O_5), and 20 pounds of potash (K_2O).

Hemp can be affected by disease and insect pests in the field. While these have not been common in initial trials, they could increase with more cultivation. Several diseases have been noted, including gray mold (*Botrytis cinerea*), white mold (*Sclerotinia sclerotiorum*), bacterial leaf spots, viruses, and Pythium root rot and blight during establishment. It would



Alyssa A. Collins

be best to avoid growing hemp in fields with a previous white mold problem in soybeans or canola or in wet fields where seed rots could be a problem. Many of the insects that cause issues with other crops, such as cutworm, grubs, flea beetles, grasshoppers, and aphids, have been reported in hemp. In Pennsylvania research trials, only Japanese beetles have been noted in hemp, and they are attracted only to the male plants. Slugs have also been reported to damage hemp. Bird damage can also be an issue with hemp, as the seed is an attractive feed source. Mourning doves seem especially fond of hemp seed. Damage from deer and woodchucks does not appear to be as severe as it does in other crops like soybean.

For seed production, hemp is harvested when seeds begin to shatter. The plants will still be green. At this time about 70 percent of the seeds will be ripe and the seed moisture is often about 22–30 percent. If harvesting is delayed, then grain losses can increase from shattering, bird damage, and grain qual-

ity. There is also a greater problem with the fiber in the stalks wrapping in the combine. Avoiding taller varieties can help reduce the amount of material going through the combine.

For fiber production, planting is best done in drilled stands at seeding rates of 35–50 pounds per acre, which should result in stands of around 15 plants per square foot. The taller fiber hemp varieties provide more competition with weeds than the shorter grain types. Fertility recommendations are slightly different for hemp grown for fiber compared to seed. At optimum P and K soil test levels a recommendation would be 150 pounds of N, 20 pounds of P_2O_5 , and 20 pounds of K_2O . There is no grain development when producing hemp fiber and the nutrients in the leaves are recycled to the soil.

Hemp for fiber is generally harvested when plants are between early bloom and seed set depending on the fiber quality. After the hemp is cut it must undergo a process called retting. This helps to break the bonds between the two different types of fibers in the hemp plant, the bast (the outer long fibers) and the hurds (inner short fibers). Field retting is the most common process and involves leaving the crop in the field for up to five weeks to allow a field decomposition process to occur. Windrows are raked two or three times before harvest to dry and remove leaf materials. Then the

crop is dried and baled in round or square bales and hauled to a storage facility. From there the hemp is processed and separated into the bast and hurds for further processing into finished products. Individual processors may have different harvest procedures.

Environmental Impacts

In the normal course of operations, farmers handle pesticides and other chemicals, may have manure to collect and spread, and use equipment to prepare fields and harvest crops. Any of these routine on-farm activities can be a potential source of surface water or groundwater pollution. Because of this possibility, you must understand the regulations you must follow concerning the proper handling and application of chemicals and the disposal and transport of waste. Depending on the watershed where your farm is located, there may be additional environmental regulations regarding erosion control, pesticide leaching, and nutrient runoff. Contact your soil and water conservation district, extension office, zoning board, state departments of agriculture and environmental protection, and local governing authorities to determine what regulations may pertain to your operation.

Risk Management

You should carefully consider how to manage risk on your farm. First, you should insure your facilities and equipment. This may be accomplished by consulting your insurance agent or broker. It is especially important to have adequate levels of property, vehicle, and liability insurance. You will also need workers' compensation insurance if you have any employees. You may also want to consider your needs for life and health insurance and if you need coverage for business interruption or employee dishonesty. For more on agricultural business insurance, see "Agricultural Alternatives: Agricultural Business Insurance."

Although multi-peril crop insurance programs are available for many crop or livestock enterprises, industrial hemp is not currently insurable under any policy, including the Whole Farm Revenue Protection (WFRP) program that insures the revenue of your entire farm operation. Industrial hemp cannot be covered under the Noninsured Assistance Program (NAP) administered by the USDA Farm Service Agency either. These programs may change in the future, but at present there are no insurance-based tools for mitigating the risk of growing industrial hemp.



Alyssa A. Collins

Other important risk management considerations for industrial hemp are distance to market and market access. Make sure you know if there is demand for your crop within a reasonable distance of your farming operation. Transportation costs can rapidly reduce the profitability of growing any crop. Contracting with industrial hemp processors prior to planting would be a good way to make sure that you have a destination for your crop after harvest.

Sample Budgets

Included in this publication are two sample industrial hemp budgets, one for grain production and one for fiber production. Because of the growth habit of the plant, producers must decide to grow the crop either for grain production or fiber production. Because no pesticides are labeled for use on industrial hemp, conventional tillage practices are used to prepare the seedbed and help control weeds. The cost of a rye cover crop for soil erosion control and weed suppression is also included in the budget.

The sample budgets should help ensure all costs and receipts are included in your calculations. Costs and returns are often difficult to estimate in budget preparation because they are numerous and variable. Therefore, you should think

Initial Resource Requirements

Grain Production (based on 100 acres)

- Registration fee: \$20.00
- THC testing per acre: \$2.00
- Total capital: \$440.00 to \$475.00
- Equipment:
 - Tillage equipment
 - Planter or grain drill
 - Cultivation equipment (if grown in rows)
 - Combine, grain storage, grain dryer

Initial Resource Requirements

Fiber Production (based on 100 acres)

- Registration fee: \$20.00
- THC testing per acre: \$2.00
- Total capital: \$425.00 to \$475.00
- Equipment:
 - Tillage equipment
 - Planter or grain drill
 - Cultivation equipment (if grown in rows)
 - Mower, rake, baler

of these budgets as approximations and make appropriate adjustments in the “Your Estimate” column to reflect your specific production and resource situation. In particular, you should carefully estimate your cost for delivering the crop to the processor. The potential profitability of any crop can be quickly eroded by transportation costs if end users are not present in the local market.

More information on the use of crop budgets can be found in “Agricultural Alternatives: Budgeting for Agricultural Decision Making.”

For More Information

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Industrial Hemp Grain Production Budget

Estimated costs per acre, conventional tillage, Pennsylvania, 2018

Item	Quantity	Unit	Price	Total	Your Estimate
Variable Costs					
<i>Custom operations</i>					
Soil test	1.0	acre	\$2.00	\$2.00	
Combine small grain	1.0	acre	\$33.10	\$33.10	
Grain hauling	320.0	bushel-mile	\$0.04	\$12.80	
<i>Fertilizer/soil amendment</i>					
Lime and spreading	0.5	ton	\$26.00	\$13.00	
Nitrogen (N)	150.0	pound	\$0.24	\$36.00	
Phosphorus (P)	30.0	pound	\$0.30	\$9.00	
Potassium (K)	20.0	pound	\$0.23	\$4.60	
<i>Other</i>					
Industrial hemp registration fee	1.0	acre	\$20.00	\$20.00	
Industrial hemp THC testing fee	1.0	acre	\$2.00	\$2.00	
Drying industrial hemp seed	32.0	bushel	\$0.46	\$14.72	
<i>Seed</i>					
Industrial hemp seed	35.0	pound	\$2.50	\$87.50	
Rye cover crop seed	2.0	bushel	\$7.50	\$15.00	
<i>Operator labor</i>					
Hour	1.2	hour	\$17.00	\$20.40	
<i>Diesel fuel</i>					
Tractors	5.7	gallon	\$2.80	\$15.96	
<i>Repairs and maintenance</i>					
Implements	1.0	acre	\$7.01	\$7.01	
Tractors	1.0	acre	\$5.19	\$5.19	
Interest on operating capital	1.0	acre	\$5.95	\$5.95	
Total Variable Costs				\$304.23	
Fixed Costs					
Implements	1.0	acre	\$16.44	\$16.44	
Tractors	1.0	acre	\$12.59	\$12.59	
Land charge	1.0	acre	\$100.00	\$100.00	
Total Fixed Costs				\$129.03	
Total Costs				\$433.26	

Grain Yield Price Sensitivity

Price per pound	Yield (pounds per acre)				
	1,000	1,200	1,400	1,600	1,800
	Return per acre				
\$0.50	\$74.56	\$170.65	\$266.74	\$362.83	\$458.92
\$0.60	\$174.56	\$290.65	\$406.74	\$522.83	\$638.92
\$0.70	\$274.56	\$410.65	\$546.74	\$682.83	\$818.92
\$0.80	\$374.56	\$530.65	\$686.74	\$842.83	\$998.92

Note: a bushel of industrial hemp seed weighs approximately 44 pounds.

Industrial Hemp Fiber Production Budget

Estimated costs per acre, conventional tillage, Pennsylvania, 2018

Item	Quantity	Unit	Price	Total	Your Estimate
Variable Costs					
<i>Custom</i>					
Soil test	1.0	acre	\$2.00	\$2.00	
Hauling round bales	83.0	bale-mile	\$0.20	\$16.60	
<i>Fertilizer/soil amendment</i>					
Lime and spreading	0.5	ton	\$26.00	\$13.00	
Nitrogen (N)	100.0	pound	\$0.24	\$24.00	
Phosphorus (P)	20.0	pound	\$0.30	\$6.00	
Potassium (K)	20.0	pound	\$0.23	\$4.60	
<i>Other</i>					
Industrial hemp registration fee	1.0	acre	\$20.00	\$20.00	
Industrial hemp THC testing fee	1.0	acre	\$2.00	\$2.00	
<i>Seed</i>					
Industrial hemp seed	35.0	pound	\$2.50	\$87.50	
Rye cover crop seed	2.0	bushel	\$7.50	\$15.00	
<i>Operator labor</i>					
hour	2.3	hour	\$17.00	\$38.33	
<i>Diesel fuel</i>					
Tractors	8.7	gallon	\$2.80	\$24.41	
<i>Repairs and maintenance</i>					
Implements	1.0	acre	\$12.45	\$12.45	
Tractors	1.0	acre	\$7.72	\$7.72	
Interest on operating capital	1.0	acre	\$5.62	\$5.62	
Total Variable Costs				\$279.23	
Fixed Costs					
Implements	1.0	acre	\$27.48	\$27.48	
Tractors	1.0	acre	\$18.40	\$18.40	
Land charge	1.0	acre	\$100.00	\$100.00	
Total Fixed Costs				\$145.88	
Total Costs				\$425.11	

Fiber Yield Price Sensitivity

Price per ton	Yield (tons per acre)				
	4.0	4.5	5.0	5.5	6.0
	Return per acre				
\$80.00	-\$101.78	-\$63.44	-\$25.11	\$13.22	\$51.56
\$100.00	-\$21.78	\$26.56	\$74.89	\$123.22	\$171.56
\$120.00	\$58.22	\$116.56	\$174.89	\$233.22	\$291.56

Note: a round bale of industrial hemp fiber weighs approximately 1,200 pounds.

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