# MINNESOTA GROWN OPPORTUNITIES

**A service of the Minnesota Department of Agriculture, the Agricultural Utilization Research Institute, and the University of Minnesota to evaluate diversification options for Minnesota farms.**

## Industrial Hemp

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## I. History:

Hemp (*Cannabis sativa* L.) was widely cultivated in Europe in the mid-16th Century for food (porridge), and for fiber. Hemp was brought to South America from Spain in 1545. The original use of hemp in North America is attributed to Puritans in New England who applied the fiber to the production of cloth and household fabric. However, hemp was secondary in production and use to flax for cloth.

Strong demand for cordage and sailcloth in North America during the mid-19th century peaked U.S. hemp production at about 7,000 tons (largely produced in Kentucky, Missouri, and Illinois).

The importation of less expensive manila hemp from tropical regions in the Pacific, the introduction of the cotton gin, and steam vessels resulted in a dramatic decline in the U.S. hemp industry. Total U.S. production declined to about 3,500 tons in 1919 and 600 tons in 1929. Hemp processing was very labor intensive and although labor saving equipment was being developed, the declining industry, centered in Kentucky, was not competitive with tobacco and cotton production.

The loss of access to tropical fiber sources during World War II prompted a USDA Commodity Credit Corporation emergency program (1943 and 1944) to finance the production of hemp for seed and fiber. Under this program, hemp was grown in Blue Earth, Dodge, Faribault, Freeborn, Jackson, Kandiyohi, Le Sueur, Martin, McLeod, Meeker, Mower, Nobles, Renville, Steele, Waseca, and Yellow Medicine counties in Minnesota. Eleven government-owned processing centers (Hemp Mills), each with the capacity to process about 4,000 acres of hemp, at a throughput of about 1000 pounds of fiber per hour, were constructed.

Minnesota produced 76 tons of processed hemp fiber on about 400 acres in 1942. Production increased to 12,450 tons of processed fiber off about 30,000 acres in 1943 and then declined to 4,950 tons off about 11,000 acres in 1944.

Access to tropical fiber sources, following the war, brought an end to the hemp production in the U.S. Regulation of *Cannabis* was transferred to the Drug Enforcement Agency and the cultivation of industrial hemp remains illegal in the U.S. today.

Canada has recently (1998) allowed farmers to grow industrial hemp commercially. Canadian agriculture officials estimate that about 25,000 acres of hemp were grown across the nation in 1999.

## II. Uses:

Hemp has many potential uses for its fiber, protein meal and oil. The following survey highlights a range of potential large-scale commercial applications.

### A. Fiber Products

Hemp contains both long coarse fibers (primary bast fibers associated with the phloem bundle) and short fine fibers (secondary bast fibers-attached to woody core). Textiles for apparel can be made from the softened fiber. The coarse fiber can be used in technical textiles such as rope, twine, canvas, and carpets. Hemp fibers can be wholly or partially substituted for wood and synthetic fibers in applications such as fiberboard, insulation, fiberglass, and to strengthen cement blocks and mortar. Waste stem material and inner core (hurds) can be used as livestock bedding or mulch. Hemp fibers can be used in paper production for cardboard, specialty paper, newsprint, and filters of many kinds.

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### B. Food and Feed Products

Whole hemp seed is composed of approximately 30-40% oil and 20% protein. Researchers have found that hemp seed contains a good composition of amino acids and does contain the 8 essential amino acids for human nutrition. Hemp seeds also provide a significant amount of Vitamin E and less significant amounts of other vitamins. Hemp seed oil contains 20% Linolenic Acid and 60% Linoleic Acid, which is considered by many to be very close to the optimum fatty acid balance for human consumption.

The oil from hemp seed is not as stable as other common vegetable oils. Additions of a stabilizer can be used to control rancidity in the formulation of products such as salad oil. In Russia, hemp butter is widely considered superior to peanut butter.

The hull of the seed is removed to produce hemp flour, which can be used to make breads. After the oil is removed from the seed, the seed cake can be used as feed supplement in animal rations.

### C. Other Commercial Products

Hemp fibers can be used in fiber composite products, compression-molded parts, brake and clutch linings, and hemp oils can be used in soap, shampoo, bath gels and cosmetics.

### D. Energy Production

Ethanol, methanol, charcoal, and fuel oil can be derived from the hemp plant by various production and extraction methods, but preliminary studies generally conclude that these uses would not be competitive with food and fiber production on U.S. cropland.

## III. Growth Habit, Distribution, and Environmental Requirements:

Hemp (*Cannabis sativa)* is a herbaceous annual with a rigid woody stem that grows to heights of 3 to 19 feet. The plant has a deep taproot that may penetrate the soil to the depth of 6 feet or more.

Hemp is widely adapted and could be grown in most parts of the world.

Commercial industrial hemp production is best suited to well-drained soils of moderate to high cation exchange capacity. Excess soil moisture and soil compaction result in reduced plant populations and uneven development. This crop is not viable in semi-arid or arid conditions.

## IV. Cultural Practices:

### A. Seedbed Preparation

A well prepared, fine, firm seedbed is preferred for hemp germination and emergence. Good seed-soil contact is essential for even emergence, which, is important in early canopy development, which in turn, is needed for non-chemical weed control. Avoid spring tillage and planting operations in wet soils to reduce general soil compaction and wheel tracks.

### B. Seeding Date

Flowering in hemp is controlled by day length. Planting date must be early enough for adequate development of plant structure before flowering, yet soil temperature and conditions must be optimum for rapid emergence. Farmers in Canada have had good establishment success at soil temperatures of 50-55 degrees Fahrenheit. Germination can occur at soil temps as low as 40 degrees Fahrenheit. Hemp seedlings display less damage from frost than corn or soybeans.

Plant height and fiber production is reduced by late planting. Effect of planting date on yield and quality of seed and fiber need to be determined by research under Minnesota conditions; however mid-May seems to be a reasonable planting date for Minnesota.

### C. Method and Rate of Seeding

Hemp should be seeded with narrow spaced drills using double disc openers and press wheels. Narrow row spacing (6-8”) will promote early canopy and improve weed control. Seeding depth should be maintained between ½ inch and 1 inch. Hemp grown for fiber should be seeded at 35 plants per square foot. Hemp grown for seed should be seeded at 12-15 plants per square foot. These seeding rates are currently being used in Canada for monoecious (stamens and pistils in separate flowers on the same plant) varieties. Seeding equipment should be calibrated carefully before seeding and then rechecked during the operation due to variation in seed size across lots and varieties.

### D. Fertility and Lime Requirements

Hemp requires fertility similar to field corn. Soils testing in the medium range for phosphorus and potassium require 35 lbs/acre of $P_2O_5$ and 70 lbs/acre of $K_2O$. Nitrogen fertilizer at the rate of 70-90 lbs/acre of actual nitrogen is also recommended.

These fertility recommendations are currently used in Manitoba, Canada. Hemp nitrogen fertilization, as in corn, is dependent on the soil's ability to provide nitrogen, previous cropping and previous manure applications. Excess nitrogen will delay maturity and may cause less uniform stem size and decreased bark content. Soil pH should be maintained above 6.

## E. Variety Selection

There are two major types of industrial hemp based on end use. Varieties bred for fiber are characterized by long stalks and little branching. Varieties selected for grain have shorter stalks, more numerous branches and larger seed heads. Dual-purpose varieties are grown in some parts of the world.

European plant breeders have developed varieties with increased stem fiber content, improved grain production, and very low levels of delta-9-tetrahydro-cannabinol (THC), the psychoactive ingredients of marijuana. The bulk of the Canadian acreage is planted to monoecious varieties bred for fiber and yet it is harvested for grain with the stem residue harvested for fiber.

## F. Weed Control

Hemp growing at recommended stand densities will produce a dense canopy as early as five weeks after planting. This shading effect will retard weed growth without the use of herbicides. Uneven emergence and delayed emergence will produce a poor canopy and less than acceptable weed control. Grain producing varieties seeded in wider row spacing and reduced populations may present challenges to natural weed competition presented by the hemp crop. Currently there are no herbicides registered for use on industrial hemp.

## G. Diseases

The literature describes two major diseases of industrial hemp which have impacted production fields in Europe and Canada. Gray mold (*Botrytris cinerea*) attacks hemp stems in cool and moderate temperatures and high humidity. White mold (*Sclerotinia sclerotiorum*) also attacks stems and results in wilt and stem breaking and lodging. Pythium, Fusarium, and Rhizoctonia are common soil borne organisms which can affect emergence and growth of industrial hemp. Fungicide applications and seed treatments have been used to control diseases in other hemp producing regions of the world.

## H. Insects

The literature reviewed indicates the potential for insect pests to be of economic importance in industrial hemp. Major insect pests include; European corn borer, Lygus Plant Bug, and various species of armyworm and cutworm. Several species of nematodes can also effect hemp.

## I. Harvesting

Monoecious industrial hemp begins pollination at the base of the plant and progresses to the top. Fiber harvest can begin when pollination has begun on ¼ of the plant. Fiber quality decreases during the period from pollen shed until grain maturation. A swather or sickle bar mower is used in Canada to cut the stalks for field retting.

Grain hemp is harvested with a combine when 2/3 of the seed on individual branches is brown. In the best case, 65% of the seed is harvested due to the indeterminate nature of flowering and seed development. Grain moisture at harvest varies from 22-30%. The combine platform should be raised to cut the hemp at a height which will capture grain and minimize intake of stem material. Fan speeds on combines should be set high to remove chaff and undeveloped seeds. Grain storage requires careful management and drying to 10% moisture or less is recommended. After grain harvest the stems may be harvested. Fiber harvested this way will be of lower quality.

## J. Field Drying, Retting and Harvest

Hemp stalks destined for fiber uses must go through a process where the fiber is separated from the rest of the stem material. Field retting is currently used in Canada and requires warm temperatures and nightly dews for moisture. Retting is accomplished by soil bacteria digesting the pectin and tissue connecting the fiber to the bark and center core. It is necessary to turn the stem material once or twice to enhance uniform drying and retting and to remove the leaves from the stems. The stalks are ready to bale when the outer bark is peeling from the center core and moisture content is at 15%. The retting process takes 2-8 weeks (3-5 weeks in Manitoba).

Dense large bales are suggested for storage until processing. During storage the bales must be protected from rain due to absorbency of the hemp core.

## V. Yield Potential:

Industrial hemp has experienced improved yield of fiber and grain due to traditional plant breeding and selection. However, significant further improvements to yield and supporting agronomic traits are expected as resources are devoted to breeding and variety selection for specific regions of the country. Recent Canadian experience with industrial hemp report grain yields ranging from 300-1500 lbs/acre. Field retted and baled stem yields range from 3 1/2 to 5 tons per acre for industrial hemp grown exclusively for fiber. Residual fiber after grain production may yield ¾ to 2 ton per acre.

## VI. Production Economics and Markets:

It is clear that industrial hemp can be grown in Minnesota. It is also clear that the hemp plant can be used in a wide variety of food, feed, and industrial applications. However, it remains unclear which of those uses holds the greatest marketing opportunity, how an industry will be formed to process the hemp plant into consumer and industrial products, and whether sufficient profit can be generated throughout the chain to sufficiently reward all participants.

### A. Primary Processing

After the retted fiber is baled, it is stored until decorticated. Decortication is the process of separating the fibers from the core (hurd) of the plant. Technology does exist for this process, though it is still in need of refinement.

Because of the bulky nature of the raw material and the capital-intensive technology, decortication facilities must be located close to a large supply of raw material. Current industry thought is that the crop must be grown within 50-60 miles of a processing facility, and that several thousand acres in a region would be required to justify building a processing facility.

### B. Further Processing

Once the fibers and hurds have been separated, the fibers can be transported greater distances for final processing and manufacture. Major issues of concern to final processors include total volume available, timely product delivery, and consistency of raw material meeting specifications.

Because of the nature of high volume industrial markets, manufacturers will require good assurance that an adequate supply of raw material will be available on a consistent basis. Total production volume, timely primary processing, and year-round product storage are issues that remain to be resolved.

### C. Marketing

In the short run growers must be advised that no cash or contract markets are available in Minnesota. In part this is due to current regulations, but also due to the lack of processing infrastructure. Even if regulatory issues are resolved, hemp production will be limited to agronomic uses as a smother or green manure crop until processing infrastructure is developed and operational.

Once processing infrastructure is developed, growers will need to manage market risk, probably through contracts. Growers will need to evaluate costs of production, harvest and storage relative to contract values and determine if production is economically viable.

### D. Competition and Barriers to Entry

Hemp can be grown in many places around the world and the technology for primary processing is mobile. Minnesota producers should anticipate global competition once large-scale or industrial markets develop. There are no known competitive advantages to production in the Upper Midwest, and few barriers to entry. Quality and consistency of supply, and proximity to final processing markets will dictate where the crop will find its greatest economic advantage.

## VII. Information Resources:

Information contained in this bulletin is for informational purposes only, and is not intended to recommend, encourage, or discourage agriculture-based business development. Before engaging in any new venture consult a wide range of resources and industry professionals in order to make a well-informed decision.

Industrial Hemp in the United States: Status and Market Potential. January 2000. USDA-Economic Research Service. Publication AGES001E.
http://www.econ.ag.gov/epubs/pdf/ages001e/index.htm

Industrial Hemp as an Alternative Crop for North Dakota - North Dakota State University http://agecon.lib.umn.edu/ndsu/aer402.html

Industrial Hemp - Manitoba Agriculture and Food, Canada http://www.gov.mb.ca/agriculture/crops/

Growing Industrial Hemp, April 1999, Bill Baxter, Program Lead, Feasibility Analysis, Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, Ontario

For further information on industrial hemp or other potential diversification options for Minnesota farms contact Minnesota Grown Opportunities at:

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# Projected Costs & Returns for Industrial Hemp

## Cost of Production

The cost of production analysis below should be interpreted cautiously, given a prospective grower's own costs and expected returns based on information from a contracting company.

| **Estimated - April 1998** | | | | |
|---|---|---|---|---|
| | **Hemp Grain $ / acre** | **Hemp Grain & Residual Stalk* $ / acre** | **Notes** | **Your Farm** |
| **Operating Costs** | | | | |
| *Seed* $4.50/lb 20 lb/acre | 90.00 | 90.00 | | |
| *Fertilizer* | 32.00 | 32.00 | 1 | |
| *Chemicals* | 7.00 | 7.00 | 2 | |
| *Fuel* | 7.50 | 10.10 | | |
| *Crop/Hail Insurance* | 12.00 | 14.00 | | |
| *Other Cost* | 7.50 | 7.50 | | |
| *Licensing Fee* | 9.75 | 9.75 | 3 | |
| *Sampling and Analytical Fees* | 9.75 | 9.75 | 4 | |
| *Drying Costs* $.03/lb | 18.00 | 18.00 | | |
| *Cleaning Costs* | 3.25 | 3.25 | | |
| *Interest on Operating* | 9.80 | 9.80 | | |
| **TOTAL OPERATING COSTS** | **206.55** | **211.15** | | |
| **Fixed Costs** | | | | |
| *Land Investment Costs* | 85.00 | 85.00 | | |
| *Machinery Depreciation* | 17.50 | 21.00 | | |
| *Machinery Investment and Operating Costs* | 20.00 | 28.77 | | |
| *Storage Cost* | 2.14 | 3.54 | | |
| *Land Taxes* | 16.00 | 16.00 | | |
| **TOTAL FIXED COSTS** | **140.64** | **154.31** | | |
| **TOTAL OPERATING AND FIXED COST** | **347.19** | **365.46** | | |
| *Labour* | 25.00 | 35.00 | | |
| **TOTAL COSTS** | **372.19** | **400.46** | | |

**NOTES:**

1) 93 lb N/acre, 32 lb $P_2O_5$/acre, 44 lb $K_2O$/acre
2) Glyphosate used prior to seeding of crop.
3 & 4) Cost not yet known - this analysis assumes $300 spread over a 20 acre field.

*** Residual Stalk** is the hemp stalks remaining after harvesting hemp grain not to be confused with hemp grown exclusively for fibre.

**NET RETURN**
**(Assuming 600 lbs./acre grain yield and 3000 lbs./acre residual stock yield)**

| | Hemp Grain $ / acre | Hemp Grain & Residual Stalk* $ / acre | Notes | Your Farm |
|---|---|---|---|---|
| Revenue seed @ $.50/lb | 300 | 300 | | |
| Revenue fibre @ $120/ton | | 180 | 5 | |
| **TOTAL REVENUE** | 300 | 480 | | |
| | | | | |
| **TOTAL COSTS** | 372.19 | 400.46 | | |
| | | | | |
| **NET RETURN** | (72.19) | $79.54 | | |

**NOTES**:

5) Because Industrial Hemp has very few established markets and is not yet approved for commercial production in Minnesota cost and return assumptions are based on production experience in Manitoba and Ontario. Residual stalk (fibre) value may be expected to decrease in 2000 due to large Canadian carryover stocks from 1999.

* **Residual Stalk** is the hemp stalks remaining after harvesting hemp grain not to be confused with hemp grown exclusively for fibre.