Market Analysis for Hemp Fiber as a Feed Stock for Papermaking

Carl Houtman
USDA, FS, Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53705

Abstract

In an attempt to develop alternative crops for midwestern farmers, industrial hemp is being evaluated as a fiber source for the paper industry. This simplified analysis shows that hemp could profitably be used as a fiber source for the paper industry and that Wisconsin farmers could meet the demand for fiber by the fine paper manufacturers of Wisconsin. In contrast to the past utilization of hemp, it is essential that the whole plant be used to make paper and not just the long bast fibers.

Hemp production. rate and cultivation

Hemp (*Cannabis sativa*)as a fiber source has a long history. During World War I and II the military demand for fiber resulted in the expansion of the number of acres used for hemp production. In 1943, there were 176,000 acres planted in hemp in the US.[p. 7, ref. 1] For military purposes the primary products were canvas and rope, so the long bast fibers of the plant, which account for 25% of the dry weight of the retted stalks, were of the most interest. The balance of the stalk is called the hurds and was considered as a waste material, often used for animal bedding, soil improvement, or fuel.

In response to the request that Iowa farmers plant 45,000 acres of hemp, the Iowa extension service published a pamphlet entitled "Hemp Production Experiments"[ref. 1] in 1944. For the purposes of a market analysis a critical number from this study is the production rate of hemp per acre. An average of 4 sites with a seeding rate of 5 pecks/acre was 3.9 tons/acre of dry retted straw.[table 3, p. 15, ref. 1] The production data ranged from 3.1 to 5.0 tons/acre and largely depended on the quality of the soil.

Hemp as a raw material for paper

During the processing of hemp, a large quantity of waste material is produced. It was recognized rather early that this material could be used as a feedstock for papermaking. In 1916 the USDA published a report entitled "Hemp Hurds as a Papermaking Material".[ref. 2] The authors of this study used chemical pulping methods to reduce the material to fibers. After subsequent bleaching, the material was formed into paper. The resulting paper was judged to be of a sufficient quality to meet the specifications of the US Government Printing Office. In fact, the strength and fold endurance exceeded a typical wood-based material produced at that time.[p. 25, ref. 2] The fiber yield from the hurds ranged between 35 and 44%,[table 1, p.16, ref. 2] which, when corrected for the weight of dirt, corresponds to 38 to 47% yield. A chemical analysis of the hurds suggests that they are 55% cellulose and 25% lignin[table 2, p. 12a, ref. 3], which is similar to many hardwoods. With modern process optimization, it is likely that the fiber yield would be nearly 50%.

The value of the bast fibers as a component in paper pulp is widely acknowledged. An analysis of the bast fibers shows that they are composed of 70% cellulose and 8% lignin[table 2, p. 12a, ref. 3]. Given that this material is chemically quite different than the hurds, it likely would have to be processed separately, but would likely have a 70% yield to fiber. If one does a weighted average of 50% yield for the hurds and 70% for the bast fibers, one obtains a value of 55% fiber yield from retted hemp stalks.

$$(0.25)(70\%) + (0.75)(50\%) = 55\%$$

Pulp production in Wisconsin

The majority of paper produced from virgin fiber in Wisconsin is printing and writing paper. Thus, if the hemp production is intended to meet the fiber needs of the state, then the focus should be placed on these grades. The papermills in Wisconsin currently use a mixture softwoods and hardwoods to produce bleached grades of pulp. Table 1 shows a list of the paper companies producing chemical pulp in Wisconsin. The production rates were taken from the 1997 edition of Lockwood-Post's Directory of the Pulp, Paper and Allied Trades.[p145-153 ref. 4] The mills selected for this table all produce fine papers that could benefit from the addition of hemp pulp. In fact, the inclusion of hemp bast fibers would likely produce a high quality paper similar to cotton bond.

Table 1: Pulp production for fine papers in Wisconsin (1997)

Location	Company	Type	Pulp tons/day	Products
Brokaw	Wausau Paper	Mg-sulfite	230	office, offset and specialty papers
Kaukauna	International Paper	Kraft	420	packaging and industrial papers
Mosinee	Mosinee	Kraft	250	industrial papers
Neenah	Kimberly-Clark	Rag/Kraft	125	printing and writing papers
Nekoosa	Georgia-Pacific	Kraft	380	uncoated free sheet
Park Falls	Fraser Paper	Ca- sulfite	170	bond, offset and specialty papers
Peshtigo	Badger Paper	NH4-sulfite	155	watermark, bond and printing papers
Port Edwards	Georgia-Pacific	Mg-sulfite	220	uncoated free sheet
Rothschild	Weyerhauser	Ca-sulfite	200	uncoated free sheet
Wapaca	Filter Materials	Rags	12	filter, specialty, and industrial papers
Wisconsin Rapids	Consolidated Paper	Kraft	1016	coated printing papers
Total			3178	

Making assumptions about hemp yield per acre (3.9 tons/acre/year) and the pulp yield per ton of retted hemp (55%), one can estimate the number of acres of hemp required per year to meet the current Wisconsin demand.

$$\frac{\left(3178\frac{\text{tons pulp}}{\text{day}}\right)\left(360\frac{\text{days}}{\text{year}}\right)}{\left(3.9\frac{\text{tons hemp}}{\text{acre}\cdot\text{year}}\right)\left(0.55\frac{\text{tons pulp}}{\text{tons hemp}}\right)} = 533{,}000 \text{ acres}$$

Discussions with Russel Weisensel of the Wisconsin Agribusiness Council suggest that 1 million acres could be available for growing hemp in a crop rotation plan. Thus, it appears that the Wisconsin hemp production could meet the demand for fine paper production in Wisconsin. There are other grades of paper that could also benefit from the strength properties of hemp fiber, e.g., linerboard or packaging grades, but demand in these markets would likely exceed the production capacity of Wisconsin farmers.

Market value of hemp fiber for papermaking

The price of bleached pulp varies widely, $300 to $1000/ton, due to fluctuations in supply and demand. Given this wide variation estimating the value of hemp fiber is rather difficult. It is likely that fiber formed from the hurds will be viewed as similar to hardwood fiber. The current price of bleach pulp is near $425/ton. The production costs will be similar to the production cost of fiber from wood. In fact, an implicit assumption of the following analysis is that only minor modifications to a pulp mill

would be required to switch from wood to hemp. A recent analysis[Table IX, p. 144, ref. 5] of the pulp making process suggests that the raw material, chemical and energy costs for pulping and bleaching wood chips is $233/ton of ECF bleached pulp. Of this cost, $155 was the cost of the wood chips, assuming wood chips cost $55/ton. If one includes a 50% increase in the cost/ton to account for labor, overhead and capital, one finds that the break even point is likely near $350/ton. If one assumes that the average yield from the hemp fibers would be 55%, then a direct replacement for wood chips would suggest a value of $75/ton for the retted hemp stalks. This price is based on numbers that were generated in 1993 if one uses the chemical price index to adjust this to 1997 one gets a value of $85/ton.

With the tightening of the domestic wood chip supply, there is a strong upward price pressure. In fact, the price of domestic chips has risen to the point that chips produced in South America and Southeast Asia, with their associated transportation costs, can compete. Thus $85/ton for the value of hemp is likely a low estimate. A more realistic future value is likely $100-125.

It is likely that the bast fibers would be viewed as a higher value material on the pulp market. If, for example, one were able to produce fibers similar to cotton linters or cotton rags, then the market would likely offer $1000/ton of fiber. To translate this value to a price of the raw materials one must make several assumptions. If one assumes that the processing costs are the same as that for wood, $195/ton, that the yield to fiber is 70%, and that the required profit margin is $100/ton processed, the paper company could pay $500/ton for the bast fibers.

$$\frac{(\$1000 - \$295)}{\left(1.43 \frac{\text{tons hemp}}{\text{ton fiber}}\right)} = \$493/\text{ton hemp}$$

If one uses a value of $100/ton for hurds and $500/ton for bast fibers, the estimated market price of retted hemp stalks is $200/ton. A study of hemp cultivation in Iowa [table 3, p. 15, ref. 1] suggested an average yield of 3.9 tons/acre. Combining the market price and the yield per acre one obtains a crop value of $780/acre. Since the production, storage, and transportation costs will be similar to those of corn, $300/acre, a farmer could make a profit of $480/acre growing hemp. If the farmer were to only market the fiber, however, the profit drops to $190/acre.

Summary

This simple analysis shows that Wisconsin farmers could profitably produce hemp, and that they could meet the fiber demand in the state if 530,000 acres were planted in hemp. The profitability, for the farmer, hinges on the separation of the bast fibers from the hurds and the selling of the bast fibers at a higher price. For the purpose of this analysis, it was assumed that the paper industry would use the bast fibers, but it is also likely that other markets, e.g., textiles and building materials, could be found for them. Furthermore, one must develop markets for both the hurds and the bast fibers, if this enterprise is to be viable.

References

1 C.P Wilsie, C.A. Black and A.R. Aandahl, "Hemp Production Experiments: Cultural Practices and Soil Requirements", Publication P63, Agricultural Experiment Station, Agricultural Extension Service, Ames, Iowa, June 1944

2 L.H. Dewey and J.L. Merrill, "Hemp Hurds a Paper-making Material", USDA Bulletin No. 404, US Government Printing Office, Washington, October 14, 1916

3 E.R. Schafer and F.A. Simmonds, "A Comparison of the Physical and Chemical Characteristics of Hemp Stalks and Seed Flax Straw", Publication No. R868, USDA Forest Products Laboratory, Madison, WI, 1926

4 H. Dyer, ed. "1997 Lockwood-Post's Directory of the Pulp, Paper and Allied Trades", Miller Freeman, NY, NY, 1996

5 B. Parsad, J. Gratzl, A. Kirkman, H. Jameel, T. Rost, and V. Magnotta, "High-Kappa Pulping and Extended Oxygen Delignification Decreases Recovery Cycle Load" *TAPPI J.*, Vol. 77, No. 11, 1994, p. 135-147