Potential U.S. Production and Processing

Potential yields and processing methods, along with farmer costs and returns, are important considerations when evaluating industrial hemp as a potential U.S. crop. Revenue is dependent on yields and market prices. Generally, the lower the market price, the greater the yield must be for producers to break even or make a profit. In addition, U.S. experience with kenaf and flax may lend insights into the processing hurdles hemp may face in the United States.

Possible Yields

The Oregon study summarizes hemp yields reported by researchers from various countries since the 1900's (Ehrensing). Early in this century, U.S. dry-stem yields ranged from 2 to 12.5 tons per acre, but averaged 5 tons per acre under good conditions. Research trials in Europe during the last four decades had dry-matter yields that ranged from 3.6 to 8.7 tons per acre. In the Netherlands, research trials during the late 1980's reported dry-stem yields of 4.2 to 6.1 tons per acre. Recent commercial production in England produced average dry-matter yields of 2.2 to 3 tons per acre on several thousand acres over several years. Experimental production in Canada during 1995 and 1996 yielded 2.5 to 3 tons of dry stems per acre. According to the study, some of the variation in yield can be attributed to different measurement practices. For example, European authors generally report total above-ground dry matter, including stems, leaves, and seed, versus the dry-stem yields reported by other researchers.

Vantreese (1998) reports that hemp seed yields have increased dramatically in recent years. In 1997, world average yields reached 876 pounds per acre. Yields ranged significantly, from a high of 1,606 pounds per acre in China, where the seed is consumed, to 595 pounds per acre in France, where much of the production is certified planting seed. In Germany, current seed yields are about 1,000 pounds per acre (Thompson et al.), while those in Eastern Europe range from 350 to 450 pounds per acre (Mackie, 1998). In Canada, seed yields in 1999 averaged 800 pounds per acre (Hanks, Fall 1999).

Processing

In addition to the uncertainty about yields, there is some question as to whether hemp fibers can be profitably processed in the United States. As was outlined earlier, the technologies used to process hemp fiber have not changed much and they require capital investment and knowledgeable workers. Research is under way to streamline harvesting, retting, and fiber separation, but those technological breakthroughs have yet to occur. Traditional retting and fiber-separation

Table 7—Estimated enterprise costs for hemp production in Kentucky, 1994

Costs	Fiber[1]	Seed	Certified seed
		Dollars/acre	
Variable costs:			
Seed (pounds)	(40) 80.00	(10) 20.00	(10) 20.00
Fertilizer	33.58	33.58	33.58
Lime (tons)	(1) 10.82	(1) 10.82	(1) 10.82
Fuel, oil (hours)	(4.5) 16.02	(2.2) 12.22	(2.2) 12.22
Repairs	9.35	17.60	17.60
Interest	7.93	4.24	4.24
Total	184.12	98.46	98.46
Fixed costs[2]	46.08	41.25	64.84
Operator labor[3] (hours)	(8) 56.00	(8) 56.00	(10) 70.00
Total enterprise costs	286.20	195.71	233.30

[1] Harvested and sold as raw stalks.
[2] Depreciation, taxes, insurance.
[3] At $7 per hour.

Source: McNulty.

processes—both labor and resource intensive—could limit the ability of U.S. hemp producers to compete against major suppliers such as China, Hungary, Poland, and Romania.

Specialty oilseed crushing mills that could accommodate hemp seed do exist in the United States. According to the *Soya & Oilseed Bluebook*, companies in North Dakota, Minnesota, Georgia, and North Carolina mechanically crush flaxseed, borage, safflower, canola, sunflowerseed, crambe, peanuts, and cottonseed (Soyatech, 1999).

Estimated Costs and Returns

Both the 1995 Kentucky Task Force report (McNulty) and the 1998 Kentucky impact analysis (Thompson et al.), as well as the Oregon and North Dakota studies (Ehrensing, Kraenzel et al.), present estimated costs and returns for hemp production. All include estimates for fiber (stalk) production. The 1995 Kentucky, 1998 Kentucky, and North Dakota reports also present estimates on seed production. In addition, most of the studies compare the estimated hemp costs and returns to those for other crops.

The Kentucky Task Force estimated total costs—which include variable costs, fixed costs, and operator labor—to be $286 per acre for hemp fiber, $196 for seed, and $233 for certified seed (table 7). These costs were comparable to 1993 estimated expenses for producing corn and double-crop wheat/soybeans in Kentucky (table 8). The analysis assumed that hemp grown for fiber would be harvested and sold as raw stalks on a dry-weight basis. Various sources priced raw, dry defoliated stalks at $60 to $125 per metric ton. Yields were assumed to range from 7 to 15 metric tons per hectare (2.8-6.1 metric tons per acre), based largely on European studies. Thus, potential returns for hemp fiber ranged from a low price/low yield estimate of $170 per acre to a high price/high yield return of $759 per acre (table 8). With estimated production expenses of $286, net returns for hemp for fiber ranged from -$116 to $473 per acre. Returns for hemp seed were estimated to range from $60 to $800 per acre. Given costs of production at $196 per acre, net returns ranged from -$136 to $604 per acre (McNulty).

The Oregon report also estimated costs and returns for hemp grown for fiber, using typical costs associated with irrigated field corn in the Pacific Northwest (table 9). Variable and fixed costs for hemp were estimated at $371 and $245 per acre, respectively. The dry-matter yield was assumed to be 5 tons per acre, which is consistent with the higher average yields reported in Western Europe using well-adapted cultivars. A price of $75 per dry ton was based on the price of wood chips in the Pacific Northwest, as it was anticipated that the fiber could be used by local composite and paper companies. Given this yield and price, gross

Table 8—Estimated costs of production and returns for various crops in Kentucky, 1993 or 1994

Crop[1]	Yield per acre	Return per acre	Estimated cost per acre: Variable	Fixed	Labor	Total	Net return per acre
			Dollars				
Fiber hemp[2]	2.8-6.1 metric tons	170-759	184	46	56	286	-116 to 473
Hemp seed[3]	na	60-800	98	41	56	196	-136 to 604
Corn grain	110 bushels	231	155	46	32	233	-2
Wheat/soybeans (double crop)	45/28 bushels	300	149	44	37	230	70
Tomatoes (for processing)	27 tons	2,430	1,278	154	231	1,663	767
Burley tobacco	2,500 pounds	4,375	1,905	626	700	3,231	1,144

na = Not available.
[1] For all crops except hemp, source is University of Kentucky, Department of Agricultural Economics crop budgets for 1993.
[2] Various sources priced dry, defoliated stalks at $60 to $125 per metric ton.
[3] One source estimated returns at $60 to $171 per acre for seed (for oil and feed), while another estimated seed returns at $800 per acre (2,000 pounds per acre at 40 cents per pound).
Source: McNulty.

Table 9—Estimated production budget for hemp in the Pacific Northwest[1]

Item	Dollars/acre	Dollars/ton (dry weight)
Variable costs:		
Cultural		
Tillage and planting	40.00	8.00
Hemp seed	34.00	6.80
Fertilizer and application[3]	85.00	17.00
Irrigation	62.00	12.40
Total	221.00	44.20
Harvest[4]		
Forage chopper ($3/ton)	15.00	3.00
Raking ($1.50/ton)	7.50	1.50
Baling, large square bales ($9.80/ton)	49.00	9.80
Loading and trucking ($3.00/ton)	15.00	3.00
Total	86.50	12.80
Miscellaneous		
Operating capital interest	29.78	5.96
Pickup	7.68	1.54
Farm truck	6.34	1.27
General overhead	20.00	4.00
Total	63.80	12.76
Total variable costs	371.30	69.76
Fixed costs:		
Land rent	150.00	30.00
Insurance, machinery and equipment	3.00	0.60
Irrigation system, depreciation and interest	44.00	8.80
Machinery and equipment, depreciation and interest	48.00	9.60
Total	245.00	49.00
Total production costs	616.30	118.76
Gross income (yield = 5 tons/acre)[5]	375.00	75.00
Net projected returns	-241.30	-43.76

[1] Budget was developed using typical costs associated with irrigated field corn in the Pacific Northwest. Production practices were chosen to maximize stem dry-weight yield for possible production of composite wood products or paper. [2] 25 pounds/acre at $1.36/pound. The assumed cost of hemp seed is the average of prices reported for commercially available European hemp varieties. Cost of shipping from Europe was not included. [3] 600 pounds/acre 16-16-16 at $250/ton. [4] Based on cost of operating silage corn harvesters and local cost of raking and baling hay and grass seed straw. No costs associated with retting, such as additional irrigation, are included. [5] The dry matter yield is assumed to be 5 tons/acre, which is consistent with the higher average yields reported in Western Europe using well-adapted hemp cultivars. An assumed price of $75 per dry ton was used in the analysis since prices for wood chips in the Pacific Northwest have risen over the past decade and this trend is expected to continue.

Source: Ehrensing.

revenue would be $375 per acre and net returns would be -$241 per acre (Ehrensing).

The Oregon report presents a sensitivity analysis of net returns based on various yields and potential market prices (table 10). Most of the net returns remain negative except under the highest yield/price combinations. The analysis was further refined to see if dual production was any more profitable. The cost of combine seed harvest, $20 per acre, was added to variable costs, and stalk yields were lowered to 2.5 tons per acre with a price of $75 per ton. Again, most of the net returns are negative except for the highest yield/price combinations (table 11) (Ehrensing).

The 1998 Kentucky report estimates costs and returns for hemp grown for fiber (straw), seed (grain), certified seed, and both fiber and seed (table 12). The cost esti-

Table 10—Estimated net return per acre from hemp production in the Pacific Northwest at various price and yield levels

Yield (tons per acre)	Price (dollars/ton) 50	75	100	125
	Dollars/acre			
3	-431.70	-356.70	-281.70	-206.70
4	-399.00	-299.00	-199.00	-99.00
5	-366.30	-241.30	-116.30	8.70
6	-333.60	-183.60	-33.60	116.40
7	-300.90	-125.90	49.10	224.10

Source: Ehrensing.

Table 11—Estimated net return per acre from dual-purpose hemp production in the Pacific Northwest at various seed prices and yield levels[1]

Seed price (dollars/pound)	Seed yield (pounds/acre) 500	750	1000
	Dollars/acre		
0.30	-255	-181	-106
0.35	-231	-143	-56
0.40	-206	-106	-6
0.45	-181	-68	45
0.50	-156	-31	94
0.55	-131	7	144

[1]The cost of combine seed harvest, $20 per acre, was added to variable costs. Hemp stem yield was assumed to be 2.5 tons per acre with a price of $75 per ton. Other assumptions are the same as those used for table 9.

Source: Ehrensing.

Table 12—Estimated growing costs and returns for industrial hemp in Kentucky using 1997 technology, yields, and, prices[1]

Item	Fiber[2]	Seed[2]	Certified seed	Fiber and seed[2]
	Dollars/acre			
Variable costs:				
Seed (pounds)	(50) 125.00	(10) 25.00	(10) 25.00	(50) 125.00
Fertilizer	45.01	45.01	45.01	45.01
Herbicides	0.00	10.95	10.95	0.00
Lime (tons)	(1) 12.12	(1) 12.12	(1) 12.12	(1) 12.12
Fuel, oil (hours)	(4.5) 18.43	(2.2) 14.06	(2.2) 14.06	(2.2) 22.25
Repair	16.14	30.38	30.38	23.12
Interest	8.38	5.24	5.24	8.94
Storage	5.00	5.00	5.00	5.00
Transport to processor	27.20	8.00	5.60	24.00
Total	257.28	155.76	153.36	265.44
Fixed costs[3]	50.27	45.00	70.73	75.05
Operator labor[4] (hours)	(8) 56.00	(8) 56.00	(10) 70.00	(9) 63.00
Total enterprise costs	363.55	256.76	294.09	403.49
Stalk revenue	680.00	60.00	60.00	450.00
Stalk yield	3.4 tons/acre	0.5 tons/acre	0.5 tons/acre	2.25 tons/acre
Price per ton	200/ton	120/ton	120/ton	200/ton
Seed revenue	na	416.91	840.00	273.00
Seed yield	na	1,069 lbs/acre	700 lbs/acre	700 lbs/acre
Price per pound	na	0.39/pound	1.20/pound	0.39/pound
Total revenue	680.00	476.91	900.00	723.00
Profit	316.45	220.15	605.91	319.51

na = Not applicable.
[1] Figures are based on estimates in McNulty (1995) and updated to 1997 based on the increased costs of growing corn. Also, herbicide, storage, and transport-to-processor costs were added; estimates for repair were increased by 50 percent; 50 pounds of hemp seed per acre were assumed for cultivating hemp for fiber rather than 40 pounds.
[2] Referred to in the report as straw and grain.
[3] Fixed costs include depreciation, taxes, and insurance.
[4] At $7 per hour.

Source: Thompson et al.

mates are based on the 1995 Kentucky report and updated to 1997 with some modifications. The yields used in the analysis are from Germany. The prices, based on import prices and/or prices paid in Canada, were estimated to be 39 cents per pound for seed, $1.20 per pound for certified seed for planting, and $200 per ton for hemp stalks. The residual stalks from seed production were estimated to fetch $120 per ton. Total costs ranged from $257 to $403 per acre. According to the report, these cost estimates are consistent with those made by Reichert (1994), by Kenex Ltd., and from German cultivation data (Thompson et al.).

Estimated revenue ranges from $477 per acre for seed to $900 per acre for certified seed. Thompson et al. admit that the very high returns calculated in these estimates cannot be sustained. While most of their discussion focuses on why the price of certified seed will decrease, little attention is given to stalk prices. The price they used for stalks is the first-year (1998) price offered by Kenex Ltd., the Ontario firm contracting for hemp acreage, which is not representative of long-term stalk prices. With new crops, firms often have to offer farmers an initial premium to induce them to experiment with a new crop and to compensate them for lower initial yields and the forgone returns of a conventional crop. Thus, many of the revenue estimates likely overstate average annual returns. Given the high estimates, it is not surprising that when compared with conventional field crops, hemp net

Table 13—Estimated returns to land, capital, and management per acre for industrial hemp and common Kentucky crops, 1997

Crop	Estimated return to land, capital, and management
	Dollars/acre
Hemp, seed only	220.15
Hemp, fiber only	316.45
Hemp, seed and fiber	319.51
Hemp, certified seed only	605.91
Grain sorghum, conventional tillage	10.51
Wheat, reduced tillage	14.24
Continuous corn	75.71
Popcorn, reduced tillage	78.25
Soybeans, no-till, rotation following crop	102.20
No-till corn, rotation following soybeans	106.48
White corn, rotation following soybeans, reduced tillage	135.84
Alfalfa hay	141.34
Barley/no-till soybeans, double-crop following corn	158.09
Wheat/no-till soybeans, double-crop following corn	158.43
Grass legume hay, round bales	161.56
Dark air-cured tobacco	182.48
Dark fire-cured tobacco	1,104.87
Burley tobacco, baled, nonirrigated	1,563.48

Source: Thompson et al.

returns were higher than those for all the selected crops except tobacco (table 13).

The costs and returns in the North Dakota report are based on a dual-purpose crop in Ontario, Canada. Information from Vantreese (1997) was used as the basis for the three price/yield scenarios. Prices ranged from $5.51 to $6.80 per bushel for seed and from $40.44 to $51.45 per ton for fiber (table 14). Yield estimates ranged from 14.3 to 23.8 bushels of seed per acre and 2.5 to 3 tons of fiber per acre. Total costs were estimated at $175 per acre, while potential revenue ranged from $180 to $316 per acre, resulting in net returns of $5 to $142 per acre. The return for the low-price/low-yield hemp scenario was comparable to those for most of the comparison crops in the study. Only irrigated potatoes had higher net returns than any of the three hemp scenarios (Kraenzel et al.).

Among the studies, total costs ranged from $175 for North Dakota to $616 in Oregon (table 15). A lot of the variation can be attributed to differences in fixed costs. For example, fixed costs in the Kentucky studies, which do not include land rent, are estimated at $75 per acre or below. In the Oregon report, fixed costs are $245 per acre, including land rent and irrigation-system depreciation. When land and irrigation costs are removed, fixed costs drop to $51. Also, when land rents, estimated at $65 to $75 (Vantreese, personal communication), are added to the Kentucky estimates, fixed costs range from $106 to $150. The estimates also may differ due to varying assumptions about production practices and may reflect different cost structures among the States. The Oregon study did cite high land costs as one reason hemp production may not be viable in the Pacific Northwest (Ehrensing).

Table 14—Estimated costs and returns for hemp and other crops in North Dakota, 1998

Crop	Average yield	Average price	Total revenue	Total costs	Net returns
	Per acre	*Dollars/unit*	*Dollars/acre*		
Low-price/low-yield hemp[1]	14.3 bushels; 2.5 tons	$5.51/bushel; $40.44/ton	179.96	174.63	5.33
Average hemp[1]	19 bushels; 2.75 tons	$6.16/bushel; $45.96/ton	248.13	174.63	73.49
High-price/high-yield hemp[1]	23.8 bushels; 3 tons	$6.80/bushel; $51.47/ton	316.29	174.63	141.65
Corn grain[2]	54 bushels	2.25	121.50	159.70	-38.20
Spring wheat[2]	31 bushels	3.71	115.01	117.32	-2.31
Confectionery sunflowers[2]	1,080 pounds	0.131	141.48	140.62	0.86
Malting barley[2]	50 bushels	2.41	120.50	115.02	5.48
Irrigated potatoes[2]	32,500 pounds	0.045	1,462.50	1,017.59	444.91

[1] Estimates are for a dual-purpose crop in Ontario, Canada.
[2] From projected 1998 crop budgets for Northeast North Dakota.

Source: Kraenzel et al.

Table 15—Comparison of estimated costs and returns for hemp from the various State studies

Report	Variable costs	Fixed costs[1]	Operator labor	Total costs	Revenue	Net returns
			Dollars/acre			
1995 Kentucky:						
Fiber	184	46	56	286	170 to 759	-116 to 473
Seed	98	41	56	196	60 to 800	-136 to 604
Certified seed	98	65	70	233	na	na
Oregon:						
Fiber	371	245	na	616	375	-241
1998 Kentucky:						
Fiber	257	50	56	364	680	316
Seed	156	45	56	257	477	220
Certified seed	153	71	70	294	900	606
Fiber and seed	265	75	63	403	723	320
North Dakota:						
Fiber and seed	na	na	na	175	180 to 316	5 to 142

na = not available.
[1] In the two Kentucky studies, fixed costs include depreciation, taxes, and insurance. In the Oregon study, fixed costs include land rent ($150), irrigation-system depreciation and interest ($44), machinery depreciation and interest, and insurance.

None of the cost estimates include costs for monitoring, licensing, or regulating hemp production. These external expenses would be part of the cost of producing industrial hemp and could be borne by taxpayers or passed on to growers and/or processors. According to Thompson et al. (1998), Kenex Ltd. estimates that Canadian farmers will pay US$50 annually for a background check and to obtain the satellite coordinates for their hemp fields (fields are monitored via satellite as part of the Canadian program).

The studies also present a range of revenue estimates, which is not surprising given the uncertainty about demand and expected market prices. Overall, it seems questionable that U.S. producers could remain profitable at the low end of the estimated net returns. In addition, given the thinness of the current U.S. hemp fiber market, any overproduction could lead to lower prices and lost profitability.

U.S. Experience With Kenaf and Flax

Both kenaf and flax can be legally grown in the United States. Their recent production history may lend additional insights into the potential for hemp in the United States.

Kenaf is a relatively new crop. It can be grown in many parts of the United States, but it generally needs a long growing season to produce the necessary yield to make it a profitable crop. With a long growing season, like that found in the southern United States, kenaf can reach a height of 12 to 18 feet and produce 5 to 10 tons of dry fiber per acre annually. An estimated 8,000 acres of kenaf was grown in the United States in 1997, up from 4,000 acres in 1992 and 1993. Primary production areas are Texas, Mississippi, Georgia, Delaware, and Louisiana (Glaser and Van Dyne). Processing and product technology for kenaf-based pulp and for about six other markets have been developed, but markets must be established in each geographic area since the core fraction is very low density and expensive to ship.

Flax is grown in the United States in small quantities. Production is almost totally oilseed varieties (for linseed oil). Textile or linen flax has not been grown commercially in North America for 40 years (Domier). The United States does not produce textile flax for several reasons. First, the market for linen is very small compared with other natural fibers like cotton, which accounts for nearly one-third of U.S. fiber mill use. Linen textile imports have accounted for an annual average of 2 to 3 percent of the quantity of all fibers consumed in the United States (mill use plus net textile trade). Additionally, since 1989, linen textile imports as a percentage of total textile imports have consistently fallen from 12 percent to 4 percent in 1998 and 1999. The market remains small because the economics of producing textile flax is not very price/cost competitive. As noted earlier, many inefficiencies continue to exist in this industry, particularly the methods of harvesting and processing. Because of the length of the fiber and the variation in quality, U.S. mills are reluctant to use textile flax. Some recent developments, however, have allowed the use of textile flax waste on cotton-spinning systems. Also, a flax fiber mill reopened in Quebec in December 1997, and research and development activities are occurring in Alberta, Connecticut, Maine, Oregon, and Saskatchewan (Domier; Hanks, Fall 1999).