NORTHWEST CROPS & SOILS PROGRAM

2021 Industrial Hemp Fiber Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2021 INDUSTRIAL HEMP FIBER VARIETY TRIAL

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Hemp is a non-psychoactive variety of *cannabis sativa L*. The crop is one of historical importance in the U.S. and reemerging in worldwide importance as manufacturers seek hemp as a renewable and sustainable resource for a wide variety of consumer and industrial products. The fiber has high tensile strength and can be used to create a variety of goods. Hemp fiber consists of two types: bast and hurd. The bast fiber are the long fibers found in the bark of hemp stalks and are best suited for plastic bio-composites for vehicles, textiles, rope, insulation, and paper. The hurd fiber are short fibers found in the core of the stem and are suited for building materials, such as hempcrete and particle boards, bedding materials, and absorbents.

For decades, U.S. entrepreneurs have been importing hemp from China, Eastern Europe and Canada. Industrial hemp is poised to be a "new" cash crop and market opportunity for Vermont farms that is versatile and suitable for rotation with other small grains and grasses. To help farmers succeed, agronomic research on hemp is needed, as much of the historical production knowledge for the region has been lost. In this trial, we evaluated hemp fiber varieties to determine best cultivars for the region.

MATERIALS AND METHODS

Table 1. Agronomic information for the industrial hemp fiber variety trial 2021, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Covington silty clay loam, 0-3% slope
Previous crop	Winter grains
Plot size (ft)	5 x 20
Planting date	8-Jun
Row spacing	7"
Planting equipment	Great Plains NT60 Cone Seeder
Seeding rate (live seeds ft^{-2})	40
Mowing date	16 & 17-Aug

A trial was conducted at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the impact of variety on hemp fiber yield. The experimental design was a randomized complete block with four replications. There were thirteen hemp varieties evaluated (Table 2) in the trials. Seeding rates were adjusted for germination rates and a mortality rate of 30%. The typical seeding rate used by hemp fiber growers is between 40 and 60 lbs ac^{-1}. The trial was planted at a rate of 38.1-54.8 lbs ac^{-1} (250 live seeds m^{-2} or approximately 40 seeds sq ft^{-2}) on 8-Jun into 5'x 20' plots.

Table 2. Hemp varieties evaluated in the industrial hemp fiber trial 2021, Alburgh, VT.

Variety	Days to seed maturity	Seed supplier
Bialobrzeskie	130	King's Agriseeds
Felina 32	135	HempIt
H51	120-125	Fiacre Enterprises
Hlesia	115-120	Fiacre Enterprises
Hliana	115-120	Fiacre Enterprises
Futura 75	140	HempIt
Altair	105	UniSeeds/Seedway
Anka	110	UniSeeds/Seedway
Joey	110-120	Parkland Industrial Hemp Growers/King's Agriseeds
Lara	100-120	Parkland Industrial Hemp Growers/King's Agriseeds
Canda	100-120	Parkland Industrial Hemp Growers/King's Agriseeds
NWG 4113	110	New West Genetics
Fedora 17	130	UniSeeds/Seedway

On 7-Jul, the trial received 100 lbs ac^{-1} of nitrogen fertilizer in the form of 220 lbs of urea (46-0-0). Fertility amendments were based on soil test results indicating that no additional fertility was required for potassium or phosphorus.

On 24-Jun, plant populations were recorded by counting the number of plants in a foot-long section of the row, two times per plot. Prior to mowing, five randomly selected plant heights and stem diameters were recorded on 16-Aug within each plot. Additionally, on the same day, wet weight harvest yields were calculated by sampling the hemp biomass within a 0.25 m^2 quadrat. Harvest moisture was calculated by taking a subsample of hemp biomass and drying it at 105° F until it reached a stable weight. On 17-Aug, five plants were selected at random from each plot and run through a custom-built decorticator (Image 1). While the stalks were still fresh, they were weighed and decorticated to separate the bast and hurd fibers. As the stalks passed between the two moving gears, hurd fiber broke away and dropped to a bucket placed underneath. The bast and hurd were weighed to determined varietal differences.

Image 1. Custom built decorticator, Alburgh, VT, 2017.

The variety trial data were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, and variety treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown, except where analyzed by pairwise comparison (t-test). Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure that for 9 out of 10 times, there is a real difference between the two treatments. Treatments that were not significantly lower in performance than the top-performing treatment in a particular column are indicated with an asterisk. In this example, hybrid C is significantly different from hybrid A but not from hybrid B. The difference between C and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these hybrids did not differ in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these hybrids were significantly different from one another. The asterisk indicates that hybrid B was not significantly lower than the top yielding hybrid C, indicated in bold.

Treatment	Yield
A	6.0
B	7.5*
C	**9.0**
LSD	2.0

RESULTS

Seasonal precipitation and temperature were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 3). June was hot and dry seeing above average temperatures and below average precipitation. From seeding and establishment in June until harvest in August, there were 1885 Growing Degree Days (GDDs) accumulated, which was 24 GDDs above normal.

Table 3. Seasonal weather data collected in Alburgh, VT, 2021.

Alburgh, VT	June	July	August
Average temperature (°F)	70.3	68.1	74.0
Departure from normal	2.81	-4.31	3.15
Precipitation (inches)	3.06	2.92	2.29
Departure from normal	-1.20	-1.14	-1.25
Growing Degree Days (Base 50°F)	597	561	727
Departure from normal	73	-134	85

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Alburgh precipitation data from August-October was provided by the NOAA data for Highgate, VT. Historical averages are for 30 years of NOAA data (1991-2020) from Burlington, VT.

Table 4. The impact of variety on plant characteristics and harvest yield of industrial hemp fiber, Alburgh, VT, 2021.

Variety	Plant height	Stem diameter	Harvest moisture	Dry plant weight	Dry matter yield	Harvest population	Harvest population	Bast fiber
	cm	mm	%	lbs plant^{-1}	lbs ac^{-1}	plants ac^{-1}	plants ft^{-2}	%
Altair	160	6.7	67.4*†	0.025	8,691	352,204*	8*	34.9
Anka	190	7.1	66.2	0.036	11,434	340,059*	8*	42.2*
Bialobrzeskie	185	7.9	69.6*	0.031	10,244	348,156*	8*	37.8
Canda	162	7.0	64.8	0.037	8,190	250,996	6	37.2
Fedora 17	164	7.9	68.5*	0.027	11,758	**453,413**	**10**	35.8
Felina 32	175	8.2	68.0*	0.036	9,897	271,238	6	36.1
Futura 75	**212**	8.9	69.0*	**0.053**	**13,225**	267,190	6	37.9
H51	206*	**10.7**	69.2*	0.045*	10,988	271,238	6	44.1*
Hlesia	181	8.1	69.0*	0.031	7,866	259,093	6	40.3*
Hliana	182	8.1	69.8*	0.052*	8,131	170,030	4	**44.2**
Joey	158	7.5	64.3	0.032	7,549	250,996	6	33.4
Lara	194*	7.2	66.4	0.037	9,564	267,190	6	42.9*
NWG 4113	173	8.0	**70.0**	0.039	8,978	267,190	6	35.7
LSD (p=0.10) ‡	21.5	1.33	3.24	0.0134	NS§	114394	2.63	5.00
Trial Mean	180	7.94	67.9	0.037	9,732	289,923	7	38.7

†*Treatments marked with an asterisk did not perform statistically different than the top performing treatment shown in **bold** (p=0.10).
‡LSD; least significant at the p=0.10 level.
§NS – There was no statistical difference between treatments in a particular column (p=0.10).

Futura 75 was the variety with both the tallest average height and highest dry matter yield of 13,225 lbs ac^{-1} (Table 4). Plant heights also varied across the thirteen varieties within the trial with Futura 75 having the highest average plant height at 212 cm, surpassing other top performers including H51, and Lara. However, overall there was no significant difference between Futura 75 and the lowest yielding variety, which was Canda, at 8,190 lbs ac^{-1}. When growing hemp for fiber, it is important to consider the end use of the biomass along with yield. Bast fiber applications tend to be for finer materials like textiles, while the hurd fiber material is best suited for applications like hempcrete, paper making, composite board, or animal bedding. With an average stem diameter of 10.7 mm, variety H51 yielded a statistically thicker stalk than all other varieties trialed. Characteristically thick stems would be preferable for hurd-based end products. Stem diameter can depend on genetic composition, but is also influenced by seeding rate and the rate of germination. Intentionally crowding the plants will encourage tall and thin stalk growth; a desired outcome for bast-based end products, like textiles.

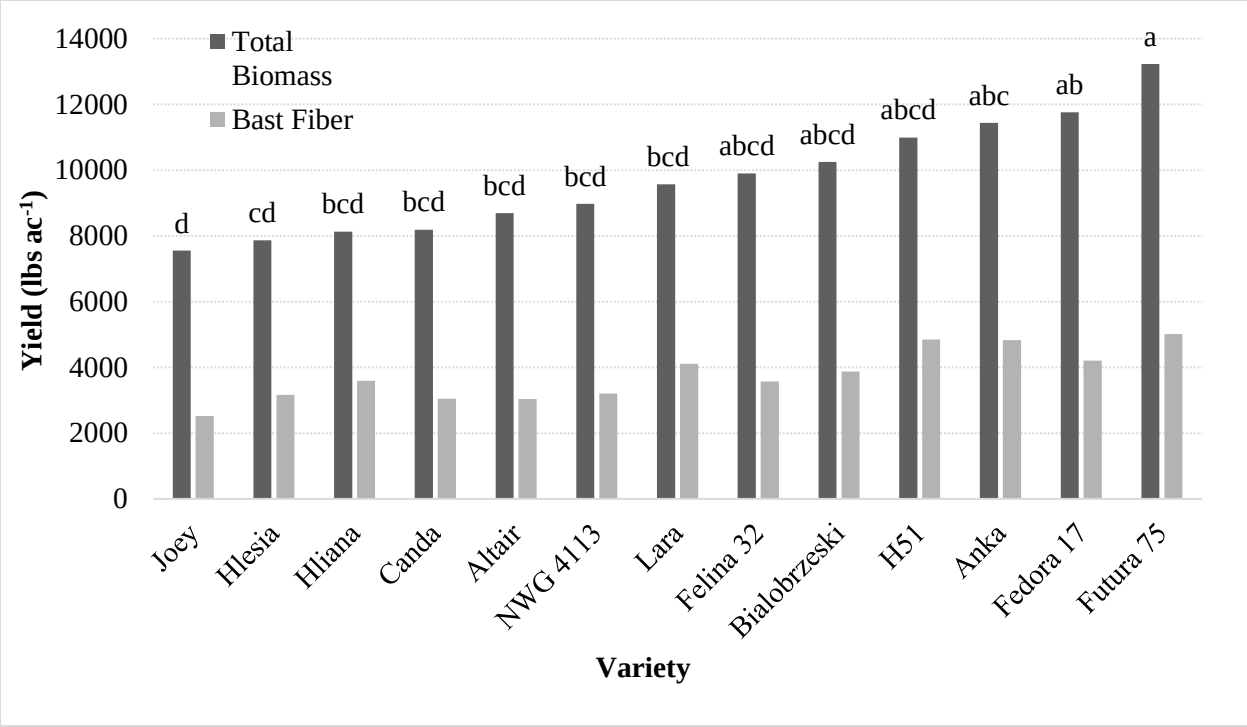

Figure 1. Dry matter biomass yields and bast fiber yields for hemp fiber variety trial Alburgh, VT 2021. Varieties with the same letter are statistically similar (p=0.10).

Hliana was the variety with the highest percent bast fiber in the trial (Figure 1), but the lowest harvest population at 4 plants sq ft^{-1}. It also had a statistically similar individual plant weight to top performer Futura 75, which indicates that at a higher germination rate, Hliana would have yielded statistically similarly to the highest yielding varieties across the board. Typical target populations for fiber production can range from 15-35 plants per square foot with highest populations often favoring bast fiber production and lowest end favoring hurd production.

DISCUSSION

Hemp grown for fiber are usually cut or harvested after the first male flowers have formed and begun to shed pollen but before female flowers have been pollenated and develop seed, typically around 70 days. Plants will largely still be green and less mature than those grown for grain production where all male plants have senesced and seeds have matured. Hemp fiber production also requires a retting process prior to baling and processing in order to separate the fibers. Retting most often takes place in the field. By leaving the plants on the ground and occasionally turning, the plant cell tissues that bind the bast fiber to the hurd break down. The speed of the field retting process is influenced by moisture and temperature which directly impacts microbial activity responsible for breaking down plant material. Warm and moist conditions will encourage increased microbial activity and thus speed the retting process, which can take anywhere from 7-45 days. With these factors in mind, appropriate infrastructure and equipment are required in order to effectively harvest and process hemp fiber. That being said, yields from this trial suggest that there is potential for hemp fiber to be grown in the Northeast and to reach similar yields to other growing regions.

The average dry matter yield across all thirteen varieties was 9732 lbs ac^{-1}, superseding the average yields from other major fiber production regions, which often range from 5000-6000 lbs ac^{-1}. Across all varieties, 38.7% of yields were comprised of bast fiber. Depending on variety and planting density, bast fiber typically represents 20-30% of the total fiber content. Populations were generally lower than desired as a result of poor germination and bird predation. On average, plants were 180 cm tall which could be as little as half of the desired height of bast fiber plantings in ideal growing conditions. Plant heights, as well as germination rates, were also likely impacted by the lack of precipitation in June. Early season weed pressure and bird predation may have also influenced populations and are other considerations for growing hemp.

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