NORTHWEST CROPS & SOILS PROGRAM

2020 Industrial Hemp Fiber Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2020 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 twenty years, 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 2020, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Covington silty clay loam, 0-3% slope
Previous crop	Corn
Plot size (ft)	5 x 20
Planting date	8-Jun
Row spacing	7"
Planting equipment	Great Plains NT60 Cone Seeder
Seeding rate (lbs ac^{-1})	76
Mowing date	7-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 nine 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 76 lbs ac^{-1} (430 live seeds m^{-2} or approximately 40 seeds sqft^{-1}) on 8-Jun into 5'x 20' plots.

Table 2. Hemp varieties evaluated in the industrial hemp fiber trial 2020, Alburgh, VT.

Variety	Days to maturity	Seed supplier
Bialobrzeskie	130-145	Bija Hemp
Henola	115-120	Bija Hemp
Hlukhivs'ki 51	120-125	Fiacre Enterprises
Hlesia	115-120	Fiacre Enterprises
Hliana	115-120	Fiacre Enterprises
Futura	129-134	UniSeeds/Seedway
Altair	100	UniSeeds/Seedway
Anka	110	UniSeeds/Seedway
Ferimon	140-145	UniSeeds/Seedway

On 23-Jun, the trial was fertilized with 200 lbs ac^{-1} of urea (46-0-0). Fertility amendments were based on soil test results indicating that no additional fertility was required for potassium or phosphorus. Select Max® was sprayed on the trial on 15-Jul at a rate of 16 oz ac^{-1} to limit weed pressure from grasses.

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, three randomly selected plant heights were recorded on 7-Aug within each plot. Additionally, on the same day, wet weight harvest yields were calculated by sampling the hemp biomass within a $0.25m^2$ quadrat. Harvest moisture was calculated by taking a subsample of hemp yield and drying it at 105° F until it reached a stable weight. On 10-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 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.

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 and July were hot and dry seeing above average temperatures and below average precipitation. From establishment in June until harvest in August, there were 1851 Growing Degree Days (GDDs) accumulated, which was 158 GDDs above normal.

Table 3. Seasonal weather data collected in Alburgh, VT, 2020.

Alburgh, VT	June	July	August
Average temperature (°F)	66.9	74.8	68.8
Departure from normal	1.08	4.17	0.01
Precipitation (inches)	1.86	3.94	6.77
Departure from normal	-1.77	-0.28	2.86
Growing Degree Days (Base 50°F)	516	751	584
Departure from normal	35	121	2

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 (1981-2010) from Burlington, VT.

Table 4. The impact of variety on plant characteristics and harvest yield of industrial hemp fiber, Alburgh, VT, 2020.

Variety	Plant height	Harvest moisture	Dry plant weight	Dry matter yield	Harvest population	Harvest population	Bast fiber
	cm	%	lbs plant^{-1}	lbs ac^{-1}	plants ac^{-1}	plants sqft^{-1}	%
Altair	108*	**38.9**	**0.026**	8,558*	712,506*	16*	22.8
Anka	110*	35.0*	0.016*	7,300*	**825,859**	**19**	29.6*
Bialobrzeskie	105*	33.5*	0.025*	4,685	331,963	8	30.5*
Ferimon	117*	37.3*	**0.026**	**9,632**	623,442*	14*	27.2*
Futura	**125**	34.7*	0.022*	7,411*	510,089*	12*	29.7*
Hlukhivs'ki 51	111*	33.6*	0.012	4,773	554,621*	13*	28.4*
Henola	86.0	28.7	0.014*	5,681	558,669*	13*	**30.7**
Hlesia	102	37.3*	0.024*	7,546*	663,926*	15*	30.3*
Hliana	107*	34.8*	0.020*	4,306	360,301	8	25.8*
LSD (0.10)	21.6	8.71	0.0117	3,092	352,465	8	5.76
Trial Mean	108	34.8	0.020	6,655	571,264	13	28.3

*Treatments marked with an asterisk did not perform statistically different than the top performing treatment shown in **bold** (p=0.10).

The variety Ferimon had the highest dry matter yield of 9632 lbs ac^{-1} (Table 4). Altair, Anka, Futura, and Hlesia all had comparable yields for biomass. Bast fiber applications tend to be for finer materials like textiles, while the hurd fiber material is best suited for other applications. It is important to consider the end use of the biomass along with yield. With the exception of Altair, each of these top performers for dry matter yields were also among top performers for the percentage of bast fibers, suggesting that Ferimon, Hlesia, Futura, and Anka would produce some of the highest yields of bast fiber within this trial (Figure 1).

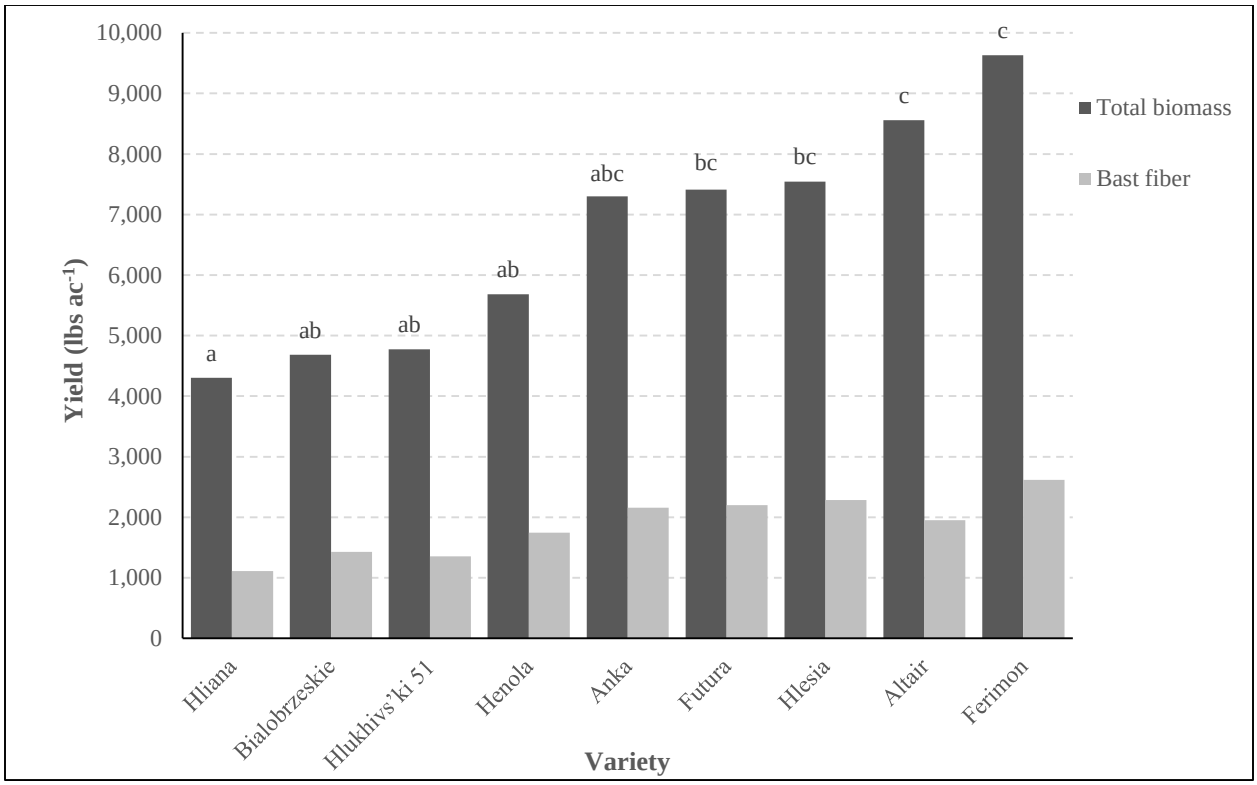

Figure 1. Dry matter biomass yields and bast fiber yields for hemp fiber variety trial Alburgh, VT 2020. Varieties with the same letter are statistically similar (p=0.10).

Bialobrzeskie and Hliana had the lowest dry matter yields within the trial in addition to the lowest harvest populations at 8 plants sqft^{-1}. Interestingly, these two varieties had statistically similar individual plant weights to Ferimon, Altair, Hlesia, Futura, Anka, and Henola. This indicates that if these varieties were grown at similar populations per acre, they would yield similarly. 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. Plant density has the potential to impact the size of plants with closer plantings encouraging vertical growth compared to less dense planting that would allow for increased stem diameter. While data on stem diameter was not collected this year, this could be another consideration to take into account depending on the operation.

Plant heights also varied across the nine varieties within the trial with Futura having the highest average plant height at 125 cm with other top performers including Altair, Anka, Bialobrzeskie, Ferimon, Hlukhivs'ki 51, and Hliana.

DISCUSSION

Hemp grown for fiber are usually first cut or harvested after the first male flowers have formed and begun to shed pollen but before female flowers have had the chance to be pollenated and develop seed. Plants will largely still be green and less mature compared to grain production where all male plants have senesced and seeds have matured. Hemp fiber production also generally requires a retting process prior to baling and processing in order to obtain the fibers. Retting, sometimes referred to as "degumming", most often takes place in the field through mowing plants and leaving them in the field for a designated period of time to

break down plant cell tissues and pectin that bind the fibers together. The speed of this process in most common cases is influenced by moisture and temperature directly impacting microbial activity which is responsible for breaking down plant material. Warm and moist conditions will encourage increased microbial activity and thus speed the retting process. Moisture is required for the process to occur but, depending on temperature, this process may require 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.

Average dry matter yield across all nine varieties was 6655 lbs ac^{-1}, within the average yields from other major fiber production regions, which often range from 5000-6000 lbs ac^{-1}. Across all varieties, 28.3% 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 108 cm tall which could be as little as half of the desired height of plants for bast fiber production where taller, thinner plants are desired. Plant heights, as well as germination (also impacting plant populations), were also likely impacted by the lack of precipitation in June and July. Early season weed pressure and bird predation may have also influenced populations and are other considerations for growing hemp.

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