2018 Industrial Hemp Fiber Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2018 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 2018, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Covington silty clay loam, 0-3% slope
Previous crop	Dry beans
Plot size (ft)	5 x 20
Planting date	8-Jun
Emergence date	15-Jun
Row spacing	7"
Planting equipment	Great Plains NT60 Cone Seeder
Planting rate (live seeds m^{-2})	250
Mowing date	3-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. Seeding rates were adjusted after accounting for germination rates and a mortality rate of 30%. The typical seeding rate used by hemp fiber growers is ~40-50 lbs ac^{-1}. The trial was planted on 8-Jun into 5'x 20' plots.

Table 2. Hemp varieties evaluated in the industrial hemp fiber trial 2018, Alburgh, VT.

Variety	Days to maturity	Seed company
Anka	110	UniSeeds
Canda	100-120	Parkland Industrial Hemp Growers
Carmagnola	160-170	Schiavi Seeds
Carmagnola selezionata	160-170	Schiavi Seeds
CFX-1	100-110	Hemp Genetics International
CFX-2	100-110	Hemp Genetics International
CRS-1	100-110	Hemp Genetics International
Eletta campana	160-170	Schiavi Seeds
Ferimon	129-134	UniSeeds
Fibranova	160-170	Schiavi Seeds
Joey	110-120	Parkland Industrial Hemp Growers
USO-31	122-127	UniSeeds

Table 3. Participating seed companies and contact information.

Hemp Genetics International	Schiavi Seeds	Parkland Industrial Hemp Growers	UniSeeds
Jeff Kostuik Saskatoon, Saskatchewan (204) 821-0522 Jeff.kostuik@hempgenetics.com	Andrea Schiavi Lexington, Kentucky info@schiaviseeds.com	Clare Dutchysen Dauphin, Manitoba (204) 629-4367 info@pihg.net	Cobden, Ontario (613) 646-9737 orders@uniseeds.ca

There were a total of twelve hemp varieties evaluated (Table 2). Seed was sourced from four seed companies (Table 3). On 9-Jul, the trial was fertilized with 150 lbs ac^{-1} of nitrogen, 30 lbs ac^{-1} of phosphorus, and 40 lbs ac^{-1} of potassium. Fertility amendments were based on soil test results. All fertility amendments were approved for use in USDA certified organic systems.

On 31-Jul, just prior to mowing, plant populations were recorded by counting the number of plants in a foot-long section of a row, three times per plot. At that time, data was collected on plant heights by measuring three randomly selected plants per plot. On 31-Jul, 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. Stem diameter was measured on 5 plant stems per plot, using a digital caliper. Infection rates from the disease, *Sclerotinia sclerotiorum*, were recorded 1 month after planting, at female flower development stage on 13-Jul, and just before mowing on 3-Aug by counting the number of infected plants per plot. Pest pressure from arthropods was recorded at those times as well, by counting the number and variety of each arthropod present on two leaves from five plants per plot. On 3-Aug, the fiber plants were mowed using a 5-foot sickle bar mower.

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

When the stalks were still fresh, they were decorticated to separate the bast and hurd fibers, using a custom built decorticator (Image 1). As the stalks passed between the two moving gears, hurd fiber broke away and dropped to the floor or a bucket placed underneath.

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 4).

Table 4. Seasonal weather data collected in Alburgh, VT, 2018.

Alburgh, VT	June	July	August
Average temperature (°F)	64.4	74.1	72.8
Departure from normal	-1.38	3.51	3.96
Precipitation (inches)	3.70	2.40	3.00
Departure from normal	0.05	-1.72	-0.95
Growing Degree Days (base 50°F)	447	728	696
Departure from normal	-27	88	115

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.

June was unseasonably cool, but experienced the typical amount of rainfall. July and August were both warmer and dryer than historical averages. Overall, there were an accumulated 1871 Growing Degree Days (GDDs) from June to August, approximately 176 more than the historical average.

Table 5. The impact of variety on plant characteristics and harvest yield of industrial hemp fiber, Alburgh, VT, 2018.

Variety	Height @ harvest	Stem diameter	Harvest population	Dry matter yield	Dry matter @ harvest	Bast fiber
	cm	mm	plants ac^{-1}	lbs ac^{-1}	%	%
Anka	**135**	4.95*	325,448	7,127	32.3*	37.4*
Canda	108	4.06	682,190	7,109	33.3*	34.7
Carmagnola	129*	4.34	638,379	8,155*	29.1	34.7
Carmagnola selezionata	117	4.56*	744,776	**10,286**	29.4	35.0
CFX-1	86.8	3.43	657,155	5,225	33.6*	23.1
CFX-2	70.1	2.73	844,914*	4,829	33.6*	19.6
CRS-1	107	4.27	738,517	5,851	**33.8**	30.1
Eletta campana	128*	**5.34**	719,741	9,665*	27.4	33.5
Ferimon	118	4.58*	444,362	5,275	32.9*	**38.8**
Fibranova	135*	4.58*	757,293	8,147*	28.4	34.6
Joey	105	4.03	**976,345**	6,489	32.8*	28.6
USO-31	110	4.92*	381,776	5,094	31.8*	37.0*
LSD (0.10)	15.1	0.893	185,475	2597	2.47	3.55
Trial mean	112	4.31	659,241	6,938	31.5	32.3

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

The variety Carmagnola selezionata had the highest dry matter yield of 10,286 lbs ac^{-1} (Table 5). The varieties Carmagnola, Eletta campana, and Fibranova had comparable yields. It is important to consider the end use of the biomass along with yield. Each of these high yielding varieties, were not top performers for percent bast fiber. Bast fiber applications tend to be for finer materials like textiles, while the hurd fiber is a more crude material. The top performers for bast fiber were Anka, Ferimon, and USO-31.

Another factor to consider is stem diameter. Depending on the end use of the biomass, a producer will want either skinnier plants with a greater bast to hurd fiber ratio or thicker plants. Stem diameter can be influenced by plant population, with greater population generally contributing to skinnier stem diameter. As to be expected, the varieties with the thickest stem diameter did not have the highest population, compared to other varieties.

Table 6. The impact of variety on disease and arthropod presence in industrial hemp fiber at female flower development (13-Jul), Alburgh, VT, 2018.

Variety	Aphids	Leafhopper	Japanese beetle	Flea beetle	Tarnished plant bug	Physical damage
	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# leaves $plant^{-1}$†
Anka	0.050	0.000	0.000	0.000	0.050	1.45
Canda	0.200	0.000	0.000	0.000	0.050	1.10
Carmagnola	0.100	0.000	0.000	0.000	0.000	1.25
Carmagnola selezionata	0.250	0.000	0.000	0.050	0.050	0.850
CFX-1	0.100	0.000	0.050	0.050	0.050	0.850
CFX-2	0.000	0.000	0.050	0.050	0.100	0.800
CRS-1	0.050	0.000	0.000	0.000	0.200	1.15
Eletta campana	0.100	0.000	0.000	0.000	0.100	1.05
Ferimon	0.100	0.050	0.000	0.000	0.150	1.35
Fibranova	0.150	0.000	0.000	0.000	0.100	1.15
Joey	0.050	0.000	0.050	0.000	0.150	0.950
USO-31	0.000	0.000	0.000	0.000	0.150	1.05
LSD (0.10)	NS	NS	NS	NS	NS	NS
Trial mean	0.096	0.004	0.013	0.013	0.096	1.08

†Physical damage from insect pests was recorded as the average number of damaged leaves per plant
NS – There was no statistical difference between treatments in a particular column (p=0.10).

Pests and diseases appeared to have a minimal effect on the overall health of the crop. There was no *Sclerotinia sclerotiorum* (Image 2) observed at the female flower development stage (13-Jul). Populations of aphid, leafhopper, Japanese beetle, flea beetle, tarnished plant bug, and overall physical damage to the crop was minimal and not significantly different between varieties (Table 6).

Image 2. Sclerotinia sclerotiorum on hemp plants, Alburgh, VT, 2016.

Table 7. The impact of variety on disease and arthropod presence in industrial hemp fiber before mowing (3-Aug), Alburgh, VT, 2018.

Variety	Aphids	Leafhopper	Japanese beetle	Flea beetle	Tarnished plant bug	Ladybug beetle	Fly	Thrips	Minute pirate bug	Physical damage
	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# leaves plant^{-1}†
Anka	0.200	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.050	1.70*
Canda	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.45*
Carmagnola	0.550	0.000	0.000	0.000	0.050	0.100	0.000	0.000	0.000	1.05
Carmagnola selezionata	0.300	0.100	0.000	0.000	0.050	0.000	0.000	0.050	0.000	1.05
CFX-1	0.100	0.000	0.000	0.000	0.000	0.000	0.050	0.000	0.000	1.20
CFX-2	0.100	0.150	0.000	0.050	0.050	0.000	0.000	0.000	0.000	1.45*
CRS-1	0.150	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.000	1.55*
Eletta campana	0.150	0.050	0.050	0.000	0.000	0.050	0.050	0.000	0.050	0.95
Ferimon	0.100	0.100	0.000	0.050	0.050	0.000	0.050	0.000	0.000	1.30*
Fibranova	0.050	0.050	0.000	0.000	0.000	0.050	0.000	0.000	0.050	0.90
Joey	0.300	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.050	1.55*
USO-31	0.450	0.000	0.100	0.100	0.000	0.050	0.000	0.000	0.000	**1.75**
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.46
Trial mean	0.238	0.042	0.013	0.017	0.0250	0.021	0.013	0.004	0.017	1.33

†Physical damage from insect pests was recorded as the average number of damaged leaves per plant.
*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment shown in **bold** (p=0.10).
NS – There was no statistical difference between treatments in a particular column (p=0.10).

Ladybug beetles, flies, thrips, and minute pirate bugs appeared when scouting prior to mowing, in addition to the same insects seen during flowering (Table 7). Aphid and leafhopper populations were greater during this scouting session and it is not surprising that ladybug beetles appeared since they are a beneficial insect that prey on aphids. There were significant differences between varieties for physical damage to the plants, however, the damage overall was low. White mold was not present, which may have been partly due to the unseasonably dry, warm summer conditions experienced.

DISCUSSION

Yield and Quality

Generally, the male flowers (pollen source) appeared 60 days after planting for early season varieties. The hemp was mowed when plants were still young and green and seed had not formed. For fiber intended for textile use, it is best to mow the crop when the male plants are shedding pollen, since at that stage the bast fiber is not heavily lignified. Some hurd buyers prefer the hemp not to be retted, since the process changes the fiber color. If retting is not required, windrows of hemp stalks can be baled when the straw is 12-16% moisture. Rotary rakes can be used to help the hemp dry.

Average dry matter yield across all twelve varieties was 6938 lbs ac^{-1}, within the average yields from Canada, which range from 5000-6000 lbs ac^{-1}. Across all varieties, bast fiber comprised 32.3% of the stalk compared to the hurd fiber. Depending on variety and planting density, bast fiber typically represents 20-30% of the total fiber content. Across all varieties, the average population was 164 plants m^{-2}, which was lower than the target population of 250 plants m^{-2}. Plant populations will be indirectly related to stem diameter.

The average height across varieties was 1.12 m, while a desirable height is 2 m or greater. However, the taller varieties may leave more possibility for lodging. The lack of heat during the early part of the season may have contributed to shorter plants.

Pest Pressure in Hemp: Disease, insects, weeds

Hemp has the potential to host a number of diseases and insects. For the most part, hemp growing regions have not indicated that disease and arthropod pests are of economic significance. During the growing season, a survey of pest incidence was conducted to gain a better understanding of any pressures that exist on hemp in the region.

Aphids infested the hemp more heavily during later stages of plant development and but did not seem to affect plant yields, since most vegetative growth had already been completed.

Early season weeds can pose a threat to hemp populations, however, due to the higher seeding rate it seemed the weeds were less competitive with the fiber hemp as compared to grain hemp, which has a lower seeding rate. The primary weeds observed the hemp trials were lamb’s quarter, ragweed, and foxtail. Currently, there are no pesticides (herbicides, insecticides, fungicides, nematicides, etc.) registered for hemp in the U.S, so growers must follow best practices to reduce the impact of pests, especially weeds.

It is important to remember that these data represent only one year of research, and in only one location. More data should be considered before making agronomic management decisions. Additional research needs to be conducted to evaluate varieties under more growing conditions.

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