NORTHWEST CROPS & SOILS PROGRAM

2017 Industrial Hemp Fiber Variety Trial

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2017 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 2017, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Covington silty clay loam, 0-3% slope
Previous crop	Dry beans
Plot size (ft)	5x20
Planting date	26-May
Emergence date	9-Jun
Row spacing	7"
Planting equipment	Great Plains NT60 Cone Seeder
Planting rate (live seeds m^{-2})	250
Mowing date	24-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 26-May into 5'x20' plots.

Table 2. Hemp varieties evaluated in the industrial hemp fiber trial 2017, Alburgh, VT.

Variety	Days to maturity
Beniko	120
Carmagnola	160-170
Carmagnola selezionata	160-170
Carmaleonte	140
Eletta campana	160-170
Felina 32	120
Fibranova	160-170
Futura 75	140

There were a total of eight hemp varieties evaluated (Table 2) that came from Schiavi Seeds (Lexington, KY). On 6-Jul, the trial was fertilized with 100 lbs ac^{-1} of nitrogen, 60 lbs ac^{-1} of phosphorus, and 60 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.

Two to three weeks after planting, vigor was measured by doing a visual assessment of each plot and using a 1=high through 5=low scale. A month after planting, plant populations were recorded by counting the number of plants in a foot-long section of a row, three times per plot. A few days before harvest, data was collected on plant heights by measuring three randomly selected plants per plot. Infection rates from the disease, *Sclerotinia sclerotiorum*, were recorded 1.5 months after planting, at female flower development stage on 12-Jul, and just before harvest on 17-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 23-Aug, 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 till it reached a stable weight. On 24-Aug, the fiber plants were mowed using a 5-foot sickle bar mower and allowed to ret in the field for approximately three weeks.

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

After retting, the stalks 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 ($p<0.10$). Across planting dates, data was analyzed using the PROC MIXED procedure in SAS.

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. Seasonal weather data collected in Alburgh, VT, 2017.

Alburgh, VT	May	June	July	August
Average temperature (°F)	55.7	65.4	68.7	67.7
Departure from normal	-0.75	-0.39	-1.90	-1.07
Precipitation (inches)	4.10	5.60	4.90	5.50
Departure from normal	0.68	1.95	0.73	1.63
Growing Degree Days (base 50°F)	245	468	580	553
Departure from normal	47	-7	-60	-28

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.

Throughout the growing season, temperature and precipitation fluctuated away from the 30-year historical averages. May-August was wetter than normal, receiving 4.99 more inches of precipitation as compared to historical averages (Table 3). Temperatures in May-August were cooler than normal by an average of 1° F per month. Overall, there were an accumulated 2293 Growing Degree Days (GDDs) from May to August, approximately 48 less than the historical average.

Table 4. The impact of variety on plant characteristics and harvest yield of industrial hemp fiber, Alburgh, VT, 2017.

Variety	Early season vigor†	Height @ harvest	Stem diameter	Harvest population	Dry matter yield	Moisture @ harvest	Bast fiber
	1 to 5 rating	cm	mm	plants ac^{-1}	lbs ac^{-1}	%	%
Beniko	3.00*	146	4.67	246*	20,442	64.9	25.8
Carmagnola	2.25	**214**	6.20*	175	25,343	68.1	23.2
Carmaleonte	**3.75**	134	5.68*	215	24,428	68.1	23.8
Carmaleonte selezionata	3.00*	204*	**7.13**	125	21,482	67.2	23.2
Eletta campana	2.25	162	4.11	**311**	12,661	68.0	18.4
Felina 32	3.50*	137	4.93	150	19,554	65.0	16.8
Fibranova	3.50*	155	5.47	181	15,428	64.7	18.8
Futura	2.75	147	4.97	198	18,449	66.2	19.6
LSD (0.10)	0.945	38.0	1.62	92.1	NS	NS	NS
Trial mean	3.00	162	5.40	200	19,723	66.5	21.2

†Early season vigor was rated on a 1 to 5 scale with 1 = high vigor and 5 = low vigor.
*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).

The varieties Carmagnola and Carmaleonte selezionata showed the greatest heights (214 and 204 cm, respectively) and stem thickness (6.20 and 7.13 mm, respectively); however, the desired stem thickness will depend on the final market for the fiber (i.e. textile versus compressed boards) (Table 4). Interestingly, these varieties also were among the top performers for yield, however, this advantage was not statistically significant. Beniko and Eletta campana had the highest populations and, unsurprisingly, the smallest stem diameter. The harvest populations were generally lower than the target seeding rate of 250 seeds per m^2. Those varieties that were near the target populations may be better adapted to the cool and wet climate of the northeast.

Table 5. The impact of variety on disease and arthropod presence in industrial hemp fiber at female flower development (12-Jul), Alburgh, VT, 2017.

Variety	Aphids	Leafhopper	Japanese beetles	Tarnished plant bug	Physical damage
	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# leaves plant^{-1}†
Beniko	0.000	0.100	0.050	0.000	0.150
Carmagnola	0.150	0.150	0.050	0.050	0.350
Carmaleonte	0.150	0.050	0.050	0.100	0.150
Carmaleonte selezionata	0.400	0.150	0.050	0.000	0.400
Eletta campana	0.000	0.250	0.050	0.050	0.450
Felina 32	0.050	0.150	0.150	0.050	0.550
Fibranova	0.300	0.050	0.050	0.050	0.500
Futura	0.200	0.250	0.00	0.050	0.400
LSD (0.10)	NS	NS	NS	NS	NS
Trial mean	0.156	0.144	0.056	0.044	0.369

†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 (12-Jul). Populations of aphid, leafhopper, Japanese beetle, tarnished plant bug, and overall physical damage to the crop was minimal and not significantly different between varieties (Table 5).

Image 2. *Sclerotinia sclerotium* infection on industrial hemp, Alburgh, VT, 2016.

Table 6. The impact of variety on disease and arthropod presence in industrial hemp fiber before mowing (17-Aug), Alburgh, VT, 2017.

Variety	Sclerotinia infection	Aphids	Leafhopper	Spiders	Tarnished plant bug	Physical damage
	% of plants	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# leaves plant^{-1}
Beniko	0.000	2.55	0.050	0.100	0.050	0.200
Carmagnola	0.000	4.80	0.000	0.000	0.000	0.400
Carmaleonte	0.063	1.50	0.000	0.050	0.000	0.450
Carmaleonte selezionata	0.000	4.20	0.000	0.000	0.000	0.350
Eletta campana	0.000	1.40	0.050	0.000	0.000	0.350
Felina 32	0.018	4.50	0.000	0.000	0.000	0.350
Fibranova	0.015	3.65	0.200	0.000	0.000	0.200
Futura	0.027	1.05	0.150	0.000	0.050	0.300
LSD (0.10)	NS	NS	NS	NS	NS	NS
Trial mean	0.281	2.96	0.056	0.019	0.013	0.325

*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).

Japanese beetles were not apparent during the second scouting session later in the season (Table 6). Aphid, leafhopper, spider, tarnished plant bug infestation and total physical damage did not appear impactful and were not significantly different among varieties. White mold was present near harvest but was minimal and not different among the varieties.

DISCUSSION

Yield and Quality

All hemp varieties matured before the end of the season. Generally, the male flowers (pollen source) appeared 60 days after planting for early season varieties and 10 days later for the late maturing varieties. Initial seed development occurred 70 days after planting for early season varieties and 80 days for the late season varieties. The hemp was mowed when plants were still young and green and seed was less than 50% ripe. 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 eight varieties was 19,723 lbs ac^{-1}, well above average yields from Canada, which range from 5,000-6,000 lbs ac^{-1}. The dry matter yield reported for these trials includes all plant material harvested, including leaves and seed heads, which may not be included in the reported Canadian yields. Across all varieties, bast fiber comprised 21.2% 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 200 plants m^{-2}, which was lower than the target population of 250 plants m^{-2}. Plant populations will be indirectly related to stem diameter. Although the unseasonably cool, wet spring conditions experienced in the Northeast were unfavorable for seedling

establishment, the hemp fiber stands looked relatively good and this was likely due to their high seeding rate compared to grain hemp.

The average height across varieties was 1.62 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 and mid-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. Similarly, *Sclerotinia sclerotiorum* infection increased later in the season, but did not seem to affect yields.

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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