NORTHWEST CROPS & SOILS PROGRAM

2018 Industrial Hemp Fiber Planting Date Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2018 INDUSTRIAL HEMP FIBER PLANTING DATE 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 consists of two types of fiber: 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 2 hemp fiber varieties over 3 planting dates to determine best planting dates for the region.

MATERIALS AND METHODS

Table 1. Agronomic information for industrial hemp fiber planting date trial 2018, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Benson rocky silt loam, 8-15% slope
Previous crop	Sunflowers
Plot size (ft)	5x20
Planting dates	7-Jun, 15-Jun, 22-Jun
Emergence dates	15-Jun, 22-Jun, 29-Jun
Varieties	Carmagnola, CRS-1
Row spacing	7"
Planting equipment	Great Plains NT60 Cone Seeder
Planting rate (live seeds m^{-2})	250
Mowing date	3-Aug

Trials were conducted at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the impact of planting date on hemp fiber yield. The experimental design was a randomized complete block with split plots and four replications. The main plots were planting dates of 7-Jun, 15-Jun, and 22-Jun.

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

Variety	Seed company	Days to maturity
CRS-1	Hemp Genetics International	100-110
Carmagnola	Schiavi Seeds	160-170

Table 3. Participating seed companies and contact information.

Hemp Genetics International	Schiavi Seeds
Jeff Kostuik Saskatoon, Saskatchewan (204) 821-0522 Jeff.kostuik@hempgenetics.com	Andrea Schiavi Lexington, Kentucky info@schiaviseeds.com

The subplots were two hemp varieties, one each of short and long maturity (Table 2). Seed was sourced from two seed companies (Table 3). Plot size was 5 x 20 feet. 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 between 40-50 lbs ac^{-1}. 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 organic systems.

On 31-Jul, a few days before mowing, plant populations were recorded by counting the number of plants in a foot-long section of a row, three times per plot. At this time, infection rates from the disease *Sclerotinia sclerotiorum* were recorded by counting the number of infected plants per plot. Pest pressure from arthropods was recorded at that time as well, by counting the number and variety of each arthropod present on two leaves from five plants per plot. Plant heights also were measured just prior to mowing 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 till it reached a stable weight. Stem diameter was measured on 5 plant stems per plot, using a digital caliper. On 3-Aug the fiber plants were mowed using a 5-foot sickle bar mower.

Image 1. Custom built decorticator, Alburgh, VT, 2018.

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 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 planting date 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 with the Tukey-Kramer adjustment, which means that each variable was analyzed with a pairwise comparison (i.e. 'planting date 1' statistically outperformed 'planting date 2', 'planting date 2' statistically outperformed 'planting date 3', etc.). Relationships between variables were analyzed using the GLM procedure.

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.

Planting date results

Table 5. The impact of planting date on plot characteristics and harvest yield of industrial hemp fiber, Alburgh, VT, 2018.

Planting date	Height @ harvest	Stem diameter	Population	Dry matter yield	Moisture @ harvest	Bast fiber
	cm	mm	plants ac^{-1}	lbs ac^{-1}	%	%
7-Jun	**136**	**5.22**	669,672	**8,915**	70.6	**30.0**
15-Jun	117	4.22	860,560*	7,342*	74.7	29.6
22-Jun	89.0	3.00	**901,241**	5,553	71.9	29.4
LSD (0.10)	9.08	0.634	151,469	1,748	NS	NS
Trial mean	114	4.15	810,491	7,270	72.4	29.8

*Treatments marked with an asterisk performed similarly to the top performing treatment (p=0.10) shown in **bold**.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

The 7-Jun planting date had the highest yield, which was similar to the 15-Jun planting date yield (Table 5). It is possible that the earlier planting dates had a greater yield since they had a longer growing season. Although the 22-Jun planting date had the highest population, it had the lowest yield and shortest average plant height. It is possible that with the high population, there was more plant competition. When considering yield, it is also important to consider stem diameter and bast fiber percentage. The bast to hurd fiber ratio is highest on thinner plants. Bast fiber is best for textiles and fine production while hurd

fiber is a cruder product. Typically, a higher plant population will result in thinner plant stem diameter, as demonstrated in this trial.

Table 6. The impact of planting date on disease and arthropod presence in industrial hemp fiber prior to mowing, Alburgh, VT, 2018.

Planting date	Minute pirate bug	Aphids	Leafhopper	Flea beetles	Ladybug beetle	Tarnished plant bug	Physical damage
	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}†
7-Jun	0.025	0.100	0.000	0.025	0.025	0.050	0.975
15-Jun	0.000	0.125	0.025	0.000	0.025	0.025	0.775*
22-Jun	0.000	0.175	0.050	0.050	0.000	0.050	**0.525**
LSD (0.10)	NS	NS	NS	NS	NS	NS	0.311
Trial mean	0.008	0.133	0.0250	0.025	0.017	0.042	0.758

†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).

Sclerotinia sclerotiorum, infection was not present (Table 6). The lack of this fungal infection may be due to it having been a relatively dry, warm summer. There was no significant difference between planting dates for arthropod pests. The 22-Jun planting date had the least physical damage, however, damage overall was very low.

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

Plant variety results

Table 7. The impact of variety on plot characteristics and harvest yield of industrial hemp fiber, Alburgh, VT, 2018.

Planting date	Height @ harvest	Stem diameter	Population	Dry matter yield	Moisture @ harvest	Bast fiber
	cm	mm	plants ac^{-1}	lbs ac^{-1}	%	%
Carmagnola	**127**	**4.43**	776,069	**8,051**	73.8	**29.3**
CRS-1	101	3.87	844,914	6,489	71.0	23.4
LSD (0.10)	7.41	0.518	NS	1427	NS	2.83
Trial mean	114	4.15	810,491	7,270	72.4	26.4

Top performing treatment (p=0.10) shown in **bold.**
NS – There was no statistical difference between treatments in a particular column (p=0.10).

When comparing between varieties across all planting dates, Carmagnola outperformed Beniko for plant height, stem diameter, yield, and bast fiber content (Table 7). There were no significant differences between the two varieties for plant population or biomass moisture.

Table 8. The impact of variety on disease and arthropod presence in industrial hemp fiber prior to mowing, Alburgh, VT, 2018.

Variety	Minute pirate bug	Aphids	Leafhopper	Flea beetles	Ladybug beetle	Tarnished plant bug	Physical damage
	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$†
Carmagnola	0.000	0.133	0.017	0.000	0.000	0.033	0.783
CRS-1	0.050	0.133	0.033	0.050	0.033	0.050	0.733
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS
Trial mean	0.008	0.133	0.025	0.025	0.017	0.042	0.758

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

There were no significant differences in arthropod pests between the two varieties (Table 8).

Planting date x variety results

There was no significant interaction between planting date and variety for yield, population, stem diameter, or fiber moisture. This means the varieties performed similarly for these criteria regardless of planting dates. However, the combination of planting date and variety had a significant interaction for bast fiber. Carmagnola had the highest bast fiber at the earlier planting date and CRS-1 had the highest bast fiber at the latest planting date (Figure 1). This indicates that understand variety performance under various agronomic conditions is essential to maximizing bast fiber.

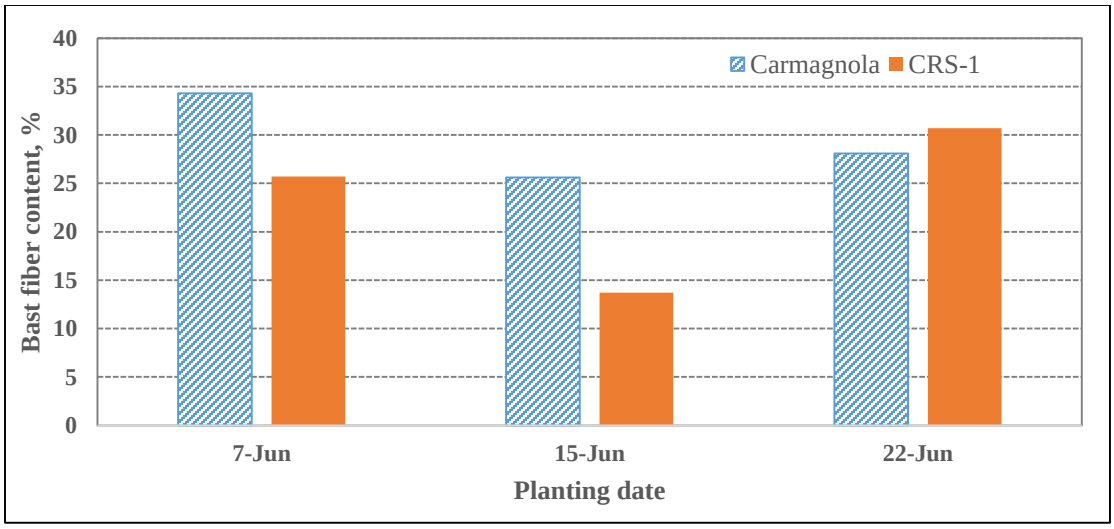

Figure 1. The effect of planting date and variety on bast fiber content (p-value = 0.0051), Alburgh, VT, 2018.

DISCUSSION

Yield and Quality

Generally, the male flowers (pollen source) appeared 60 days after planting and completed pollen drop 10 days later for the early maturity variety. The hemp was mowed when plants were still young and green and seed had not formed. For hemp 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 planting dates and varieties was 7,270 lbs ac^{-1} and was above average yields from Canada, which range from 5000-6000 lbs ac^{-1}. The dry matter yield reported in the project includes all plant material harvested, including leaves and seed heads, which may not be included in the reported Canadian yields. Across all planting dates and varieties, bast fiber comprised 29.8% 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. The average population was 200 plants m^{-2}, which was lower than the target population of 250 plants m^{-2}. Poor early season establishment seen in this trial emphasizes the need to evaluate strategies to improve germination and early season vigor (i.e. seed treatments, seeding rates, starter fertilizers), especially in cool, wet spring seasons. The average height across varieties was 1.14 m, while a desirable height is 2 m or greater. However, the taller varieties may leave more possibility for lodging. Below average rainfall may have led 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. Although *Sclerotinia sclerotiorum* infection was present the previous two years, it was not present this year, which may have been due to the unseasonably warm, dry summer. 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. The primary weeds observed in 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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