2016

Industrial Hemp Planting Date X Variety Trial

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2016 INDUSTRIAL HEMP PLANTING DATE X 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 re-emerging worldwide importance as manufacturers seek hemp as a renewable and sustainable resource for a wide variety of consumer and industrial products. The crop produces a valuable oilseed, rich in Omega-3 and other essential fatty acids that are often absent in western diets. When the oil is extracted from the seed, what remains is a marketable meal co-product, which is used for human and animal consumption. The fiber has high tensile strength and can be used to create cloth, rope, building materials, and even a form of plastic. For twenty years, U.S. entrepreneurs have been importing hemp from China, Eastern Europe and Canada to manufacture travel gear, apparel and accessories, body care and cosmetics, foods like bread, beer, and salad oils, paper products, building materials and animal bedding, textiles, auto parts, housewares, and sporting equipment. Industrial hemp is poised to be a "new" cash crop and market opportunity for Vermont farms that is nutritious, 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 planting dates and varieties to determine adaptability to the region.

MATERIALS AND METHODS

Trials were conducted at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the impact of variety and planting date on hemp yield. Pest pressure from disease, arthropods, and weeds were also monitored in the trials. The experimental design was a randomized complete block with four replications in the first three planting dates and three replications in the fourth planting date. Each planting date by variety trial was conducted as an individual experiment. Hence, there were four trials evaluating hemp varieties and they were planted on 4 different planting dates (26-May, 2-Jun, 12-Jun, and 17-Jun). There were a total of 12 hemp varieties evaluated (Table 3) that came from five seed companies (Table 2); however the varieties evaluated at each planting date varied. Late arrival of seed due to import issues kept us from including all varieties at each of the planting dates. The trial was planted into 5'x20' plots. On 1-Jul, planting dates 26-May, 2-Jun, and 17-Jun were fertilized with 500 lbs ac^{-1} Pro-gro (5-3-4; North Country Organics, Brandon, VT), 500 lbs ac^{-1} Pro-booster (10-0-0; North Country Organics, Brandon, VT), and 50 lbs ac^{-1} sodium nitrate (16-0-0). Fertility amendments were based on soil test results. All fertility amendments were approved for use in organic systems.

Two to three weeks after planting, vigor was measured by doing a visual assessment of each plot and using a 1=low through 5=high scale. A few days before harvest, plant heights were measured by randomly taking the height of 3 plants per plot. Infection rates of *Sclerotinia sclerotiorum* were recorded by counting the number of infected plants per plot and aphid incidence/severity was recorded by documenting absence, presence, or heavy infestation. On 9-Sep, 29-Sep, 3-Oct, and 29-Sep, the hemp was harvested for planting dates 26-May, 2-Jun, 12-Jun, and 17-Jun, respectively, using an Almaco SPC50 small plot combine. Harvest moisture was calculated by taking a 100g subsample of hemp seed and drying it at 105°F till it reached a stable weight. Test weight was also measured using a Berckes Test Weight Scale, which weighs a known volume of grain. Shortly after harvest, populations were measured by counting the number of plant stalks in a 0.25 ft^2 quadrat, twice per plot.

Table 1. Agronomic information for industrial hemp planting date by variety trial 2016, Alburgh, VT.

Location	**Borderview Research Farm** **Alburgh, VT**
Soil type	Covington silty clay loam, 0-3% slope
Previous crop	Heirloom winter wheat
Replications	4 replicates 26-May, 2-Jun, 12-Jun 3 replicates 17-Jun
Plot size (ft)	5x20
Planting dates	26-May, 2-Jun, 12-Jun, 17-Jun
Row spacing	7”
Planting equipment	Great Plains NT60 Cone Seeder
Planting rate (lbs ac^{-1})	25
Harvest dates	9-Sep, 29-Sep, 3-Oct, and 29-Sep

Table 2. Participating seed companies and contact information.

Schiavi Seeds	**Full Sun Company**	**Hemp Genetics International**	**Parkland Industrial Hemp Growers**	**Valley Bio Limited**
Andrea Schiavi Lexington, Kentucky info@schiaviseeds.com	Netaka White Ripton, Vermont (802) 377-3541 netaka@fullsuncompany.com	Jeff Kostuik Saskatoon, Saskatchewan (204) 821-0522 Jeff.kostuik@hempgenetics.com	Canda Chafe Dauphin, Manitoba (204) 629-4367 info@pihg.net	Reuben Stone Cobden, Ontario (613) 646-9737 info@valleybio.com

Table 3. Hemp varieties evaluated in the planting date and variety trials 2016, Alburgh, VT.

Variety	Seed company	Days to maturity
Fedora 17	AssoCanapa	120
Felina 32	AssoCanapa	120
Futura 75	AssoCanapa	140
USO 31	AssoCanapa	90-100
Full sun	Full Sun Company	---
CFX-2	Hemp Genetics International	100-110
CRS-1	Hemp Genetics International	100-110
Grandi	Hemp Genetics International	100-110
Katani	Hemp Genetics International	100-110
Canda	Parkland Industrial Hemp Growers	100-120
Delores	Parkland Industrial Hemp Growers	100-120
Anka	Valley Bio Limited	110

For each planting date, the variety 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 soil amendment 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.

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

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.

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. The growing season was dryer than normal with May-September getting 7.27 fewer inches of precipitation as compared to historical averages (Table 4). Temperatures in June-July were comparable to normal averages, while May and August-September were at least 1.8 degrees warmer than normal, per month. Overall, there were an accumulated 2562 Growing Degree Days (GDDs) at base 50°F this season, approximately 268 more than the historical average. Hemp seed has been shown to produce well with 1460 GDDs at base 50°F in Saskatchewan, Canada.

Table 4. Seasonal weather data collected in Alburgh, VT, 2016.

Alburgh, VT	May	June	July	August	September
Average temperature (°F)	58.1	65.8	70.7	71.6	63.4
Departure from normal	1.80	0.00	0.10	2.90	2.90
Precipitation (inches)	1.50	2.80	1.80	3.00	2.50
Departure from normal	-1.92	-0.88	-2.37	-0.93	-1.17
Growing Degree Days (base 50°F)	340	481	640	663	438
Departure from normal	74	7	1	82	104

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.

Planting Date 1: May 26, 2016

Table 5. The impact of variety on plot characteristics and harvest yield of industrial hemp at the 26-May planting date, Alburgh, VT, 2016.

Variety	Early season vigor†	Height @ harvest	Population @ harvest	Yield	Test weight	Moisture @ harvest	Aphid severity‡	Sclerotinia infection
	1 to 5 rating	cm	plants ft^{-2}	lbs ac^{-1}	lbs bu^{-1}	%	0 to 2 rating	% of plants
Anka	1.75	**199***	**5.53***	2200	40.7	**30.3***	1.00	0.168*
CFX-2	2.00	128	4.65*	1860	42.3	21.9	1.00	0.927*
CRS-1	1.50	157	5.02*	2200	41.5	24.2	1.00	0.157*
Canda	2.50	161	5.25*	2160	41.6	23.5	1.00	**0.042***
Delores	1.75	154	3.53	1720	41.8	24.7	1.00	0.191*
Grandi	2.00	107	3.63	1550	41.6	22.0	1.00	1.74

Katani	1.50	105	3.58	1260	41.9	22.4	1.00	1.05*
LSD (0.10)	NS	22.6	1.19	NS	NS	3.36	NS	1.06
Trial mean	1.86	144	4.46	1850	41.6	24.1	1.00	0.611

†Early season vigor was rated on a 1 to 5 scale with 1 = low vigor and 5 = high vigor.
‡Aphid severity was rated as absent = 0, present = 1, or heavy infestation = 2
*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10). Treatments in **bold** were top performers for the given variable.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

When comparing 7 varieties at the 26-May planting date (Table 5), there was no significant difference seen across yield, test weight, vigor, or aphid severity. The variety 'Anka' was shown to have significantly higher moisture content at 30.3%, compared to all other varieties. This likely was due to the fact that it had a later relative maturity than the other varieties in the trial. Higher moisture at maturity may be advantageous during harvest, as more mature, tougher plants appear to catch in the combine more easily. The variety Anka also had a significantly higher plant height, at 199 cm, compared to all other varieties. Anka showed the greatest plant population per square foot and was comparable to 'CFX-2', 'CRS-1', and 'Canda'. *Sclerotinia sclerotiorum* infection rates were comparable among all varieties; however, the infection rate in 'Grandi' was significantly higher than all other varieties.

Planting Date 2: June 2, 2016

Table 6. The impact of variety on plot characteristics and harvest yield of industrial hemp at the 2-Jun planting date, Alburgh, VT, 2016.

Variety	Early season vigor†	Height @ harvest	Population @ harvest	Yield	Test weight	Moisture @ harvest	Aphid severity‡	Sclerotinia infection
	1 to 5 rating	cm	plants ft^{-2}	lbs ac^{-1}	lbs bu^{-1}	%	0 to 2 rating	% of plants
Anka	3.50*	**181***	3.67*	689*	43.4	37.7	1.25	0.269*
CFX-2	3.00*	102	3.26	529*	42.8	39.6	1.50	0.445*
CRS-1	3.50*	143	2.60	598*	41.8	38.4	1.25	0.724*
Canda	**3.75***	144	3.21	**751***	42.4	39.4	1.25	0.650*
Delores	3.25*	154	4.19*	721*	41.9	**42.2***	1.00	**0.134***
Full sun	2.25	168*	**4.70***	609*	43.5	37.5	1.50	0.351*
Grandi	3.50*	110	3.35	336	43.1	41.9*	1.25	8.15
Katani	**3.75**	104	2.60	365	42.9	40.0*	1.00	10.2
LSD (0.10)	0.861	27.2	1.25	225	NS	2.44	NS	5.09
Trial mean	3.31	139	3.45	575	42.7	39.6	1.25	3.12

†Early season vigor was rated on a 1 to 5 scale with 1 = low vigor and 5 = high vigor.
‡Aphid severity was rated as absent = 0, present = 1, or heavy infestation = 2
*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10). Treatments in bold were top performers for the given variable.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

When comparing 8 hemp varieties at the 2-Jun planting date (Table 6), Canda and ‘Katani’ showed the best vigor, which was comparable with all other varieties except ‘Full sun.’ The variety Canda had the highest yield at 751 lbs ac^{-1}, which was comparable to yields achieved by Anka, CFX-2, CRS-1, ‘Delores’, and Full sun. Moisture content was highest in Delores, which was comparable to Grandi and Katani. Overall the moisture content of the seed was extremely high. It is likely that green material in the seed sample at harvest caused moisture readings to be inflated. The variety Anka again had a significantly higher plant height, at 181 cm, which was comparable to Full sun. Population was significantly higher for Full sun, at 4.70 plants per square foot and was comparable to Anka and Delores. *Sclerotinia sclerotiorum* infection was comparable among all varieties, except for Grandi and Katani, which had significantly higher infection rates. Interestingly, these varieties tend to be shorter in stature and shading from taller varieties may have caused a moist climate conducive to disease infection.

Planting date 3: June 12, 2016

Table 7. The impact of variety on plot characteristics and harvest yield of industrial hemp at the 12-Jun planting date, Alburgh, VT, 2016.

Variety	Early season vigor†	Height @ harvest	Yield	Test weight	Moisture @ harvest	Aphid severity‡
	1 to 5 rating	cm	lbs ac^{-1}	lbs bu^{-1}	%	0 to 2 rating
Anka	**4.00***	**185**	391	41.8	40.5	1.25
CFX-2	2.50	111	421	40.9	40.3	1.25
CRS-1	2.50	143	478	41.5	40.8	1.50
Canda	3.50*	158	482	42.1	39.2	1.00
Delores	3.25*	158	428	42.0	40.6	1.75
Full sun	2.00	175*	430	41.9	39.2	1.75
Grandi	2.75	102	317	41.8	39.0	1.50
Katani	2.75	100	307	41.7	40.0	1.50
LSD (0.10)	0.777	14.0	NS	NS	NS	NS
Trial mean	2.91	142	407	41.7	40.0	1.44

†Early season vigor was rated on a 1 to 5 scale with1 = low vigor and 5 = high vigor.
‡Aphid severity was rated as absent = 0, present = 1, or heavy infestation = 2
*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10). Treatments in bold were top performers for the given variable.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

When comparing 8 varieties at the 12-Jun planting date (Table 7), no significant differences were seen across yield, test weight, moisture, or aphid severity. Overall yield was low and harvest moisture extremely high both likely due to a later than optimum harvest for varieties at this planting date. However, plant height was highest for Anka, which was comparable with Full sun. Also, vigor was best for Anka, and comparable with Canda and Delores.

Planting date 4: June 17, 2016

Table 8. The impact of variety on plot characteristics and harvest yield of industrial hemp at the 17-Jun planting date, Alburgh, VT, 2016.

Variety	Early season vigor†	Height @ harvest	Population @ harvest	Yield	Test weight	Moisture @ harvest	Aphid severity‡	Sclerotinia infection
	1 to 5 rating	cm	plants ft^{-2}	lbs ac^{-1}	lbs bu^{-1}	%	0 to 2 rating	% of plot
Anka	4.00	138	5.33	473	42.2	36.2*	1.67	1.12
CFX-2	3.33	123	4.60	419	41.6	35.6	1.33	0.75
CRS-1	4.00	149	6.84	421	41.2	32.0	1.00	1.64
Canda	4.33	142	4.46	623	42.6	35.3	1.00	0.48
Delores	4.00	135	4.34	394	41.7	31.8	0.00	0.32
Fedora	3.00	152	8.06	836*	42.3	35.1	1.33	1.46
Felina	3.67	175	6.08	888*	42.3	36.8*	0.67	2.22
Futura	3.67	167	5.21	**904***	42.0	**38.0***	1.00	1.02
Grandi	3.67	96.6	4.22	380	41.4	35.0	1.00	4.24
Katani	3.67	117	4.09	405	41.3	34.9	0.67	2.74
USO-31	4.00	142	4.59	332	42.4	31.7	0.67	1.70
LSD (0.10)	NS	NS	NS	169	NS	2.37	NS	NS
Trial mean	3.76	140	5.33	552	41.9	34.8	0.940	1.61

†Early season vigor was rated on a 1 to 5 scale with 1 = low vigor and 5 = high vigor.
‡Aphid severity was rated as absent = 0, present = 1, or heavy infestation = 2
*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10). Treatments in bold were top performers for the given variable.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

When comparing 11 varieties at the 17-Jun planting date (Table 8), no significant differences were seen across test weight, height, population, vigor, aphid severity, or *Sclerotinia sclerotiorum* infection. The variety 'Futura' showed the highest yield at 904 lbs ac^{-1}, which was comparable with 'Fedora' and 'Felina.' Moisture content was highest for Futura at 38.0%, which was comparable with Anka and Felina. Overall the moisture content of the seed was extremely high. It is likely that green material in the seed sample at harvest caused moisture readings to be inflated.

Across planting dates

Table 9. The impact of planting date, across all varieties, on plot characteristics and harvest yield of industrial hemp, Alburgh, VT, 2016.

Planting date	Early season vigor†		Yield		Test weight		Moisture @ harvest	
	1 to 5 rating		lbs ac^{-1}		lbs bu^{-1}		%	
26-May	1.86	C	1850	A	41.6	B	24.1	A
2-Jun	3.31	B	575	B	42.7	A	39.6	C
12-Jun	2.91	B	407	B	41.7	B	40.0	C
17-Jun	3.76	A	552	B	41.9	B	34.8	B
p-value	<.0001		<.0001		0.0001		<.0001	
Trial mean	3.00		812		42.0		65.0	

†Early season vigor was rated on a 1 to 5 scale with 1 = low vigor and 5 = high vigor.
Within a column, values followed by the same letter are not significantly different from each other.

When comparing yield and quality measurements between planting dates (Table 9), there were many significant differences in vigor, yield, test weight, and harvest moisture of the seed. The 26-May planting date had the highest yields at 1850 lbs ac^{-1} and the lowest moisture at 24.1%. The 2-Jun planting showed the highest test weight at 42.7 lbs bu^{-1}. The 17-Jun planting the best vigor performance and was likely due to warmer temperatures and adequate soil moisture at the time of planting.

DISCUSSION

Yield and Quality

All hemp varieties at all planting dates reached full plant maturity. Generally, the male flowers (pollen source) appeared after 38 days and late season varieties matured by 45 days after planting. Seed development occurred after 45 days and up to 60 days after planting, for the late season varieties. While the first planting date showed significantly higher yields, harvest yields for the following plantings were much lower than expected and were likely due to delayed harvest. The first planting date was harvested on time, when plants were still young and green and seed was 50 to 70% ripe. The first planting date produced average yields of 1850 lbs ac^{-1} across varieties, and out-performed average yields from Canada, which range from 500-1200 lbs ac^{-1}. Unfortunately, the plot combine used to harvest experimental trials had an engine malfunction and caused our remaining hemp harvest to be delayed past optimum harvest stages. The remaining planting dates were harvested when the plants had gotten more mature, which made combining more difficult, and seed had shattered and dropped by the later date.

All measured populations averages at 3.45 to 5.33 plants ft^{-2}, which was lower than the ideal rate of 7-10 plants ft^{-2} (generally 23-27 lbs of seed ac^{-1}). Low populations may have been influenced by the dry soil conditions at planting. In spite of a low seeding rate, the first planting date yielded very well. This encourages more evaluation of the effect of seeding rate on yield.

Test weights for all varieties and across planting dates were lower than the average test weight seen in Canada, which is 44 lbs bu^{-1}. Lower test weights also may have been a result of the warm and extremely dry weather conditions during seed development stages.

Moisture content varied by variety, with Anka typically having a higher moisture percentage in comparison to other varieties. This makes sense as Anka was described as requiring the longest growing season to mature. A higher moisture percentage may be more advantageous during harvest, as the plants may be more flexible and less likely to get caught in the combine. As recommended from growing hemp in Saskatchewan, Canada, hemp harvest can begin when field moisture is at 20%, however, seed would need to start drying within 4 hours as it otherwise will heat up. Seed should be dried to 8-10% moisture for long term storage. Ideally, hemp is harvested in the 12-15% range. Interestingly, when looking at moisture across planting dates, the first planting date had the lowest moisture content, which was still relatively high at 24.1%. The high moisture contents seen in this trial may have been due to a large amount of trash material (stem, leaf, etc.) that was harvested with seed, especially with the later plantings that were more difficult to harvest.

Differences in height could be seen when comparing varieties. Anka and Full sun tend to be the tallest varieties across several planting dates. Differences in height were apparent in the first three planting dates, but not in the last planting date. This could be because all varieties in the last planting date had less time to mature. A taller variety may be advantageous if hoping to grow hemp for dual purposes, both grain and fiber. However, if the primary interest is in grain production, a taller variety may leave more possibility for lodging and increase difficulties at harvest.

Pest Pressure in Hemp

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.

Early in the season, root development was weak and random sampling indicated that some plants had root rot that was identified to be caused by *Fusarium* spp. and *Rhizoctonia* spp. Lesions on the stem were also identified at this time and were identified as *Botrytis* spp., *Epicoccum nigrum*, and *Fusarium* spp. Lesions on hemp leaves were noticed and later identified as being *Alternaria* spp., *Cladosporium* spp., and *Botrytis* spp. These diseases did not appear to negatively affect yields. *Sclerotinia sclerotium* (Figure 1) infected all varieties and was present across all planting dates. It did not appear to have an impact on yields. *Sclerotinia sclerotiorum* tended to be lower in the taller hemp varieties and it may be possible that shorter plants were shaded by other taller varieties near them in the trials. Aphids infested the hemp during later stages of plant development and but did not seem to affect plant yields, since most vegetative growth had already been completed. Later planting dates appeared to have more aphid pressure and was likely due to delays in harvest.

During the early growth stages of hemp, weed pressure appeared to be problematic. The hemp plants were small, weak, and had poor root development while weeds seemed to be growing much quicker. About one month after planting, the hemp grew rapidly and successfully gained over the weeds, without any weed control. The primary weed pressure in the hemp trials was lambsquarter, 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.

Figure 1. ***Sclerotinia sclerotium*** **infection on industrial hemp, Alburgh, VT, 2016.**

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. It was clear that all varieties were able to mature when planted between 26-May and 17-Jun in northwestern, VT. Due to issues at harvest, we were unable to determine if yields were impacted by the planting date or the later than optimum harvest time. Additional research needs to be conducted to evaluate both varieties and planting dates in the northeast.

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