2017 Industrial Grain Hemp Planting Date Trial

Dr. Heather Darby, UVM Extension Agronomist
Abha Gupta, Erica Cummings, Lindsey Ruhl, and Sara Ziegler
UVM Extension Crops and Soils Technicians
(802) 524-6501

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2017 INDUSTRIAL GRAIN HEMP PLANTING DATE TRIAL

Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

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 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 three hemp grain varieties over four planting dates to determine best planting dates for the region.

MATERIALS AND METHODS

Table 1. Agronomic information for the industrial hemp grain planting date 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 dates	20-May, 29-May, 5-Jun, 12-Jun
Emergence dates	31-May, 8-Jun, 15-Jun, 24-Jun
Row spacing	7"
Planting equipment	Great Plains NT60 Cone Seeder
Planting rate (live seeds m^{-2})	125
Harvest date	12-Sep

The trial was conducted at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the impact of planting date on yield for three hemp grain varieties. 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% to a target of 125 live seeds m^{-2}. The typical seeding rate used by hemp grain growers is ~25 lbs ac^{-1}. The trial was planted on 20-May, 29-May, 5-Jun, and 12-Jun.

Table 2. Hemp grain varieties evaluated in the planting date trial 2017, Alburgh, VT.

Variety	Seed company	Days to maturity
Anka	Valley Bio Limited Reuben Stone Cobden, Ontario (613) 646-9737 info@valleybio.com	110
CRS-1	Hemp Genetics International Jeff Kostuik Saskatoon, Saskatchewan (204) 821-0522 jeff.kostuik@hempgenetics.com	100-110
Fedora17	Schiavi Seeds Lexington, Kentucky info@schiaviseeds.com	120

There were three hemp grain varieties evaluated, each of differing days to maturity (Table 2). The trial was planted into 5’x20’ plots. 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 organic systems.

A month after each planting, plant populations were recorded by counting the number of plants in three one-foot sections of a row 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, and just before harvest 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 12-Sep, the grain plots were harvested using an Almaco SPC50 small plot combine. Test weight was also measured using a Berckes Test Weight Scale, which weighs a known volume of grain. Harvest moisture was calculated by using an OHaus (Parsippany, New Jersey) MB 23 moisture analyzer.

Data was analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within the trial were treated as random effects, and planting dates and varieties 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. Seasonal weather data collected in Alburgh, VT, 2017.

Alburgh, VT	**May**	**June**	**July**	**August**	**September**
Average temperature (°F)	55.7	65.4	68.7	67.7	64.4
Departure from normal	-0.75	-0.39	-1.90	-1.07	3.76
Precipitation (inches)	4.10	5.60	4.90	5.50	1.80
Departure from normal	0.68	1.95	0.73	1.63	-1.80
Growing Degree Days (base 50°F)	245	468	580	553	447
Departure from normal	47	-7	-60	-28	129

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. September was unseasonably warm and dry, averaging 3.76° F warmer and 1.80 fewer inches of precipitation. Overall, there were an accumulated 2293 Growing Degree Days (GDDs) this season, approximately 81 more than the historical average. However, much of this heat gain came at the end of the season.

Results by Planting Date x Variety

There were no significant planting date by variety interactions in this study. This indicates that the varieties responded similarly across the planting dates.

Results by Planting Date

Across all varieties, planting date had a significant impact on plant height, yield, and test weight (Table 4, Figure 4). The 5-Jun planting date was the top performer in all three of these categories and yielded 574 lbs ac^{-1}. The 29-May planting date performed comparably for yield and height. The 12-Jun planting date yielded comparably, as well.

Table 4. The impact of planting date across all varieties on plot characteristics and harvest yield of industrial hemp, Alburgh, VT, 2017.

Planting date	Height @ harvest	Population	Yield	Test weight	Moisture @ harvest
	cm	plants ac^{-1}	lbs ac^{-1}	lbs bu^{-1}	%
20-May	101	252,431	322	34.4	13.8
29-May	118*	335,879	555*	37.7	13.0
5-Jun	**127***	329,621	**574***	**40.4***	11.8
12-Jun	109	331,707	555*	37.1	15.7
LSD (0.10)	12.5	NS	133	1.45	NS
Trial mean	113	312,410	501	37.4	13.6

*Treatments marked with an asterisk did not perform statistically worse than 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).

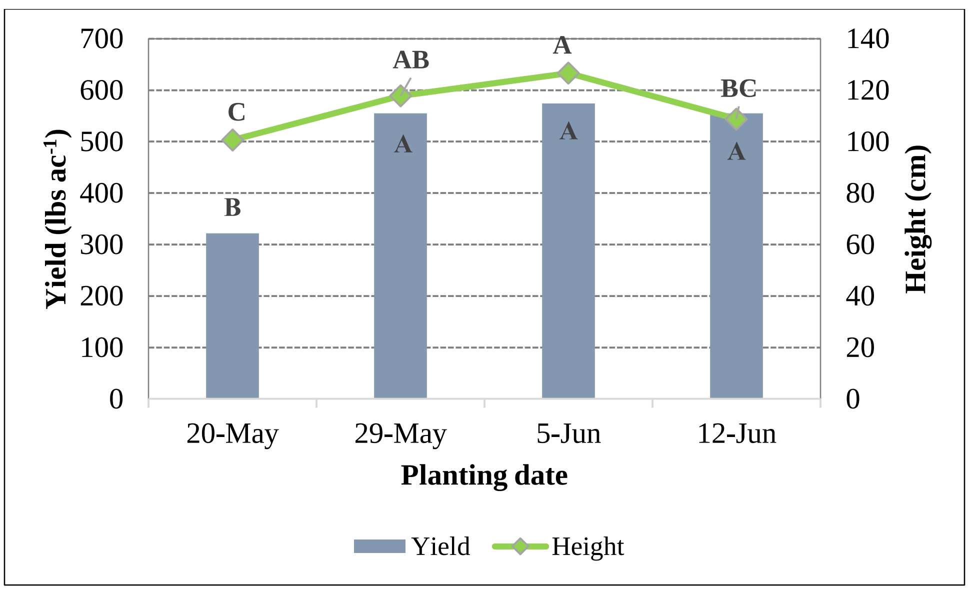

Figure 4. The effect of planting date on yield (p-value = 0.0075) and height (p-value = 0.0082). *Columns and lines that share the same letter did not perform statistically different from each other, Alburgh, VT, 2017.*

When evaluating arthropod presence across varieties, low levels of aphids, leafhoppers, spiders, Japanese beetles, tarnished plant bugs, and insect damage were present at the female flower development stage (Table 5). The presence of leafhoppers was significantly lower for the 5-Jun and 12-Jun plantings; however, populations were generally low for all four planting dates.

Table 5. The impact of planting date on disease and arthropod presence in industrial hemp at female flower development across all varieties, Alburgh, VT, 2017.

Variety	Aphids	Leafhopper	Spiders	Japanese beetles	Tarnished plant bug	Physical damage
	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}†
20-May	0.217	0.167	0.000	0.000	0.033	0.417*
29-May	0.300	0.117	0.017	0.000	0.117	**0.217***
5-Jun	0.333	0.050*	0.000	0.017	0.033	1.05
12-Jun	0.150	**0.033***	0.000	0.067	0.017	0.917
LSD (0.10)	NS	0.085	NS	NS	NS	0.188
Trial mean	0.250	0.092	0.004	0.021	0.050	0.650

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

Table 6. The impact of planting date on disease and arthropod presence in industrial hemp at harvest (12-Sep) across all varieties, Alburgh, VT, 2017.

Variety	Sclerotinia infection	Aphids	Leafhopper	Japanese beetles
	% of plants	# plant^{-1}	# plant^{-1}	# plant^{-1}
20-May	0.731	0.717	0.000	0.017
29-May	0.722	4.30	0.017	0.000
5-Jun	0.662	2.17	0.000	0.000
12-Jun	0.489	2.73	0.000	0.000
LSD (0.10)	NS	NS	NS	NS
Trial mean	0.651	2.48	0.004	0.004

NS – There was no statistical difference between treatments in a particular column (p=0.10).

When evaluating arthropod insect presence just prior to harvest across varieties, low levels of aphids, leafhoppers, and Japanese beetles were present (Table 6). The disease, *Sclerotinia sclerotiorum* (Table 6, Image 1), had infected a minimal number of plants and no significant difference was seen between planting dates.

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

Field Results by Variety

Table 7. The impact of variety across all planting dates on plot characteristics and harvest yield of industrial hemp, Alburgh, VT, 2017.

Variety	Height @ harvest	Population	Yield	Test weight	Moisture @ harvest
	cm	plants ac^{-1}	lbs ac^{-1}	lbs bu^{-1}	%
Anka	**128***	**353,612***	**541***	**39.3***	12.7
CRS-1	91.8	255,039	395	34.2	14.4
Fedora	120*	328,578*	567*	38.8*	13.5
LSD (0.10)	10.8	74,803	115	1.25	NS
Trial mean	113	312,000	501	37.4	13.6

*Treatments marked with an asterisk did not perform statistically worse than 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).

Across all planting dates, the varieties Anka and Fedora were consistently top performers in this trial. Both varieties performed comparably for yield with Fedora yielding 567 lbs ac^{-1} and Anka yielding 541 lbs ac^{-1}, and in plant height, plant population, and test weight (Table 7, Figure 5).

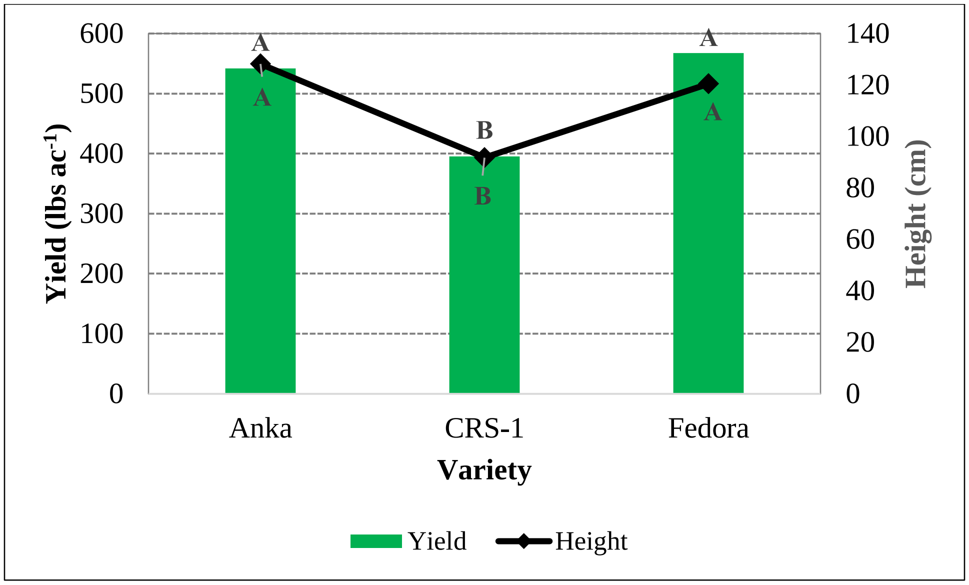

Figure 5. The effect of variety on yield (p-value = 0.03) and height (p-value <0.0001). Columns and lines that share the same letter did not perform statistically different from each other, Alburgh, VT, 2017.

Table 8. The impact of variety on disease and arthropod presence in industrial hemp at female flower development across all planting dates, Alburgh, VT, 2017.

Variety	Aphids	Leafhopper	Spiders	Japanese beetles	Tarnished plant bug	Physical damage
	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}†
Anka	0.188	0.050	0.013	0.013	0.025	0.725
CRS-1	0.150	0.138	0.000	0.013	0.063	0.700
Fedora	0.413	0.088	0.000	0.038	0.063	**0.525**
LSD (0.10)	NS	NS	NS	NS	NS	0.163
Trial mean	0.250	0.092	0.004	0.021	0.050	0.650

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

Across all planting dates, several arthropod insects were present in very low populations on hemp plants during the female flower development stage, including aphids, leafhoppers, spiders, Japanese beetles, and tarnished plant bugs, and populations were not statistically different between varieties (Table 8). Physical damage due to insect pests was apparent on all three varieties, while Fedora statistically showed the lowest signs of damage.

Table 9. The impact of variety on disease and arthropod presence in industrial hemp at harvest (12-Sep) across all planting dates, Alburgh, VT, 2017.

Variety	Sclerotinia infection	Aphids	Leafhopper	Japanese beetles
	% of plants	# plant^{-1}	# plant^{-1}	# plant^{-1}
Anka	0.584	2.30	0.000	0.000
CRS-1	0.939	3.53	0.000	0.000
Fedora	0.430	1.61	0.013	0.013
LSD (0.10)	NS	NS	NS	NS
Trial mean	0.651	2.48	0.004	0.004

NS – There was no statistical difference between treatments in a particular column (p=0.10).

Prior to harvest, aphid populations increased and *Sclerotinia sclerotiorum* infection had appeared across all planting dates (Table 9). Leafhoppers and Japanese beetles were also present; however, these pest and disease occurrences were not statistically different between varieties.

DISCUSSION

Yield and Quality

All hemp varieties and all planting dates reached full plant maturity. Generally, the male flowers (pollen source) appeared after 40 days and late season varieties matured by 55 days after planting. Seed development began after 65 days and up to 75 days after planting, for the late season varieties.

The hemp was harvested on time, when plants were still young and green and seed was 50 to 70% ripe and seed moisture was within the acceptable range of 10-20% moisture. As recommended from growing hemp in Saskatchewan, Canada, hemp harvest can begin when field moisture is at 20% and plants are relatively pliable and less likely to get wrapped in the combine. 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.

Average yield across all four planting dates was 501 lbs ac^{-1} and was in the low range compared to average yields from Canada, which range from 500-1200 lbs ac^{-1}. The first planting date (20-May) performed particularly poorly, with a yield of 322 lbs ac^{-1}. Low yields were likely due to poor seedling stands. Unfortunately, the unseasonably cool, wet spring conditions experienced in the Northeast led to seed rot, stunted growth, and weak seedling establishment. The 20-May planting experienced especially cool temperatures, whereas the average temperature for June was 9.7° F higher. The average population across planting dates was 77.2 plants m^{-2}, which is much lower than the target population of 125 plants m^{-2}. Poor early season establishment seen in this trial encourages the need to evaluate strategies to improve germination and early season vigor (i.e. seed treatments, seeding rates, and starter fertilizers). Weed pressure was high due to a combination of poor stands along with cool temperatures that made the hemp less able to compete with weeds. Because weed pressure was high, weed seed and plant material were harvested along with the hemp seed. In spite of threshing, weed seed, chaff, and plant stems remained in the harvest, which affected the test weight. None of the treatments in the trial met the standard test weight for hemp of 44 lbs bu^{-1}.

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. Early in the season, lesions on hemp leaves were noticed and later identified as being *Alternaria* spp., *Aspergillus* spp., and *Cladosporium* spp. These diseases did not appear to negatively affect yields. 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.

During the early growth stages of hemp, plants were small, weak, and had poor root development while weeds quickly grew. In the 2016 hemp trials, about one month after planting, the hemp grew rapidly and successfully overtook the weeds without any weed control. However, due to low populations and stand establishment in 2017, the hemp was a poor competitor against weeds. The primary weeds present 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. It was clear that due to unseasonably cool, wet, early season conditions, all planting dates underperformed. Additional research needs to be conducted to evaluate varieties in more growing conditions.

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