NORTHWEST CROPS & SOILS PROGRAM

2018 Industrial Grain Hemp Variety Trial

Dr. Heather Darby, UVM Extension Agronomist
UVM Extension Crops and Soils Technicians
(802) 524-6501

Visit us on the web: http://www.uvm.edu/nwcrops

THE UNIVERSITY OF VERMONT EXTENSION

2018 INDUSTRIAL GRAIN HEMP VARIETY 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 hemp grain varieties to determine best cultivars for the region.

MATERIALS AND METHODS

Table 1. Agronomic information for the industrial hemp grain variety trial 2018, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Benson rocky silt loam, 3-8% 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})	125
Harvest date	10-Sep

The trial was conducted at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the impact variety has on hemp grain yield. The experimental design was a randomized complete block with four replications. Nine grain varieties (Table 2) were planted on 8-Jun for the trial. 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 approximately 25 lbs ac^{-1}.

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

Variety	Seed company	Days to maturity
CFX-1	Hemp Genetics International	100-110
CFX-2	Hemp Genetics International	100-110
CRS-1	Hemp Genetics International	100-110
Katani	Hemp Genetics International	100-110
Canda	Parkland Industrial Hemp Growers	100-120
Joey	Parkland Industrial Hemp Growers	110-120
Anka	UniSeeds	110
Ferimon	UniSeeds	129-134
USO-31	UniSeeds	122-127

Table 3. Participating seed companies and contact information.

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

Seed was sourced from three seed companies (Table 3). The trial was planted into 5'x20' plots. 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.

A few days before harvest, 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 also 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 10-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.

The data was analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within trials were treated as random effects, 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 4).

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

Alburgh, VT	June	July	August	September
Average temperature (°F)	64.4	74.1	72.8	63.4
Departure from normal	-1.38	3.51	3.96	2.76
Precipitation (inches)	3.70	2.40	3.00	3.50
Departure from normal	0.05	-1.72	-0.95	-0.16
Growing Degree Days (base 50°F)	447	728	696	427
Departure from normal	-27	88	115	109

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.

The summer months were hot and dry. July through September were an average of 3.41º F warmer than historical averages and received an average of 0.94 inches less precipitation than historical averages. June received an expected amount of precipitation; however, it was cooler than historical averages. Overall, there were an accumulated 2298 Growing Degree Days (GDDs) from June to September, approximately 285 more than the historical average.

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

Variety	Height @ harvest	Population	Moisture @ harvest	Test weight	Yield @ 10% moisture	Seed oil
	cm	plants m^2	%	lbs bu^{-1}	lbs ac^{-1}	%
Anka	**162**	388,035	14.7	35.6	854*	21.9
Canda	117	488,172	12.8	36.6	983*	20.2
CFX-1	100	356,741	14.0	37.3	**1035**	22.4
CFX-2	93.3	275,379	13.1	38.7	941*	22.1
CRS-1	118	388,035	14.5	**42.0**	923*	22.8
Ferimon	146*	400,552	19.3	34.1	776	23.1
Joey	117	425,586	14.1	38.5	846*	22.4
Katani	86.0	331,707	13.6	37.2	836*	19.2
USO-31	128	337,966	16.1	34.8	756	21.7
LSD (0.10)	16.1	NS	NS	3.11	225	NS
Trial mean	119	376,908	14.7	37.2	883	21.8

*Treatments marked with an asterisk performed statistically similar 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).

There were no significant differences for population, or percent seed oil between varieties (Table 5). Yields were low compared to past years and ranged from 1035 to 756 lbs of seed per acre. The variety CRS-1 had the highest test weight, however, this was still below the industry average of 44 lbs bu^{-1}. The varieties Anka and Ferimon were the tallest varieties, however, with tall varieties it is important to make sure the combine can accommodate their height and to consider the possibility of lodging.

Table 6. The impact of variety on disease and arthropod presence in industrial hemp at female flowering (31-Jul), Alburgh, VT, 2018.

Variety	Aphids	Leafhopper	Japanese beetle	Flea beetle	Tarnished plant bug	Physical damage
	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$	# $plant^{-1}$†
Anka	0.100	0.000	0.050	0.000	0.200	1.50
Canda	0.000	0.000	0.000	0.000	0.150	1.30
CFX-1	0.000	0.000	0.000	0.000	0.250	1.15
CFX-2	0.150	0.000	0.000	0.000	0.100	1.10*
CRS-1	0.100	0.000	0.000	0.000	0.050	1.20
Ferimon	0.000	0.000	0.050	0.100	0.000	1.60
Joey	0.050	0.050	0.000	0.050	0.200	1.45
Katani	0.150	0.000	0.000	0.050	0.050	**0.750**
USO-31	0.100	0.050	0.050	0.000	0.000	1.40
LSD (0.10)	NS	NS	NS	NS	NS	0.360
Trial mean	0.0722	0.0111	0.0167	0.0222	0.111	1.27

†Physical damage from insect pests was recorded as the average number of damaged leaves per plant.
*Treatments marked with an asterisk performed statistically similar 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).

At the female flower development stage, pest pressure was minimal (Table 6). Aphids, leafhoppers, Japanese beetles, flea beetles, and tarnished plant bugs were present in very low populations and there were no significant differences in their incidence by variety. The varieties Katani and CFX-2 had the least physical damage from pests, however, damage was low overall.

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

Table 7. The impact of variety on disease and arthropod presence in industrial hemp at harvest (7-Sep), Alburgh, VT, 2018.

Variety	Sclerotinia infection	Aphids	Leafhopper	Ladybug	Tarnished plant bug	Physical damage
	% of plants	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}	# plant^{-1}†
Anka	0.000	0.050*	0.000	0.050	0.000	0.650
Canda	0.000	0.150*	0.000	0.000	0.100	1.00
CFX-1	0.058	0.500	0.000	0.000	0.050	0.900
CFX-2	0.000	0.100*	0.000	0.000	0.050	1.05
CRS-1	0.000	0.050*	0.050	0.100	0.000	1.15
Ferimon	0.080	0.200*	0.000	0.100	0.050	1.00
Joey	0.000	0.050*	0.000	0.100	0.000	1.00
Katani	0.000	0.100*	0.050	0.050	0.000	1.00
USO-31	0.000	**0.000**	0.000	0.000	0.050	1.10
LSD (0.10)	NS	0.253	NS	NS	NS	NS
Trial mean	0.015	0.133	0.011	0.044	0.033	0.983

*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10) shown **bold**.
NS – There was no statistical difference between treatments in a particular column (p=0.10).

While there was no *Sclerotinia sclerotiorum* infection (Image 1) present during the flowering stage, the infection appeared prior to harvest. The infection incidence was not significantly different between varieties (Table 7). The presence of aphids increased, compared to earlier in the season, and incidentally beneficial ladybugs appeared as they prey on aphids. CFX-1 had the greatest incidence of aphids, however, the pest pressure was low overall. Japanese beetles and flea beetles were not present at this stage of development, though they had been present earlier in the season.

DISCUSSION

Yield and Quality

All hemp varieties 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 twelve varieties was 883 lbs ac^{-1} and was in the low range compared to average yields from Canada, which range from 500-1200 lbs ac^{-1}. Low yields were partially attributed to poor stands following planting. The cool and wet weather in June had an impact on stand establishment. Likely the largest impact on yield was due to bird predation. This was the first year that we observed such an impact from birds on the hemp yields. In some cases, seed heads were completely decimated by bird feeding. Across all varieties, the average population was 93.1 plants m^{-2}, which was lower than the target population of 125 plants m^{-2}. Poor early season establishment encourages the need to evaluate strategies to improve germination and early season vigor (i.e. seed treatments, seeding rates, starter fertilizers). None of the treatments in the trial met the standard test weight for hemp of 44 lbs bu^{-1}. This may be due to drought conditions through much of the growing season.

The differences in height may be of special interest for farmers who would like to grow these varieties for both grain and fiber production. A taller variety may be more advantageous for fiber production; however, it may leave more possibility for lodging and wrapping in the combine. All varieties used in this trial are dual purpose cultivars for both fiber and grain use, except for Katani, which is intended for grain production only.

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 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 gained over the weeds without any weed control. However, due to low populations and stand establishment in 2017, the hemp was a poor competitor against the weeds. In 2018, the stand appeared better than in 2017, however, not as robust as in 2016. This was likely due to the cool start to the season and then the dry, very hot summer months. 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. It was clear that due to unseasonably cool, wet, early season conditions, all varieties underperformed. Additional research needs to be conducted to evaluate varieties under more growing conditions.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Program would like to give a special thanks to Roger Rainville and the staff at Borderview Research Farm for their generous help with the trials. We would like to acknowledge Abha Gupta, Sara Ziegler, Lindsey Ruhl, John Bruce, Catherine Davidson, Hillary Emick, Amanda Gervais, Haley Jean, and Rory Malone for their assistance with data collection, and data entry. This information is presented with the understanding that no product discrimination is intended and neither endorsement of any product mentioned, nor criticism of unnamed products, is implied.

UVM Extension helps individuals and communities put research-based knowledge to work.

THE UNIVERSITY OF VERMONT EXTENSION