2016

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NORTHWEST CROPS & SOILS PROGRAM

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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

2016 INDUSTRIAL HEMP SEEDING RATE 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 production knowledge on this crop has been lost. In this trial, we investigated optimal seeding rates for yield and pest pressure. Current seeding rate recommendations for hemp grain production range from 15-25 lbs ac^{-1}. Germination rates are around 85% and seed mortality, which according to Ontario and Manitoba agriculture governmental sources, ranges widely at 10-70%, with 30% most commonly used. After accounting for germination and mortality rates, growers could potentially over-seed by 25-85%, to account for loss. Therefore, the trial was designed to gain more information on ideal seeding rates.

MATERIALS AND METHODS

A trial was conducted at Borderview Research Farm in Alburgh, Vermont to evaluate the impact of seeding rates on yield, weed, arthropod, and disease pests in industrial hemp (Table 1). The experimental design was a randomized complete block with split plots replicated 4 times. Main plot treatments consisted of five seeding rates: 20, 25, 30, 35, 40 lbs ac^{-1}, and split plots were two varieties: 'Anka', from Valley Bio Limited (Cobden, Ontario), and 'CFX-2', from Hemp Genetics International (Saskatoon, Saskatchewan). The variety Anka requires approximately 110 days to maturity and tends to be taller than CFX-2, which requires approximately 103 days to maturity. The trial was planted into 5'x20' plots on 26-May. On 1-Jul the trial was 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.

On 9-Sep, 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 13-Sep, the hemp was harvested using an Almaco SPC50 small plot combine. Harvest moisture was calculated by taking a 100g subsample 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 seeding rate 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
Plot size (ft)	5x20
Industrial hemp varieties	Anka and CFX-2
Planting date	26-May
Emergence date	31-May
Row spacing	7.5”
Planting equipment	Great Plains NT60 Cone Seeder
Planting rate (lbs ac^{-1})	20, 25, 30, 35, 40
Harvest date	13-Sep

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 ($p<0.10$).

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 2). 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) 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 2. 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.

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* infected at most 0.379% of plants per plot and also likely had a negligible effect on yield. Aphids infested the hemp during later stages of plant development and did not seem to affect plant yields, since most vegetative growth had already been completed. Early season weeds appeared to be problematic, as the hemp plants were small, weak, and had poor root development, while weeds continued to grow. However, about one month after planting, the hemp grew rapidly and gained over the weeds, without cultivation or herbicide application. It is important to note that 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.

Seeding Rate

Hemp yield and test weight were not impacted significantly by seeding rate. The average yield across all seeding rates was 1140 lbs seed per acre (Table 3), which is well within the yield range seen in Canada, at 500-1200 lbs ac^{-1}. The mean

test weight for the trial was 42.5 lbs bu^{-1}, which was slightly lower than the average test weight from Canada, at 44 lbs bu^{-1}. Plant populations measured at harvest were highest for the 35 lbs ac^{-1} seeding rate (Table 3). Plant populations at harvest were statistically similar among the other treatments. There was no significant differences seen comparing harvest moisture, height, and *Sclerotinia sclerotium* infection rates among seeding rate treatments. Aphid severity was significantly worse for the 20 lbs ac^{-1} treatment. It is unclear why the lowest seeding rate may have led to greater aphid populations. Regardless, populations of all pest were low and likely did not impact overall yields.

Table 3. The impact of seeding rate on plot characteristics and harvest yield of industrial hemp, Alburgh, VT, 2016.

Seeding rate	Yield	Test weight	Population @ harvest	Moisture @ harvest	Height @ harvest	Aphid severity†	Sclerotinia infection
lbs ac^{-1}	lbs ac^{-1}	lbs bu^{-1}	plants ft^{-2}	%	cm	0 to 2 rating	% of plot
20	1310	42.3	4.65	30.0	153	1.50	0.379
25	1180	42.4	5.12	29.6	158	1.13*	0.185
30	1340	42.6	5.49	29.3	160	1.30*	0.250
35	1390	42.5	**7.07***	32.1	154	1.13*	0.214
40	1470	42.9	5.51	29.8	149	**1.00***	0.145
LSD (0.10)	NS	NS	1.20	NS	NS	0.353	NS
Trial mean	1340	42.5	5.56	69.8	155	1.20	0.235

†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).

Variety

Both Anka and CFX-2, across all seeding rates, performed well in terms of harvest yield (Table 4), outperforming Canadian yield averages of 500-1200 lbs ac^{-1}, and there was no significant difference between the two varieties. Test weight was significantly higher for Anka compared to CFX-2 across all seeding rates, at 42.9 lbs bu^{-1}, but still lower than Canadian averages of 44 lbs bu^{-1}. Populations, harvest moisture, and aphid infestation was not significantly different across all treatments. The variety CFX-2 was significantly shorter than Anka across all seeding rates at 117 cm. *Sclerotinia sclerotium* was significantly lower for Anka compared to CFX-2, at 0.136% of the plot infected compared to 0.333% of the plot.

Table 4. The impact of variety on plot characteristics and harvest yield of industrial hemp, Alburgh, VT, 2016.

Variety	Yield	Test weight	Population @ harvest	Moisture @ harvest	Height @ harvest	Aphid severity†	Sclerotinia infection
	lbs ac^{-1}	lbs bu^{-1}	plants ft^{-2}	%	cm	0 to 2 rating	% of plot
Anka	1450	**42.9‡**	5.70	32.7	192	1.20	**0.136**
CFX-2	1230	42.1	5.43	27.7	**117**	1.20	0.333
LSD (0.10)	NS	0.50	NS	NS	7.30	NS	0.146
Trial mean	1340	42.5	5.56	69.8	155	1.20	0.235

†Aphid severity was rated as absent = 0, present = 1, or heavy infestation = 2.
‡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).

Seeding Rate x Variety Interaction

There were no significant interactions observed between variety and seeding rate. This indicates that these varieties performed similarly across the various seeding rates.

DISCUSSION

Based on this study, seeding rates of 20, 25, 30, 35, and 40 lbs ac^{-1} across the varieties Anka and CFX-2 had comparable yields. Therefore, it is possible that any seeding rate between 20-40 lbs ac^{-1} may have similar yield outcomes. However, there was considerable variation in the data collected, especially for yield measurements (CV=49). Variation in yields was primarily a result of issues at harvest. 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. It is interesting to note that populations were statistically similar except for the seeding rate of 35 lbs ac^{-1}. Clearly, additional years of research need to be conducted to determine optimum seeding rates for the northeast.

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