2019

Industrial Hemp Fertility Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2019 INDUSTRIAL HEMP FERTILITY 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 crop produces a valuable oilseed and oilseed meal. 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. manufacturers have been importing hemp from China, Eastern Europe, and Canada. Today, industrial hemp is re-emerging as a locally grown product in the U.S. To help farmers succeed, agronomic research on hemp is needed, as much of the historical production knowledge for the region has been lost. Specifically, there is a lack of nitrogen (N) response information for New England, which is important for establishing nutrient recommendations in the region. In this trial, the impact of 4 N rates on industrial hemp grain yield and quality was evaluated.

MATERIALS AND METHODS

The trial was initiated at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate the impact of nitrogen fertility rates on hemp grain yield. The experimental design was a randomized complete block with four replications. On 25-Apr, 57 lbs ac^{-1} of N, 57 lbs ac^{-1} of phosphorus (P), and 57 lbs ac^{-1} of potassium (K) was applied to the tract of land where the trial was later initiated. Industrial hemp seed of the variety 'Anka' (Uniseeds, Cobden, Ontario, 110 days to maturity) was planted into 5 x 20' plots at a rate of 125 live seeds m^{-2} with a Great Plains NT60 Cone Seeder on 7-Jun. There were 5' buffers between replicates and the soil type was Covington silty clay loam with 0-3% slopes.

Table 1. Agronomic information for the industrial hemp grain variety trial 2019, Alburgh, VT.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Covington silty clay loam, 0-3% slopes
Previous crop	Corn
Variety	Anka
Plot size (ft)	5 x 20
Planting date	7-Jun
Row spacing	7"
Replicates	4
Planting equipment	Great Plains NT60 Cone Seeder
Seeding rate (live seeds m^{-2})	125
Harvest date	6-Sep

Treatments included four N application rates (75, 100, 125, 150 lbs N ac^{-1}) and an untreated control. On 3-Jul, N treatments were applied in the form of urea (46-0-0). On 6-Sep, the plots were harvested with an Almaco (Nevada, IA) SPC50 small plot combine. Test weight was 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. Prior to harvest, stem subsamples were collected for

nutrient analysis. The samples were dried down for storage and sent to Dairy One (Ithaca, NY) on 29-Oct, and were analyzed for percent carbon (C) and N, C:N ratio, P, and K. Oil was extruded from the seeds with an AgOil M70 oil press (Mondovi, WI) on 27-Nov and 3-Dec, and the amount of oil captured was measured to determine oil content.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 2008). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$. Variations in genetics, soil, weather, and other growing conditions can result in variations in yield and quality. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or 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. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 90% of the time. Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk.

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

In the example to the right, treatment C was significantly different from treatment A, but not from treatment B. The difference between C and B is 1.5, which is less than the LSD value of 2.0 and so these treatments were not significantly different 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 treatments were significantly different from one another. The asterisk indicates that treatment B was not significantly lower than the top yielding treatment, 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 (Table 2). A cool and wet spring led to a cool June, which was 1.46° F cooler than average and accumulated 29 fewer Growing Degree Days (GDDs) than normal.

Table 2. Seasonal weather data collected in Alburgh, VT, 2019.

Alburgh, VT	June	July	August	September
Average temperature (°F)	64.3	73.5	68.3	60.0
Departure from normal	-1.46	2.87	-0.51	-0.62
Precipitation (inches)	3.06	2.34	3.50	3.87
Departure from normal	-0.63	-1.81	-0.41	0.23
Growing Degree Days (base 50°F)	446	716	568	335
Departure from normal	-29	76	-13	17

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 average July temperature was 2.87° F higher than the 30-year normal, while precipitation was below the normal in June and August. Temperatures were less than one degree below normal during August and September. The hotter than average July resulted in 76 more monthly GDDs than average. Overall, 2065 GDDs were accumulated Jun-Sept, 51 GDDS above the 30-year normal.

Additional N fertilizer increased hemp grain yield (Table 3). The 125 lbs N ac^{-1} treatment was the top performer, yielding 1279 lbs ac^{-1} at 10% moisture, which was significantly higher than the yields of the control and the 75 lbs N ac^{-1} treatment. The 100 and 150 lbs N ac^{-1} treatments had yields that were statistically similar to both the 125 lbs N ac^{-1}. There were no significant differences between treatments for seed moisture at harvest, test weight, and seed oil content. Grain hemp is generally harvested at a moisture of 10-20% and the average from the trial was 16.8%. The average trial test weight was 39.5 lbs bu^{-1}, which is below the industry average of 44 lbs bu^{-1}.

Table 3. The impact of nitrogen fertility rates on harvest metrics of grain hemp, Alburgh, VT, 2019.

Treatment	Dry matter yield	Yield @ 10% moisture	Seed moisture at harvest	Test weight	Seed oil content
lbs N ac^{-1}	**lbs ac^{-1}**	**lbs ac^{-1}**	**%**	**lbs bu^{-1}**	**%**
0	502[c]	557[c]	18.7	**40.6**	**22.4**
75	797[bc]	885[bc]	17.9	39.6	**22.4**
100	1054[ab]	1171[ab]	20.1	39.3	21.0
125	**1151[a]**	**1279[a]**	14.9	38.8	19.2
150	1045[ab]	1161[ab]	**12.2**	39.1	21.5
LSD (0.10)	314	349	NS	NS	NS
Trial mean	910	1011	16.8	39.5	21.3

* Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**
NS – There was no statistical difference between treatments in a particular column (p=0.10).

Results from the whole plant biomass nutrient analysis are displayed in Table 4. Carbon, N, P, K, and the carbon to nitrogen ratio did not differ significantly by treatment. On average the hemp plants contained 2.78% N, 0.587 P, and 2.05% K.

Table 4. Biomass nutrient analysis results by nitrogen fertility rate, Alburgh, VT, 2019.

Treatment	C:N	N	C	P	K
lbs N ac^{-1}		**%**	**%**	**%**	**%**
0	18.3	2.56	45.8	0.59	1.96
75	**15.9**	**2.93**	**46.3**	0.55	1.89
100	17.5	2.63	45.7	0.62	**2.22**
125	16.1	2.88	45.5	0.56	2.06
150	16.3	2.87	45.4	**0.63**	2.12

LSD (0.10)	NS	NS	NS	NS	NS
Trial mean	16.8	2.78	45.7	0.587	2.05

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

DISCUSSION

These results indicate that the application of N can increase hemp grain yields. Rates between 100 and 125 lbs N ac^{-1} resulted in the highest yields. There was no additional yield gain from applying 150 lbs N ac^{-1}. It is important to remember that these data represent only one year of research, and in a year with fewer accumulated GDDs than average due to the unusually cold and wet spring. Further research is needed to establish sound agronomic recommendations for the region.

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 Catherine Davidson, Hillary Emick, Haley Jean, and Lindsey Ruhl 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.

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