2021 Industrial Hemp Fertility Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2021 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 paper, cloth, rope, building materials, and even a form of plastic. 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 five nitrogen rates on industrial hemp 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 and fiber yield. The experimental design was a randomized complete block with split plots and four replications. The ground was prepared for planting with a disk & spike tooth harrow. Industrial hemp seed of the varieties Canda (Parkland Industrial Hemp Growers, Dauphin, Manitoba, 110 days to maturity) and Felina 32 (Uniseeds, Cobden, Ontario, 135 days to maturity) was planted into 5 x 20’ plots at a rate of 55 lbs ac^{-1} with a Kverneland seed drill on 8-Jun. There were 5’ buffers and the soil type was Covington Silty Clay loam, 0-3% slopes.

Table 1. Agronomic information for the industrial hemp grain variety trial, Alburgh, VT, 2021.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Covington Silty Clay loam, 0-3% slopes
Previous crop	Sweet corn
Variety	Canda, Felina 32
Plot size (ft)	5’ x 20’
Planting date	8-Jun
Row spacing	7”
Replicates	4
Planting equipment	Kverneland seed drill
Seeding rate (lbs ac^{-1})	55
Harvest date	2-Sep, 14-Sep

Treatments included four N application rates (50, 100, 150, and 200 lbs N ac^{-1}) and an untreated control, applied to two hemp varieties, Felina 32 and Canda. Heights and populations were measured on 24-Aug by measuring three heights of stems and by counting plant populations in 0.25 m^2 quadrat within each plot. On 15-Jul, N treatments were applied in the form of urea (46-0-0). On 2-Sep and 14-Sep, the plots were harvested for grain with an Almaco (Nevada, IA) SPC50 small plot combine. Harvest moisture was calculated by using an OHaus (Parsippany, New Jersey) MB 23 moisture analyzer. After the grain harvest, 5 stems per plot were harvested and decorticated to determine the percent of bast and hurd fractions. Oil was extruded from the seeds with an AgOil M70 oil press (Mondovi, WI) on 19-Jan 2021, 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. 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. Treatment B was not significantly lower than the top yielding treatment, indicated in bold. A lack of significant difference is indicated by shared letters.

Treatment	Yield
A	6.0^{b}
B	7.5^{ab}
C	**9.0^{a}**
LSD	2.0

RESULTS

Weather data 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).

Table 2. Temperature and precipitation summary for Alburgh, VT, 2021.

Alburgh, VT	June	July	August	September
Average temperature (°F)	70.3	68.1	74.0	62.8
Departure from normal	2.81	-4.31	3.25	0.14
Precipitation (inches)	3.06	2.92	2.29	4.09
Departure from normal	-1.20	-1.14	-1.25	0.42
Growing Degree Days (50°F-	597	561	727	394
Departure from normal	73	-134	85	7

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1991-2020) from Burlington, VT.

The summer months included both above average and below average temperatures, including a warm June and a July that was 4.31 degrees colder than normal. Temperatures were above average for June and August, and from June to September, 2279 Growing Degree Days (GDDs) were accumulated; 31 above the normal. The season brought lower than average levels of precipitation, resulting in 3.59 fewer inches of rain than is considered typical for the summer months. There were 12.36 inches of precipitation during the growing season.

Impacts of nitrogen rate

There were no significant differences in grain yields across fertility treatments within the trial with an average yield of 1669 lbs ac^{-1} at 10% grain moisture (Table 3). Grain hemp is generally harvested at a moisture of 10-20% and the average from the trial was 19.4%. Similarly test weights remained consistent across all fertility treatments. Grain moisture appeared to be impacted in some manner by fertility applications with the highest observed moisture seen in the 100 lbs N ac^{-1} treatment at 20.9% and was statistically similar to the control, 150, and 200 lbs N ac^{-1} treatments. Between the two varieties, it appeared as if they responded similarly to fertility treatments regarding hemp grain metrics, with no fertility x variety interactions occurring.

Table 3. The impact of nitrogen fertility rates on grain hemp yields, Alburgh, VT, 2021.

Treatment	**Test weight**	**Grain Moisture at harvest**	**Dry matter grain yield**	**Grain yield @10% moisture**
lbs N ac^{-1}	lbs bu-1	%	**lbs ac^{-1}**	**lbs ac^{-1}**
0	39.8	20.0 ab†	1500	1666
50	40.0	18.4 b	1581	1757
100	39.5	**20.9 a**	1435	1594
150	40.0	18.8 ab	1467	1630
200	39.5	19.1 ab	1527	1697
LSD (0.10)	NSŧ	2.42	NS	NS
Trial Mean	39.8	19.4	1502	1669

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

Oil yields from pressing the seed are displayed below in Table 4. On average, the grain was 17.0% oil and yielded 282 lbs ac^{-1} or 37.0 lbs gal ac^{-1}. The 200 lbs N ac^{-1} treatment produced grain with the highest percent oil content, at 18.3%. These results were significantly similar to the 150 and 100 lbs N ac^{-1} treatments, as well as the control. The 50 lbs N ac^{-1} treatment produced grain with the lowest percent oil content at 15.3%, which was significantly lower than the other treatments and the control. When looking at oil yields, the total amount produced on a per acre basis were not significantly different across treatments, likely as a result of consistent grain yields across treatments.

Table 4. Oil yields of hemp grain by nitrogen fertility rate, Alburgh, VT, 2021.

Treatment	Oil Content		
lbs N ac-1	**%**	**lbs ac-1**	**gal ac-1**
0	16.8 ab†	278	36.4
50	15.3 b	271	35.5
100	17.0 a	271	35.5
150	17.7 a	287	37.6
200	**18.3 a**	304	39.9
LSD (0.10)	1.53	NS‡	NS
Trial mean	17.0	282	37.0

† 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).

Plant heights, stem diameter, populations, whole plant dry matter, bast percentage and hurd percentage did not appear to be impacted by fertility treatments in this trial (Table 5). The 150 lbs N ac^{-1} treatment produced plants with the highest percent bast fiber, but this was not significantly different than any of the other treatments or the control. The stalks consisted of 33.6% bast fiber on average, and 66.4% hurd fiber on average. Bast fiber grows on the outside of the stalk and provides most of the tensile strength of the plant, while the hurd fibers consist of the woody, inner component. The 200 lbs N ac^{-1} treatment produced the highest overall dry matter straw yields at 12,136 lbs ac^{-1} with the 150 lbs N ac^{-1} treatment producing second highest straw yields at 10,807 lbs N ac^{-1}. These were statistically similar to the control and 50 lbs N ac^{-1} treatments.

Table 5. Hemp straw harvest metrics by nitrogen fertility rate, Alburgh, VT, 2021.

Treatment	**Height**	**Stem diameter**	**Population**	**Whole plant dry matter**	**Bast**	**Hurd**	**Dry matter straw yield**
	cm	mm	plants ac-1	%	%	%	**lbs ac-1**
0	130	5.76	380543	38.9	34.2	65.8	7509 ab†
50	136	6.38	453413	38.2	28.9	71.1	8481 ab
100	125	5.32	364349	38.3	31.5	68.5	6360 b
150	130	6.33	497944	35.4	37.4	62.6	10807 ab
200	128	6.08	477703	36.2	35.7	64.3	**12136 a**
LSD (0.10)	NS‡	NS	NS	NS	NS	NS	4915
Trial Mean	130	5.97	434790	37.4	33.6	66.4	9059

† 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).

DISCUSSION

Grain and fiber yields did not increase consistently with increasing nitrogen rate, and not all of the nitrogen treatments resulted in higher yields than the untreated control. As a whole, results were more nuanced and less predictable than linear and plateauing responses to increased nitrogen application rates observed in many other crops. While yields did not show clear increases for grain, significantly higher straw yields were observed in the 200 lbs N ac^{-1} in addition to highest observed oil content at the same application rate. Two varieties were evaluated in this trial to determine if there were response differences between hemp varieties to nitrogen rates. There were no significant variety x nitrogen rate interactions indicating the varieties responded similarly to increasing rates of nitrogen. Both selected varieties (Felina 32 and Canda) have the potential to be grown as either grain or fiber crops, however some differences were observed. When looking solely at varietal differences within the trial, higher grain yields were observed in Canda which also impacted the total oil production on a per acre basis. Conversely, higher straw yields and plant heights were observed in Felina 32. Felina 32 and Canda responded differently to fertility treatments regarding oil content on a percentage basis ($p=0.0074$) and yields ($p=0.0881$). Felina 32 saw highest oil percentages at the top three fertility application rates with a linear increase peaking at 200 lbs N $^{ac-1}$ (19.4%), whereas highest values for Canda were seen at the 50 lbs N ac^{-1} treatment and no linear trend for application rates. Several other potential confounding factors may be responsible for this including adequate in-field fertility prior to supplemental fertility applications, bird predation, or establishment to name a few. It is important to remember that these data represent only one year of research. Further research is needed to establish sound agronomic recommendations for the region.

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