NORTHWEST CROPS & SOILS PROGRAM

2021 Hemp Cannabidiol Drying Trial

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

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

THE UNIVERSITY OF VERMONT EXTENSION

2021 HEMP CANNABIDIOL DRYING 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 re-emerging worldwide importance as medical providers and manufacturers seek hemp as a renewable and sustainable resource for a wide variety of consumer and industrial products. Hemp grown for all types of end-use (health supplement, fiber, and seed) contains less than 0.3% tetrahydrocannabinol (THC). Some hemp varieties intended to produce a health supplement contain relatively high concentrations of a compound called cannabidiol (CBD), potentially 10-15%. The compound CBD has purported benefits such as relief from inflammation, pain, anxiety, seizures, spasms, and other conditions. The CBD compound is the most concentrated in the female flower buds of the plant, however, it is also in the leaves and other plant parts as well.

To produce hemp for flower, the plant is generally grown intensively as a specialty crop and the flowers are cultivated for maximum growth. The various cannabinoids and terpenes concentrated in the flower buds are often extracted and incorporated into topical products (salves, lip balm, lotion) and food and is available in pill capsules, powder form, and more, which can be found in the market today. To help farmers succeed, agronomic research on hemp is needed in the United States. In 2021, the Northwest Crops and Soils (NWCS) Program conducted a trial to determine the impact of drying temperature and humidity on CBD and other cannabinoids derived from hemp flowers.

Participants of State Hemp Programs intending to grow are required to follow state and federal regulations regarding hemp production and registration. Growers must register within their intended state for production and must adhere to the most current or active rules and regulations for production within a grower's given state. Regulations are subject to change from year to year with the development and approval of proposed program rules and it is important to note that regulations may vary across state lines and may be impacted by pending federal regulations. Please refer to this https://agriculture.vermont.gov/sites/agriculture/files/documents/PHARM/hemp/Vermont_State_plan_2021_12_1.pdf for a detailed outline of the most recent approval from the Agricultural Marketing Service of the USDA of the Vermont Hemp Production Plant. The approved plan supports the Vermont Hemp Rules and governs registration, production, sampling and compliance for hemp cultivation beginning in 2022.

Additional information regarding the Vermont Agency of Agriculture, Food and Markets (VAAFM) Hemp Program can be found on the VAAFM website here:

https://agriculture.vermont.gov/public-health-agricultural-resource-management-division/hemp-program

MATERIALS AND METHODS

Seedlings of the hemp (cultivar 'Lifter') were transplanted on 6-Jun at Borderview Research Farm in Alburgh, VT. Prior to planting, the plants were fertilized (Table 1). Plots consisted of five plants spaced 5' apart in the row and between rows. Irrigation was applied on a weekly basis at an average rate of 1000 gallons of water per acre delivered via drip tape. Adjustments in water rate were made based on weekly rainfall amounts.

Table 1. Agronomic information for the hemp used in this CBD hemp drying trial, Alburgh, VT, 2021.

Location	Borderview Research Farm, Alburgh, VT
Soil type	Benson rocky silt loam, 3-5% slope
Previous crop	Corn
Plant spacing (feet)	5 x 5
Field planting date	6-Jun
Fertilization	180 lbs N ac^{-1}, 20 lbs P ac^{-1}, 72 lbs K ac^{-1}
Harvest date	5-Oct through 8-Oct

Plants were harvested by hand using bypass loppers or chainsaw depending on trunk diameter. Each harvested plant was broken down into smaller branched sections and larger "fan" or "sun" leaves were removed by hand, while smaller leaves were left attached since they subtend from the flower bract. Remaining stems were then bucked using the BuckmasterPro Bucker (Maple Ridge, BC, Canada) (Image 1) and remaining leaf material and buds were collected. Wet bud and leaf material was then run through the Centurion Pro Gladiator Trimmer (Maple Ridge, BC, Canada) (Image 2). Wet bud weight and unmarketable bud weight were recorded. The flower buds were then dried at 80º F or ambient temperature with airflow until dry enough for storage without molding.

Image 1. Triminator BuckMaster Pro (Maple Ridge, BC, Canada).

Image 2. Centurion Pro Gladiator Trimmer (Maple Ridge, BC, Canada).

The drying trial began at harvest, when Lifter hemp plants were debudded, weighed, and placed in two dryers, one with an 80º F temperature treatment and one with a 105º F treatment. Samples dried at ambient temperatures were placed on similar hardware cloth trays and placed in two separate rooms. Locations for each drying temperature were further differentiated by the use of a dehumidifier and lack of dehumidifier, with all treatments receiving airflow through use of a fan. Within dryers, two middle shelves were filled with equal amounts of hemp flower where each tray section was a replicate. Fans, driers and dehumidifiers remained on throughout the duration of the drying period. Samples dried at 105° F were started on 5-Oct and were removed from dryers on the morning of 6-Oct for both the dehumidifier and no-dehumidifier treatments. Samples dried at 80° F began drying on 6-Oct and were pulled on the afternoon of 7-Oct (dehumidifier) and morning of 8-Oct (no dehumidifier). Ambient samples began drying on 8-Oct and were pulled on afternoon of 12-Oct (dehumidifier) and afternoon of 14-Oct (no dehumidifier). Samples were monitored for temperature and relative humidity throughout the drying period however data were lost through technical errors.

Subsamples of flower material from each treatment and replications were sent to Bia Diagnostic Laboratories (Colchester, VT) for analysis of cannabinoids profiles. Analyzed cannabinoids included tetrahydrocannabinolic acid (THCA), delta-9-tetrahydrocannabinol (D9-THC), cannabidiolic acid (CBDA), and CBD with a total potential THC and CBD included. Total potential THC and CBD indicate the maximum amounts of each compounds that can be contained in a sample, accounting for losses through

decarboxylation. CBDA and THCA are converted during decarboxylation (removal of a carboxyl group) when exposed to heat such as through combustion or increased temperatures.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 1999). 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.

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. 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. Treatments that were not significantly different in a particular column are indicated by sharing the same letter. In the example to the right, treatment C is significantly different from treatment A but not from treatment B. Top performers are displayed in bold.

Treatment	Yield
A	6.0[b]
B	7.5[ab]
C	**9.0[a]**
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 2). The growing season initially saw hot periods, especially through plant establishment. July was unusually cool with an average temperature of 68.1º F, over 4 degrees cooler than normal. Dry conditions persisted across the entire growing season resulting in below average precipitation for the season. Average temperatures during the growing period were 5.97 degrees higher than the 30-year average for the season with 2496 Growing Degree Days (GDDs), which was a 4.69% higher accumulation for the year.

Table 2. Seasonal weather data collected in Alburgh, VT for July-October 2021.

Alburgh, VT	June	July	August	September	October
Average temperature (°F)	70.3	68.1	74.0	62.8	54.4
Departure from normal	2.81	-4.31	3.25	0.14	4.07
Precipitation (inches)	3.06	2.92	2.29	4.09	6.23
Departure from normal	-1.20	-1.14	-1.25	0.42	2.40
Growing Degree Days (base 50°F)	597	561	727	394	217
Departure from normal	73	-134	85	7	79

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.

Impacts of temperature

Based on the temperature of the drying environment alone (Table 3), significant differences in treatments were observed for D9-THC, CBDA, CBD, and total cannabinoids. The CBD concentrations for the 80° F treatment was significantly higher than all other treatments at 1.45% with a trial average of 0.914%. The D9-THC showed similar trends with highest observed values seen under the 80° F treatment at 0.135%. CBDA concentrations were highest under the 105° F treatment at 22.0%, significantly higher than the other two temperature treatments. At the time of testing, the 105° F environment produced the greatest concentrations of cannabinoids at a level that was statistically similar to the 80° F environment, and significantly higher than the ambient environment. The cannabinoid THC did not show a significant difference in any of the three drying temperatures.

Table 3. Dryer temperatures and cannabinoid content, 2021.

Temperature	THCA	D9-THC	CBDA	CBD	Total THC‡	Total CBD†	Total Cannabinoids
	%	%	%	%	%	%	%
105° F	0.517	0.046[b§]	**22.0[a]**	0.659[b]	0.500	17.5	**20.9[a]**
80° F	0.570	**0.135[a]**	20.2[b]	**1.45[a]**	0.635	19.2	20.2[a]
Ambient	0.660	0.067[b]	17.3[c]	0.636[b]	0.646	15.8	16.9[b]
LSD (0.10)[¥]	NS[€]	0.025	0.992	0.447	NS	NS	1.03
Trial Mean	0.582	0.083	19.8	0.914	0.594	17.5	19.3

‡ Total potential THC = (0.877 x THCA) + Δ-9 THC.

† Total potential CBD = (0.877 x CBDA) + CBD.

§Treatments within a column with the same letter are statistically similar. Top performers are displayed in **bold.**

¥LSD - Least significant difference.

€NS - No significant difference between treatments.

Impacts of humidity control

An exploration of humidity's effect on cannabinoid potency during drying was conducted by creating two additional environments: one with a dehumidifier and one without (Table 4). In terms of percent total cannabinoids, using a dehumidifier produced a significantly higher result at 20.7% than the buds dried in ambient humidity at 18%. Some differences were observed in decarboxylated components with significantly higher values seen in those samples dried with no dehumidifier at 0.111% D9-THC and 1.16% CBD. Statistically significant differences were also observed in CBDA and total potential CBD with highest values seen in samples dried under the presence of a dehumidifier.

Table 4. The influence of a dehumidifier on cannabinoid content, 2021.

Environment	THCA	D9-THC	CBDA	CBD	Total THC‡	Total CBD†	Total Cannabinoids
	%	%	%	%	%	%	%
Dehumidifier	0.662	0.055	**21.6**	0.668	0.635	**19.6**	**20.7**
No dehumidifier	0.503	**0.111**	18.1	**1.16**	0.552	15.4	18.0
LSD (0.10)¥	NS€	0.0203	0.8098	0.3647	NS	3.21	0.838
Trial Mean	0.582	0.083	19.8	0.914	0.594	17.5	19.3

‡ Total potential THC = (0.877 x THCA) + Δ-9 THC.

† Total potential CBD = (0.877 x CBDA) + CBD.

¥LSD - Least significant difference.

€NS - No significant difference between treatments. Top performers are displayed in **bold.**

Interactions

Table 5 and Figure 1 illustrate the combined influences of temperature and humidity control during drying on chemical potency of hemp flowers. There were a few significant interactions between humidity control and drying temperature. Differences were observed across drying environments with the temperature impacts varying across humidity control treatments. The interactions for D9-THC (0.0001), CBDA (<0.0001), CBD (0.0023), and total cannabinoids (<0.0001) were similar. THCA showed statistically similar results across all six treatments, as did total potential THC and total potential CBD. Most growers currently grow hemp specifically for the cannabinoid CBD, which yielded the highest content in the 80°F environment with no dehumidifier.

Table 5. Combined variable impact on cannabinoid content, 2021.

Treatment	Temperature	THCA	D9-THC	CBDA	CBD	Total THC‡	Total CBD†	Total Cannabinoi-
		%	%	%	%	%	%	%
Dehumidifier	105° F	0.556	0.052	21.1	0.901	0.540	19.4	20.3
Dehumidifier	80° F	0.685	0.060	24.9	0.603	0.660	22.5	23.5
Dehumidifier	Ambient	0.743	0.053	18.7	0.499	0.705	16.9	18.1
No Dehumidifier	105° F	0.478	0.041	22.8	0.416	0.460	15.5	21.4
No Dehumidifier	80° F	0.455	0.211	15.5	2.288	0.610	15.9	16.9
No Dehumidifier	Ambient	0.577	0.081	15.9	0.773	0.587	14.7	15.8
p-value (0.10)		NS¥	0.0001	<0.0001	0.0023	NS	NS	<0.0001
Trial Mean		0.582	0.083	19.8	0.914	0.594	17.5	19.3

‡ Total potential THC = (0.877 x THCA) + Δ-9 THC.

† Total potential CBD = (0.877 x CBDA) + CBD.

¥ NS - No significant difference between treatments. Top performers are displayed in **bold.**

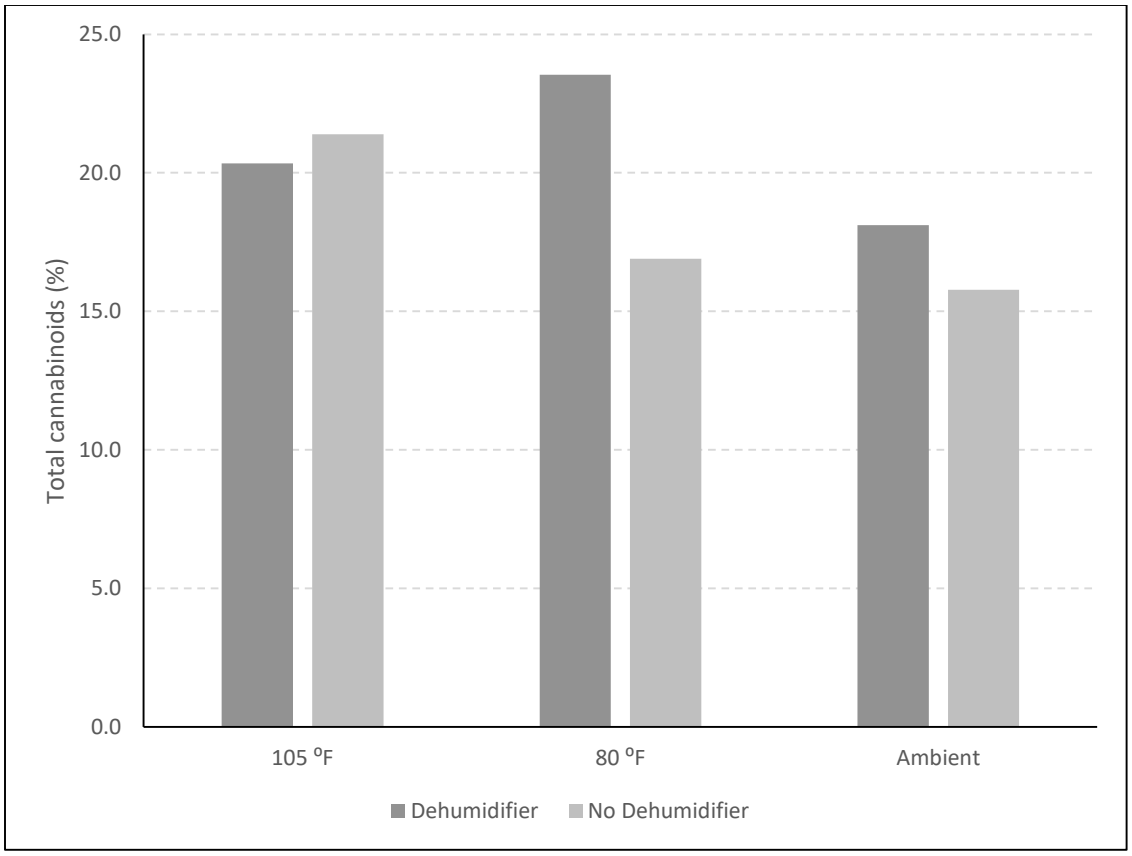

Figure 1. Total cannabinoids as a function of the treatments, Alburgh, VT, 2021.

DISCUSSION

While the use of higher temperatures results in faster drying rates, producers should consider the potential impact of drying temperature on the quality of their product. Highest total potential cannabinoid concentrations within this trial were observed in those treatments dried with additional heat and under the presence of a dehumidifier. While our study indicated higher drying temperatures resulted in higher overall cannabinoid levels, when compared to ambient temperatures, additional quality considerations should be made depending on market and post drying handling practices. There is greater potential for leaf and trichome shattering for over-dried samples, especially if repeatedly handling flower material. This could have a greater impact on the quality of product. Additionally, those samples dried at ambient temperatures in our study showed some slight molding during the first few days of the study and furthermore, required turning to encourage airflow across flowers. These factors could have also detrimentally impacted flower quality resulting in the lower observed cannabinoid concentrations.

This trial also did not track terpene concentration over the various drying conditions, which could be an additional quality consideration as many terpenes are highly volatile and experience greatest loss in drying temperatures starting at 70° F. Drying methods could also be tailored to the desired cannabinoid or terpene profiles of the grower to produce the highest concentrations of one or more compounds at the expense of another. Data for relative humidity and temperature over the drying period were lost, humidity gauges could

be used to monitor, and control drying time to determine ideal drying times and maximize efficiency, especially for those growers with limited drying capacity.

ACKNOWLEDGEMENTS

Special thanks to Roger Rainville and the staff at Borderview Research Farm for their generous help with the trials. This project was supported by and was funded through our partnership with Hatch Act Multistate Research Fund and Vermont IPM Extension Implementation Program. This work was funded by the Northeastern IPM Center through Grant #2018-70006-2882 from the National Institute of Food and Agriculture, Crop Protection and Pest Management, Regional Coordination Program. We would also like to thank Henry Blair, Catherine Davidson, Hillary Emick, Ivy Krezinski, Scott Lewins, Lindsey Ruhl, Sophia Wilcox Warren, and Sara Ziegler for their assistance with data collection and entry. The information is presented with the understanding that no product discrimination is intended, and no endorsement of any product mentioned or criticism of unnamed products is implied.

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