Hemp Flower Harvest Date

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THE UNIVERSITY OF VERMONT EXTENSION

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In the Northeast, hemp harvest can take place any time from late August through October or later depending on hemp varieties and weather conditions. Harvest for auto flowering varieties can generally be determined with the use of relative maturity dates for individual varieties, whereas full term or photoperiod sensitive varieties require careful monitoring through the use of visual or aromatic cues. Primarily, harvest date for flower crops is determined by a number of noticeable changes in the physical characteristics of trichomes, bracts, and pistils. The trichomes, known as capitate-stalked resin glands, will begin to form as stalked structures capped with a bulbous head (similar to a small mushroom) on flower surfaces. Depending on growth operation, these glands will also begin to turn opaque and eventually amber before degradation. Other flower components such as the bracts of each individual flower will begin to swell, similar to as if flowers were pollenated, and pistils of each flower will begin to turn brown. Once approximately 90% of those pistils have begun browning, in conjunction with these other visual cues, we generally begin to harvest plants.

However, outdoor cultivation can bring various challenges as a result of environmental conditions and pest pressure. A major concern for Northeast growers, and other cooler or erratic weather regions, is the shortening of days and increased risks of frost damage for crops. Risk of frost or crop loss as a result of pest pressure can be major driving factors that will often hasten the necessity for harvest. Harvest date can also impact the chemical composition of flowers impacting cannabinoid and terpene concentrations. Concerns revolving around low cannabinoid concentrations as a result of early harvest are a major concern as crop value can be determined by these concentrations. Additionally, many farmers have concerns surrounding the production of compliant crops. Main concerns often revolve around leaving a crop too long in the field, resulting in THC spikes above action limits as plants are left in the field beyond target harvest date.

Participants of State Hemp Programs intending to grow are required to follow regulations regarding hemp production and registration. Growers must register within their intended state for production, and must adhere to 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 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

To better understand how harvest time impacts flower quality, UVM Extension initiated their hemp flower harvest date study at Borderview Research Farm in Alburgh, VT in 2021.

MATERIALS AND METHODS

The experimental design was a randomized complete block with 4 replicates. Plots consisted of three plants spaced 5' apart in the row and between rows, from which one plant was selected for the harvest date study to be sampled on a weekly basis (Table 1). Treatments consisted of the 7 unique harvest dates and individual hemp flower varieties including Lifter, Forbidden V, Bhutan Glory, and JM.

Fertility amendments were based on soil test results received from the University of Vermont Agricultural and Environmental Testing Laboratory (Burlington, VT). On 6-Apr, all plots were fertilized with 57 lbs N ac^{-1}, 57 lbs P ac^{-1}, 57 lbs K ac^{-1}, using 19-19-19 fertilizer. All entries were transplanted into black plastic mulch with drip tape irrigation.

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

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Benson rocky silt loam, 3-5% slope
Previous crop	Corn
Plant spacing (ft)	5 x 5
Planting date	9-Jun
Fertilization	57 lbs N ac^{-1}, 57 lbs P ac^{-1}, 57 lbs K ac^{-1}
Harvest Dates	HD 1: 14-Sep HD 2: 21-Sep HD 3: 28-Sep HD 4: 5-Oct HD 5: 12-Oct HD 6: 19-Oct HD 7: 26-Oct

Four hemp cultivars were selected from the Variety Trial established at Borderview Research Farm for use in the Harvest Date Trial (Table 2). Cultivars were selected based on relative maturity with the aim of capturing the development of cannabinoids and trichomes over a seven-week period for "Early," "Mid," and "Late" maturing varieties. The "Early" varieties for this trial were 'Lifter' and 'JM,' "Mid" variety was 'Bhutan Glory,' and the "Late" maturing variety was 'Forbidden V.' Plants for the harvest date trial were grown adjacent to the variety trial, where approximate flowering week and harvest week were recorded for each variety. The selection of these varieties to fall within the early, mid, and late maturing categories were selected using aforementioned visual cues, which included trichome formation, bract development, and pistil senescence. Dates from planting to flowering and harvest are recorded for each variety in Table 2.

Table 2. Approximate flowering and harvest times for selected CBD cultivars.

Variety	Flowering Week	Harvest Week	Weeks to finish
Bhutan Glory	34	40	6
Forbidden V	35	42+	7
JM	32	41	9
Lifter	33	39	6

+ Varieties with a "+" listed next to harvest date could have had an additional 1-2 weeks to fully mature.

Each plot was established using seed propagated plants started within the UVM Greenhouses (Burlington, VT) with the exception of 'JM' which was grown from clonally propagated plants obtained from the supplier. Greenhouse temperatures were maintained at 70-75º F during the day and 68-72º F at night and received 18 hours of supplemental light at 400 W/m^2 from 1000W metal halide fixtures. Greenhouse pests, including thrips and fungus gnats, were managed with predatory mites, insects, and nematodes including *Amblyseius cucumeris, Orius insidiosus, Stratiolaelaps scimitus, and Steinernema feltiae.* All entries were transplanted into black plastic mulch with drip tape irrigation. At each given harvest date, one 12" cola was selected per plant and flowers were collected randomly from each. Sampled flower was observed under microscope and pictures were taken of harvest dates to observe trichome formation. A subsample for each individual variety and harvest date was collected from each harvested cola. Samples from each plot were sent to Bia Diagnostic Laboratories (Colchester, VT) to be analyzed for cannabinoids and terpenes.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 2008) when datasets were complete. 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 $p<0.10$. When data were missing, the Mixed Procedure of SAS (SAS Institute, 2008) was used. Treatment mean pairwise comparisons were made using the Tukey-Kramer adjustment at the 0.10 level of significance. 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 p-value is presented for each variable (i.e. yield). The p-value refers to whether the treatment was statistically significant overall, while the letters are drawn from the means comparison. In the example to the right, treatment C was significantly different from treatment A, but not from treatment B. A lack of significant difference is indicated by shared letters.

Treatment	**Yield**
A	**2100a**
B	1900ab
C	1700b
LSD	300

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 3). The growing season initially saw hot periods especially through plant establishment. July was unusually cool with an average temperature of 68.1, 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 a 4.69% higher growing degree day accumulation for the year.

Table 3. Seasonal weather data collected in Alburgh, VT, 2021.

Alburgh, VT	June	July	August	Sept	Oct
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 (50-86°F)	597	561	727	394	217
Departure from normal	73	-134	85	7	79

Historical averages are for 30 years of data provided by the NOAA (1991-2020) for Burlington, VT.

Variety x Harvest Date interactions

Within the harvest date study, there were a number of significant interactions between the selected varieties and harvest date indicating that varieties responded differently to harvest date for these significant interactions (Table 5). Of the measured parameters for cannabinoids and moisture, CBD, CBDA, CBDV, CBDVA, total cannabinoids, and harvest moisture were all significant. This suggests that for each of these significant interactions, levels of the various cannabinoids and flower moisture at harvest reacted differently for harvest dates. Varieties analyzed showed differing chemical profiles and maturation rates as observed in each of these qualities.

Table 5. Variety by harvest date interactions for cannabinoid profiles. Alburgh, VT, 2021.

Variety	**Harvest Date**	**CBDVA**	**CBDV**	**CBDA**	**CBD**	**D9-THC**	**THCA**
		%	%	%	%	%	%
Bhutan Glory	1	0.350	0.000	2.50	0.018	0.000	0.085
Bhutan Glory	2	0.010	0.000	6.48	0.080	0.000	0.228
Bhutan Glory	3	0.075	0.000	9.53	0.073	0.000	0.338
Bhutan Glory	4	0.088	0.000	10.2	0.118	0.000	0.345
Bhutan Glory	5	0.110	0.000	10.6	0.085	0.000	0.368
Bhutan Glory	6	0.100	0.013	11.4	0.128	0.000	0.398
Bhutan Glory	7	0.088	0.023	9.63	0.129	0.000	0.295
Forbidden V	1	0.998	0.000	2.31	0.010	0.000	0.083
Forbidden V	2	2.350	0.000	3.22	0.010	0.030	0.125
Forbidden V	3	4.625	0.013	6.30	0.123	0.000	0.248
Forbidden V	4	5.040	0.043	7.73	0.105	0.000	0.290
Forbidden V	5	5.845	0.055	9.56	0.103	0.000	0.365
Forbidden V	6	5.590	0.045	9.44	0.000	0.000	0.363
Forbidden V	7	5.448	0.063	9.72	0.123	0.000	0.368
JM	1	0.030	0.000	7.17	0.038	0.000	0.268
JM	2	0.073	0.030	12.0	0.133	0.000	0.463
JM	3	0.060	0.008	11.9	0.113	0.000	0.445
JM	4	0.063	0.033	12.4	0.145	0.000	0.453

JM	5	0.070	0.053	12.4	0.210	0.000	0.453
JM	6	0.068	0.050	11.9	0.203	0.000	0.448
JM	7	0.060	0.050	11.0	0.230	0.000	0.388
Lifter	1	0.118	0.000	14.0	0.103	0.000	0.510
Lifter	2	0.128	0.038	14.1	0.123	0.000	0.555
Lifter	3	0.160	0.010	18.7	0.173	0.000	0.765
Lifter	4	0.178	0.080	19.3	0.228	0.000	0.775
Lifter	5	0.193	0.123	21.6	0.373	0.008	0.830
Lifter	6	0.158	0.095	17.8	0.840	0.068	0.665
Lifter	7	0.180	0.098	21.1	0.730	0.065	0.793
p-value		<.0001	<.0001	NS	0.0009	0.0041	NS
Trial mean		1.152	0.033	11.2	0.169	0.006	0.418

†**NS –** Not significant at the p=0.10 level.

Table 5 continued. Variety by harvest date interactions for cannabinoid profiles. Alburgh, VT, 2021

Variety	**Harvest Date**	**Total potential THC**	**Total potential CBD**	**Total Cannabinoids**	**Moisture**
		%	%	%	%
Bhutan Glory	1	0.075	2.21	3.06	73.3
Bhutan Glory	2	0.198	5.76	7.04	74.4
Bhutan Glory	3	0.293	8.43	10.4	75.1
Bhutan Glory	4	0.303	9.02	11.0	76.2
Bhutan Glory	5	0.323	9.37	11.4	75.7
Bhutan Glory	6	0.348	10.1	12.4	74.3
Bhutan Glory	7	0.290	8.56	10.4	72.7
Forbidden V	1	0.070	2.04	3.5	74.8
Forbidden V	2	0.140	2.83	5.9	74.8
Forbidden V	3	0.213	5.65	11.7	76.9
Forbidden V	4	0.255	6.88	13.5	74.4
Forbidden V	5	0.320	8.49	16.3	74.3
Forbidden V	6	0.318	8.28	15.7	72.7
Forbidden V	7	0.320	8.64	16.0	73.6
JM	1	0.235	6.33	7.82	71.9
JM	2	0.405	10.7	13.1	73.3
JM	3	0.390	10.5	13.0	71.9
JM	4	0.398	11.0	13.4	71.3
JM	5	0.398	11.11	13.6	72.5
JM	6	0.395	10.7	13.0	70.7
JM	7	0.338	9.88	12.0	71.9
Lifter	1	0.490	12.4	15.2	73.0
Lifter	2	0.490	12.5	15.4	73.9
Lifter	3	0.673	16.6	20.4	75.4
Lifter	4	0.680	17.2	21.0	68.0
Lifter	5	0.733	19.3	23.6	70.0
Lifter	6	0.648	16.5	20.1	35.7
Lifter	7	0.763	19.2	23.3	26.5
p-value		NS†	NS	0.0049	<.0001
Trial mean		0.375	10.0	13.3	70.3

†**NS –** Not significant at the p=0.10 level.

When looking at individual varieties over the seven-week period, Bhutan Glory and Lifter showed greatest gains in total cannabinoids after week two, whereas total cannabinoids for JM were highest after week 1 and remained fairly consistent throughout the remaining 6-week harvest period. Forbidden V on the other hand showed greatest gains in total cannabinoids up through week 5 (Figure 1). Total cannabinoid concentrations for Lifter remained high after week 3 ranging from 20.1% - 23.6% and was among the earliest maturing varieties within the trial. After week 6, disease pressure was high in the Lifter plots and flower moisture dropped severely as infected tissue dried down. While each of these varieties showed some differences in cannabinoid development across the seven-week sampling period, each did show a general plateauing effect in cannabinoid development however after different sampling periods. It is also worth noting that the THC and CBD concentrations tracked similarly over time: as one increased or decreased over time, the other did as well.

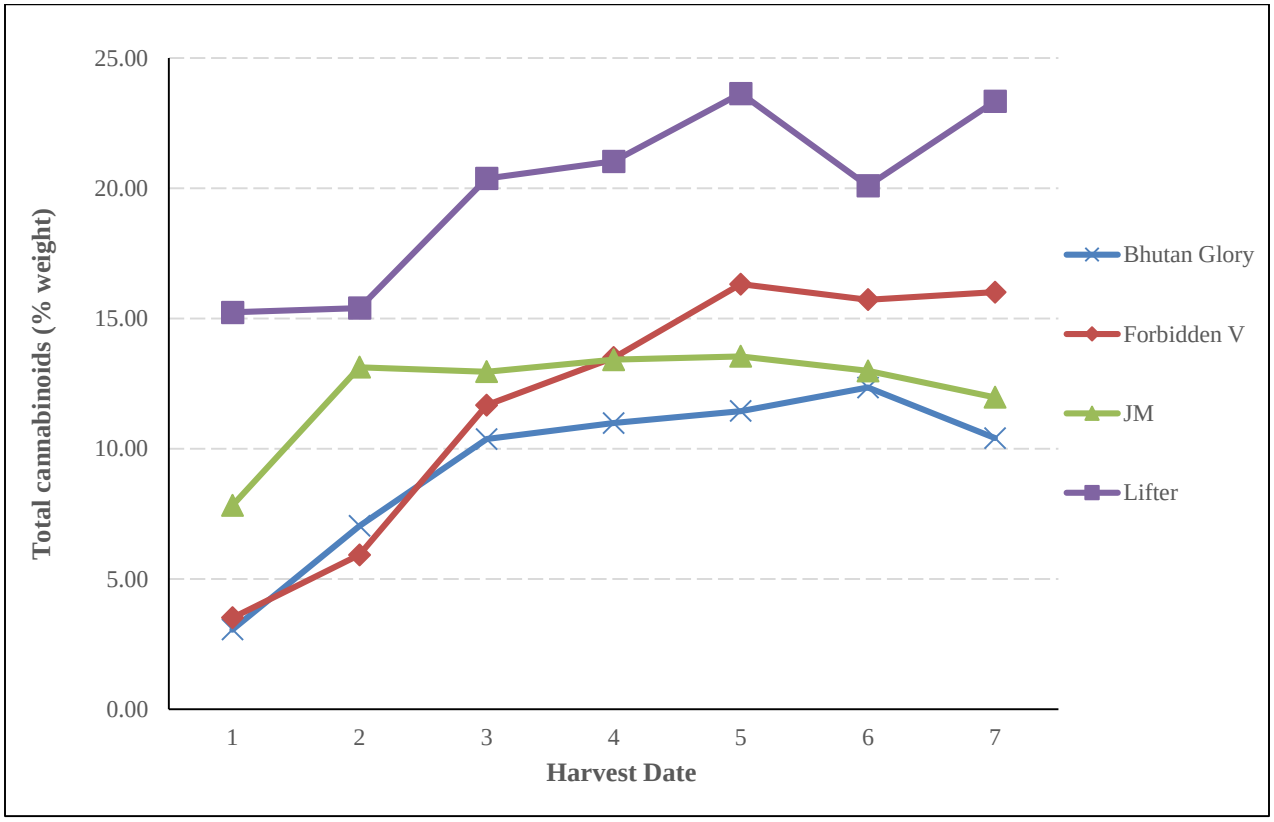

Figure 1. Total cannabinoids for each variety over four-week harvest date period. Alburgh, VT, 2021.

Terpene profiles were analyzed for each harvest date and replication for each variety (Table 6). Results are included for 17 analyzed, unique terpenes, which have distinct chemical compositions and associated aromas that contribute to individual plant characteristics, as well at overall total terpene concentrations. The cannabis plant contains a wide array of non-cannabinoids that contribute to aromatic profiles and may potentially have similar health benefits to some cannabinoids. Terpenes make up one group of many types of compounds found in hemp. Some terpenes may have medicinal uses as anti-irritants, anti-inflammatories, anti-microbials, or pain relievers, however, the medicinal effects of many known compounds remains to be unseen. As highly volatile compounds, many of these terpenes can be subject to high levels of loss as a

result of various harvest, drying, processing, or storage methods. Each of these factors should be carefully considered when evaluating and determining your growing practices, as well as desired end-product.

Similar to cannabinoid profiles, a large number of these terpenes showed statistically significant variety x harvest date interactions, which once again indicates that these varieties responded differently to changes in harvest dates. Terpene concentrations that showed significant interactions included total terpenes, camphene, beta-myrcene, carene, limonene, linalool, caryophyllene, and alpha-humulene. Terpene profiles are known to differ across unique hemp cultivars, and variations can be observed within the same varieties based on drying temperatures and other handling as many of these compounds are highly volatile. This could be a further contributing factor as each variety may have responded differently to environmental conditions influencing the volatility of these compounds. In particular, disease incidence and severity was particularly high in the Lifter variety during the last two harvest dates, greatly impacting the overall terpene concentrations and flower quality as a whole.

Table 6. Variety by harvest date interactions for terpenes. Alburgh, VT, 2021.

Variety	Harvest Date	Total terpenes	Alpha-pinene	Camphene	Beta-myrcene	Beta-pinene	Carene	Limonene	Ocimene	Eucalyptol
		mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g
Bhutan Glory	1	5.83	0.929	0.000	1.13	0.389	0.000	0.187	0.000	0.000
Bhutan Glory	2	8.78	1.25	0.000	2.63	0.589	0.000	0.289	0.011	0.030
Bhutan Glory	3	19.0	2.80	0.037	6.29	1.63	0.011	0.769	0.061	0.000
Bhutan Glory	4	12.4	1.67	0.000	4.42	0.885	0.000	0.567	0.013	0.000
Bhutan Glory	5	22.0	2.71	0.031	10.3	1.86	0.000	1.634	0.103	0.000
Bhutan Glory	6	25.3	2.67	0.077	11.3	1.88	0.022	2.02	0.118	0.000
Bhutan Glory	7	17.5	1.91	0.045	7.95	1.30	0.000	1.25	0.055	0.000
Forbidden V	1	5.89	0.694	0.000	0.975	0.291	0.000	0.177	0.171	0.000
Forbidden V	2	9.41	0.470	0.000	1.32	0.161	0.000	0.204	0.169	0.000
Forbidden V	3	17.7	1.30	0.011	4.90	0.524	0.000	0.781	0.012	0.000
Forbidden V	4	22.7	1.41	0.000	7.24	0.750	0.000	1.04	0.049	0.000
Forbidden V	5	26.2	3.34	0.083	10.3	1.11	0.029	2.02	0.096	0.000
Forbidden V	6	29.7	2.00	0.054	11.5	1.38	0.034	2.34	0.617	0.000
Forbidden V	7	29.7	1.93	0.088	11.4	1.39	0.033	2.44	0.109	0.000
JM	1	6.19	0.121	0.000	2.30	0.100	0.000	0.271	0.000	0.307
JM	2	14.4	0.349	0.000	6.48	0.350	0.000	0.823	0.037	0.273
JM	3	9.24	0.282	0.000	5.02	0.244	0.000	0.590	0.030	0.163
JM	4	13.1	0.764	0.000	6.79	0.539	0.000	0.937	0.050	0.222
JM	5	18.3	1.18	0.022	10.5	0.939	0.025	1.69	0.090	0.359
JM	6	16.4	1.09	0.011	9.41	0.825	0.014	1.51	0.075	0.355
JM	7	15.7	0.944	0.023	8.92	0.790	0.000	1.49	0.066	0.259
Lifter	1	17.6	2.10	0.012	6.02	1.20	0.000	0.566	0.061	0.020
Lifter	2	18.1	2.22	0.023	6.89	1.27	0.000	0.695	0.054	0.010
Lifter	3	30.3	3.08	0.044	13.02	2.08	0.026	2.37	0.179	0.031
Lifter	4	20.6	2.19	0.030	9.88	1.44	0.000	1.48	0.096	0.021
Lifter	5	31.5	3.77	0.096	13.80	2.22	0.048	3.34	0.201	0.041
Lifter	6	18.6	2.56	0.055	7.64	1.43	0.025	1.97	0.113	0.016
Lifter	7	18.0	2.68	0.069	5.90	1.56	0.029	1.74	0.113	0.020
p-value (0.10)		<.0001	NS	0.0372	<.0001	NS	0.0816	<.0001	NS	NS
Trial mean		17.9	1.73	0.029	7.29	1.04	0.011	1.26	0.098	0.076

NS – Not significant.

Table 6 continued. Variety by harvest date interactions for terpenes. Alburgh, VT, 2021.

Variety	Terpinene	Terpinolene	Linalool	Caryophyllene	Alpha-humulene	Cis-Nerolidol	Gualiol	Caryophyllene Oxide	Bisabolol
	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g	mg/g
Bhutan Glory	0.000	0.000	0.059	1.78	0.69	0.067	0.123	0.142	0.325
Bhutan Glory	0.000	0.000	0.086	2.34	0.85	0.000	0.253	0.162	0.296
Bhutan Glory	0.000	0.000	0.325	4.06	1.40	0.094	0.398	0.576	0.464
Bhutan Glory	0.000	0.000	0.115	2.59	0.90	0.000	0.321	0.713	0.203
Bhutan Glory	0.000	0.000	0.118	3.17	1.05	0.000	0.103	0.570	0.292
Bhutan Glory	0.000	0.011	0.156	4.73	1.62	0.000	0.259	0.337	0.119
Bhutan Glory	0.000	0.000	0.107	3.18	0.994	0.000	0.082	0.372	0.225
Forbidden V	0.000	0.000	0.080	2.12	0.827	0.140	0.045	0.144	0.221
Forbidden V	0.000	0.000	0.359	4.00	1.72	0.253	0.173	0.200	0.390
Forbidden V	0.000	0.000	0.763	5.34	2.08	0.292	0.235	0.612	0.480
Forbidden V	0.000	0.000	0.989	7.04	2.84	0.157	0.227	0.656	0.316
Forbidden V	0.000	0.000	1.177	5.92	2.40	0.146	0.136	0.615	0.329
Forbidden V	0.000	0.010	1.219	6.93	2.78	0.173	0.190	0.279	0.175
Forbidden V	0.000	0.013	1.237	7.28	2.91	0.168	0.181	0.345	0.196
JM	0.026	0.000	0.035	2.02	0.821	0.000	0.000	0.133	0.049
JM	0.010	0.000	0.284	3.02	1.51	0.000	0.062	0.224	0.134
JM	0.000	0.000	0.118	1.73	0.748	0.000	0.000	0.271	0.050
JM	0.074	0.000	0.076	2.36	0.927	0.000	0.000	0.293	0.061
JM	0.033	0.013	0.064	2.13	0.916	0.000	0.000	0.229	0.040
JM	0.041	0.010	0.026	2.06	0.822	0.000	0.000	0.137	0.030
JM	0.028	0.000	0.049	2.10	0.815	0.000	0.000	0.185	0.053
Lifter	0.000	0.000	0.771	4.24	1.81	0.112	0.208	0.204	0.299
Lifter	0.000	0.000	0.487	4.10	1.55	0.074	0.130	0.243	0.335
Lifter	0.000	0.000	1.169	4.76	1.95	0.033	0.269	0.425	0.385
Lifter	0.000	0.000	0.898	2.69	1.12	0.072	0.148	0.388	0.174
Lifter	0.017	0.017	1.362	4.09	1.68	0.000	0.193	0.449	0.224
Lifter	0.004	0.017	0.589	2.77	1.09	0.019	0.089	0.135	0.047
Lifter	0.011	0.031	0.619	3.53	1.36	0.045	0.114	0.110	0.067
p-value (0.10)	NS	NS	0.0001	0.0015	0.0001	NS	NS	NS	NS
Trial mean	0.009	0.004	0.476	3.65	1.44	0.066	0.141	0.327	0.213

NS – Not significant.

Impact of harvest date

Cannabinoid concentrations were analyzed and grouped by harvest date (HD). When data was analyzed by harvest date, each of the analyzed cannabinoids within the trial appeared to peak in week five (12-Oct) of the trial, with averages remaining high in the weeks following (Table 7). Significant differences in cannabinoids levels were observed across the seven harvest dates as well. Highest total cannabinoids were observed in HD5 at 16.2% and were statistically similar to HD6 and HD7 at 15.3% and 15.4%. Lowest values for each tested cannabinoid were additionally observed in the first harvest date with total cannabinoids at 7.41% across all varieties. Total potential THC showed an increasing trend over time from the first to the fifth harvest dates, but values, on average for all varieties tested below the 0.300% limit only in the first harvest date (0.218%) yet were statistically similar to the second harvest date at 0.308%. Similar to previous years, the value for cannabinoids showed greatest increases after the second harvest date for those varieties tested, suggesting greatest increases in cannabinoids occurring during the last week of September and first few weeks of October for these tested varieties.

Table 7. Cannabinoid concentrations for hemp harvest dates. Alburgh, VT, 2021.

Harvest Date	CBDVA		CBDV		CBDA		CBD		D9-THC		THCA	
	%		%		%		%		%		%	
1	0.374	d†	0.000	d	6.49	d	0.042	E	0.000	b	0.236	c
2	0.640	c	0.017	c	8.96	c	0.086	de	0.008	ab	0.343	b
3	1.23	b	0.008	d	11.6	b	0.120	cde	0.000	b	0.449	a
4	1.34	ab	0.039	b	12.4	ab	0.149	cd	0.000	b	0.466	a
5	**1.55**	**a**	0.058	a	**13.5**	**a**	0.193	bc	0.002	b	**0.504**	**a**
6	1.48	a	0.051	a	12.7	ab	0.293	ab	**0.017**	**a**	0.468	a
7	1.44	ab	**0.058**	**a**	12.9	ab	**0.303**	**a**	0.016	a	0.461	a
LSD (0.10)	0.224		0.009		1.33		0.100		0.013		0.556	
Trial mean	1.15		0.033		11.2		0.169		0.006		0.418	

†Within a column treatments marked with the same letter were statistically similar (p=0.10).
Top performing treatments are in **bold.**

Table 7 continued. Cannabinoid concentrations for hemp harvest dates. Alburgh, VT, 2021.

Harvest Date	Total potential THC		Total potential CBD		Total Cannabinoids		Moisture	
	%		%		%		%	
1	0.218	d†	5.74	d	7.41	e	73.2	a
2	0.308	d	7.95	c	10.4	d	74.1	a
3	0.392	b	10.3	b	13.8	c	74.8	a
4	0.409	ab	11.0	ab	14.7	bc	72.5	a
5	**0.443**	**a**	**12.1**	**a**	**16.2**	**a**	73.1	a
6	0.427	ab	11.4	ab	15.3	ab	63.4	b
7	0.428	ab	11.6	a	15.4	ab	61.2	b
LSD (0.10)	0.047		1.18		1.46		3.4	
Trial mean	0.375		10.0		13.3		70.3	

†Within a column treatments marked with the same letter were statistically similar (p=0.10).
Top performing treatments are in **bold.**

Similarly, terpene profiles were analyzed by harvest date (Table 8). Compared to cannabinoid concentrations, terpene profiles appeared to react differently to harvest date for the varieties within this trial. These were essentially grouped into two categories in which peak concentrations were either observed after HD1 or peaking in HD5 for those analyzed terpenes. Those that showed peak values in HD5 included alpha-pinene, camphene, Beta-myrcene, beta-pinene, carene, limonene, and ocimene. Furthermore, total terpene concentrations peaked during the fifth harvest date which coincided with a number of these unique terpene peak concentrations: primarily alpha-pinene, beta-myrcene, and limonene which constituted larger proportions of the profiles. Each of these analyzed terpenes generally falls within one of two categories: monoterpenes and sesquiterpenes. Distinctions in terpene structure, synthesis, and volatility may be contributing factors to those peak periods for analyzed terpenes.

Table 8. Terpene concentrations for hemp harvest dates. Alburgh, VT, 2021.

Harvest date	Alpha-pinene		Camphene		Beta-myrcene		Beta-pinene		Carene		Limonene		Ocimene		Eucalyptol		Terpinene	
	mg/g		mg/g		mg/g		mg/g		mg/g		mg/g		mg/g		mg/g		mg/g	
1	0.961	c†	0.003	c	2.61	f	0.495	e	0.000	d	0.300	d	0.058	b	0.082	ab	0.007	ab
2	1.07	c	0.006	c	4.33	e	0.594	de	0.000	d	0.503	d	0.068	b	0.078	ab	0.003	b
3	1.87	b	0.023	b	7.31	d	1.12	bc	0.009	cd	1.13	c	0.070	b	0.049	b	0.000	b
4	1.51	bc	0.007	c	7.08	d	0.903	cd	0.000	d	1.01	c	0.052	b	0.061	ab	**0.019**	**a**
5	**2.75**	**a**	**0.058**	**a**	**11.23**	**a**	**1.53**	**a**	**0.026**	**a**	**2.17**	**a**	0.123	ab	**0.100**	**a**	0.012	ab
6	2.08	ab	0.049	a	9.96	b	1.38	ab	0.024	ab	1.96	ab	**0.231**	**a**	0.093	ab	0.011	ab
7	1.87	b	0.056	a	8.55	c	1.26	ab	0.015	bc	1.73	b	0.086	b	0.070	b	0.010	ab
LSD (0.10)	0.714		0.016		1.15		0.322		0.010		0.261		0.124		0.048		0.015	
Trial mean	1.73		0.029		7.29		1.04		0.011		1.26		0.098		0.076		0.009	

†Within a column, treatments marked with the same letter were statistically similar (p=0.10) Top performing treatments are in **bold.**

Table 8 continued. Terpene concentrations for hemp harvest dates. Alburgh, VT, 2021.

Harvest date	Terpinolene		Linalool		Caryophyllene		Alpha-humulene		Cis-nerolidol		Gualiol		Caryophyllene oxide		Bisabolol		Total terpenes	
	mg/g		mg/g		mg/g		mg/g		mg/g		mg/g		mg/g		mg/g		mg/g	
1	0.000	b†	0.236	c	2.54	b	1.04	b	0.080	ab	0.094	c	0.156	c	0.224	bc	8.88	f
2	0.000	b	0.304	c	3.36	ab	1.41	a	0.082	ab	0.154	abc	0.207	bc	0.289	ab	12.7	e
3	0.000	b	0.594	ab	3.97	a	1.54	a	**0.105**	**a**	**0.225**	**a**	0.471	a	**0.345**	**a**	19.0	cd
4	0.000	b	0.519	ab	3.67	a	1.45	a	0.057	b	0.174	ab	**0.512**	**a**	0.189	cd	17.2	d
5	0.007	a	**0.680**	**a**	3.83	a	1.51	a	0.037	b	0.108	bc	0.466	a	0.221	bc	**24.5**	**a**
6	**0.012**	**a**	0.497	b	**4.12**	**a**	**1.58**	**a**	0.048	b	0.134	bc	0.222	bc	0.093	e	22.5	ab
7	0.011	a	0.503	ab	4.02	a	1.52	a	0.053	b	0.094	c	0.253	bc	0.135	de	20.2	bc
LSD (0.10)	0.007		0.179		0.851		0.319		0.046		0.075		0.092		0.086		2.71	
Trial mean	0.004		0.476		3.65		1.44		0.066		0.141		0.327		0.213		17.9	

†Within a column, treatments marked with the same letter were statistically similar (p=0.10) Top performing treatments are in **bold.**

Throughout the analyzed harvest dates, pictures were taken for each variety and are included below (Images 1, 2, 3, and 4) for comparison. As mentioned previously, there are a number of visual cues that are traditionally used for determining harvest window, of which these pictures attempt to capture. This includes overall form of harvested cola, pistils of sampled flowers, and capitate resin glands (bracts are not included in the following picture set). As the selected cultivars fell into "early," "mid," and "late" maturing categories, pictures for each reflect their relative maturities. In image 1, harvested Lifter cola shows denser flower clusters along the cola and approximately 50% pistil browning with well-formed trichomes. Conversely other varieties, especially Forbidden V, showed must less developed clusters of flowers and very sparse trichome development along the flowers and leaves. As flowers continued developing over time (Image 2), overall flower biomass began increasing especially for Forbidden V, Bhutan Glory, and JM, whereas Lifter remained fairly similar in shape and form having done so earlier on. Trichomes further developed over the two-week period between HD 1 and HD3 with greater densities of trichomes observed on flower surfaces. Looking at harvest dates as a whole, HD5 (Image 3) showed highest total cannabinoid concentrations which coincided with a number of visual cues including floral density, trichome formation, coloration, and pistil senescence. However, some damage to surrounding fan leaves or flower clusters was observed as the result of increased disease pressure or frost. At this period, this did not appear to yet impact flower quality. Upon reaching HD7 (Image 4) each individual variety had appeared to have reached full maturity, however Lifter in particular had succumbed to severe disease pressure. This ultimately had little impact on cannabinoids as trichomes were relatively intact, however terpene concentrations appeared to drop from the fifth to the sixth and seventh sampling periods.

Image 1. Harvest date 1 pictures for harvested cola, flower pistils, and trichomes of Forbidden V, Bhutan Glory, Lifter and JM cultivars (pictured from left to right).

Image 2. Harvest date 3 pictures for harvested cola, flower pistils, and trichomes of Forbidden V, Bhutan Glory, Lifter and JM cultivars (pictured from left to right).

Image 3. Harvest date 5 pictures for harvested cola, flower pistils, and trichomes of Forbidden V, Bhutan Glory, Lifter and JM cultivars (pictured from left to right).

Image 4. Harvest date 7 pictures for harvested cola, flower pistils, and trichomes of Forbidden V, Bhutan Glory, Lifter and JM cultivars (pictured from left to right).

DISCUSSION

With many concerns surrounding hemp compliancy and overall crop quality, hemp harvest timing and pre-harvest sampling can be one of the most important components of hemp production. Furthermore, pre-harvest sampling for compliancy is required for many growers and becomes another important factor and will be an early indicator for crop compliancy. Rules and regulations for sampling can differ between states so it is important to follow your states growing requirements. Vermont rules and regulations can be found online here:

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

Various quality parameters are evaluated for hemp crops with a wide array of cannabinoids and terpenes being produced by plants. These can serve as important parameters for distinguishing the quality of the crop and be major considerations for end users in purchasing. Within the study, terpene levels that were observed peaked after the first harvest date or the fifth harvest date. Many of these known, analyzed terpenes fall into general categories of monoterpenes and sesquiterpenes that may have various, or potentially unknown, health benefits when consumed in conjunction with the cannabinoids produced by the hemp plant. When looking at peak cannabinoid levels throughout all harvest dates (regardless of variety) the majority appeared to have highest concentrations in the fifth harvest date, coinciding with peak terpene concentrations for some analyzed terpenes. When broken down by variety, each of these did appear to act differently which could be expected based on differences in chemical profiles and maturation rates.

It is important to note that these tested varieties may perform differently in other growing regions. A longer window for harvest, or other environmental conditions, may lead to non-compliant crops. Studies within other warmer, more southernly regions, have shown some cultivars exceeding THC limits in the later weeks of September for similar cultivars. More research would be required in order to determine the main cause of some of these discrepancies, however it may be that chemical expressions may differ based on growing conditions.

Some of these currently recommended visuals cues did seem to coincide with peak chemical compositions for cannabinoids, however other considerations should be taken into account when determining when to harvest a hemp crop. While higher concentrations of cannabinoids can be more desirable, peak does not always coincide with compliant. Additional sampling prior to required state sampling periods may be most useful in determining your ideal harvest window and allow for harvest of compliant crops. Various other factors for harvest date determination can include harvest time and labor, total planted acres, desired end product, equipment limitations, and disease pressure to name a few. Working within the confines of our Northeast climate, weather can often dictate harvest through cold and wet fall conditions or even hard frosts. These are but a few items to take into account and harvesting some crop regardless of cannabinoids or terpene concentrations is more important than losing and entire crop to inclement weather or disease.

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