NORTHWEST CROPS & SOILS PROGRAM

2022 Hemp Flower Harvest Date

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THE UNIVERSITY OF VERMONT EXTENSION

2022 HEMP FLOWER HARVEST DATE

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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 the growth, 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 and compliance sampling as a result of state and federal regulations in effect. 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 intending to grow hemp are required to follow state and federal regulations regarding hemp production and registration. Growers must either register with their intended state for production or adhere to federal 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. For the 2023 growing season, the Vermont Agency of Agriculture, Food and Markets Hemp program is no longer accepting registrations for growing or processing hemp in the state of Vermont.

Please refer to this website https://www.ams.usda.gov/rules-regulations/hemp for detailed information on USDA hemp guidelines for production.

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 2022.

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 6 unique harvest dates and individual hemp flower varieties including Lifter, Elektra, and Sky Temple.

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 flower harvest date trial, Alburgh, VT, 2022.

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Benson rocky silt loam, 3-5% slope
Previous crop	Spring Grains
Plant spacing (ft)	5 x 5
Planting date	6-Jun
Fertilization	57 lbs N ac^{-1}, 57 lbs P ac^{-1}, 57 lbs K ac^{-1}
Harvest Dates	HD 1: 9-Sep HD 2: 16-Sep HD 3: 23-Sep HD 4: 30-Sep HD 5: 7-Oct HD 6: 14-Oct

Three 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" variety for this trial was 'Lifter'; "Mid" variety was 'Elektra,' and the "Late" maturing variety was 'Sky Temple.' 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. Harvest times for 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
Elektra	32-33	39
Lifter	31-33	38
Sky Temple	31-34	41+

+ 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). 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 saw cooler overall temperatures with well above average precipitation, especially during the establishment period of the hemp plants in the month of June and during harvest and maturation periods in October. As a result, growing conditions accumulated below average Growing Degree Days (GDDs) and temperatures that were an average of 3.67 degrees cooler than the 30-year average.

Table 3. Seasonal weather data collected in Alburgh, VT, 2022.

Alburgh, VT	June	July	August	Sept	Oct
Average temperature (°F)	65.3	71.9	70.5	60.7	51.5
Departure from normal	-2.18	-0.54	-0.2	-1.99	1.24
Precipitation (inches)	8.19	3.00	4.94	4.4	2.56
Departure from normal	3.93	-1.06	1.4	0.73	-1.27
Growing Degree Days (50-86°F)	459	674	630	343	184
Departure from normal	-64	-20	-11	-44	46

*Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2020) from Burlington, VT.

Variety x Harvest Date interactions

Within the harvest date study there were no significant interactions between the selected varieties and harvest dates, indicating that cannabinoid concentrations of these three varieties responded similarly across the harvest dates within the sampling period (Table 4).

Table 4. Variety by harvest date interactions for cannabinoid profiles. Alburgh, VT, 2022.

Variety	Harvest date	CBDVA	CBDV	CBDA	CBGA	CBG	CBD	THCA
		%	%	%	%	%	%	%
Elektra	1	0.040	0.0000	6.94	0.180	0.010	0.038	0.288
Elektra	2	0.050	0.0100	7.64	0.275	0.020	0.048	0.315
Elektra	3	0.042	0.0050	7.00	0.212	0.020	0.044	0.217
Elektra	4	0.044	0.0185	7.34	0.279	0.030	0.074	0.294
Elektra	5	0.033	0.0193	6.90	0.251	0.021	0.133	0.271
Elektra	6	0.030	0.0448	6.49	0.187	0.014	0.229	0.238
Lifter	1	0.075	0.0050	9.21	0.155	0.008	0.045	0.385
Lifter	2	0.075	0.0075	8.99	0.198	0.020	0.040	0.380
Lifter	3	0.088	0.0050	10.49	0.172	0.032	0.095	0.426
Lifter	4	0.058	0.0078	6.58	0.187	0.027	0.097	0.270
Lifter	5	0.075	0.0323	9.01	0.214	0.031	0.198	0.355
Lifter	6	0.074	0.0117	8.41	0.165	0.011	0.240	0.319
Sky Temple	1	0.028	0.0000	5.89	0.363	0.008	0.023	0.233
Sky Temple	2	0.040	0.0000	6.17	0.275	0.008	0.033	0.243
Sky Temple	3	0.028	0.0000	5.53	0.196	0.007	0.023	0.215
Sky Temple	4	0.025	0.0043	5.70	0.281	0.021	0.039	0.217
Sky Temple	5	0.030	0.0088	6.13	0.299	0.023	0.074	0.220
Sky Temple	6	0.036	0.0212	6.40	0.207	0.012	0.157	0.242
p-value		NS†	NS	NS	NS	NS	NS	NS
Trial Mean		0.048	0.0113	7.24	0.228	0.018	0.089	0.284

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

Table 4, continued. Variety by harvest date interactions for cannabinoid profiles. Alburgh, VT, 2022.

Variety	Harvest date	Total potential THC	Total potential CBD	Total Cannabinoids	Moisture
		%	%	%	%
Elektra	1	0.253	6.13	7.50	76.2
Elektra	2	0.278	6.75	8.36	70.9
Elektra	3	0.254	6.18	7.62	67.8
Elektra	4	0.263	6.51	8.09	69.8
Elektra	5	0.238	6.18	7.62	62.2
Elektra	6	0.208	5.92	7.23	43.1
Lifter	1	0.338	8.12	9.88	76.5
Lifter	2	0.335	7.93	9.71	72.0
Lifter	3	0.383	9.30	11.32	72.3
Lifter	4	0.245	5.87	7.24	67.5
Lifter	5	0.312	8.10	9.92	60.8
Lifter	6	0.304	7.62	9.26	44.2
Sky Temple	1	0.203	5.19	6.55	74.9
Sky Temple	2	0.213	5.44	6.76	71.7
Sky Temple	3	0.187	4.88	6.00	68.8
Sky Temple	4	0.190	5.03	6.29	65.2
Sky Temple	5	0.204	5.45	6.81	59.3
Sky Temple	6	0.212	5.77	7.08	44.2
p-value		NS†	NS	NS	NS
Trial Mean		0.255	6.44	7.93	64.9

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

Impact of harvest date

Cannabinoid concentrations were analyzed and grouped by harvest date (HD). When data was analyzed by harvest date, many of the individual analyzed cannabinoids appeared to peak at varying points across the harvest dates and significant differences were observed throughout each analyzed cannabinoid and overall moisture content (Table 5). However, total cannabinoids concentrations and total potential CBD did not appear to be impacted by harvest date for the three selected varieties, nor did CBDVA. CBDV showed a clear increasing trend over time, as did CBD with peak concentrations observed in the sixth harvest date for each variety. Other cannabinoids showed peak concentrations in HD 2 (16-Sep) which included THCA at 0.313% and total potential THC at 0.275%, also observed in HD 3. As expected, the highest moisture content was observed in the first harvest date at 75.9% and steadily decreased over time as plants matured and dried down. At the end of the sampling period, sampled plant material for HD 6 had, on average, dried down to 43.8% moisture. In addition to the moisture content being driven by maturation of flower, it was also impacted by diseased tissue and overall plant senescence as the growing season came to a close.

Table 5. Cannabinoid concentrations for hemp harvest dates. Alburgh, VT, 2022.

Harvest Date	CBDVA	CBDV		CBDA		CBGA		CBG		CBD		THCA	
	%	%		%		%		%		%		%	
HD1	0.048	0.0017	b	7.35	ab	0.233	abc	0.008	c	0.035	c	0.302	ab
HD2	0.055	0.0058	b	7.60	ab	0.249	ab	0.016	abc	0.040	c	**0.313**	**a**
HD3	0.053	0.0033	b	**7.68**	**a**	0.193	bc	0.020	ab	0.054	c	0.286	ab
HD4	0.042	0.0102	b	6.54	b	0.249	ab	**0.026**	**a**	0.070	c	0.260	b
HD5	0.046	0.0201	a	7.35	ab	**0.255**	**a**	0.025	a	0.135	b	0.282	ab
HD6	0.044	**0.0267**	**a**	6.93	ab	0.190	c	0.012	bc	**0.202**	**a**	0.260	b
LSD (0.10)	NS	0.0094		1.104		0.0586		0.010		0.057		0.0486	
Trial Mean	0.048	0.0113		7.24		0.228		0.018		0.089		0.284	

†Within a column treatments marked with the same letter were statistically similar (p=0.10).

Top performing treatments are in **bold.**

NS – Not significant at the p=0.10 level.

Table 5, continued. Cannabinoid concentrations for hemp harvest dates. Alburgh, VT, 2022.

Harvest Date	Total potential THC		Total potential CBD	Total cannabinoids	Moisture	
	%		%	%	%	
HD1	0.264	ab	6.48	7.98	**75.9**	**a**
HD2	**0.275**	**a**	6.71	8.28	71.5	ab
HD3	**0.275**	**a**	6.79	8.31	69.6	ab
HD4	0.233	ab	5.81	7.20	67.5	c
HD5	0.251	b	6.58	8.12	60.8	c
HD6	0.234	b	6.28	7.68	43.8	d
LSD (0.10)	0.0384		NS	NS	6.40	
Trial Mean	0.255		6.44	7.93	64.9	

†Within a column treatments marked with the same letter were statistically similar (p=0.10).

Top performing treatments are in **bold.**

NS – Not significant at the p=0.10 level.

Throughout the analyzed harvest dates, pictures were taken for each variety and are included below (Images 1, 2, and 3) 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). In Image 1, harvested Lifter and Elektra colas (first and second sets pictured respectively) show denser flower clusters along the stems and approximately 50% pistil browning with well-formed trichomes. Conversely, Sky Temple showed much less robust colas and flower clusters were not as filled out. Pistils were also almost entirely white during this first sampling date. Between the second and third harvest dates, each of the varieties appeared to develop substantially denser buds as overall flower biomass began increasing, especially for Sky Temple. By HD3, it appeared as if Lifter and Elektra had reached peak densities and trichomes had begun to amber, compared to Sky Temple in which trichomes had become well-formed and also turned opaque. Additionally, as Lifter and Elektra appeared to be well developed, some leaf disease was also noticeable, especially on Lifter. While cannabinoid concentrations were fairly consistent for these three varieties across the six harvest dates, the overall visual flower quality clearly began to diminish past the third harvest date, especially for the Lifter and Elektra with increased disease pressure. Upon reaching HD6 (Image 3), each individual variety had appeared to have reached full maturity. However, Lifter in particular had succumbed to severe disease pressure while Elektra and Sky Temple appeared to be less impacted by leaf disease. This ultimately had little impact on cannabinoids as trichomes were relatively intact, however, as overall flower dry matter dropped significantly upon reaching HD 6, flower was much more brittle and of a lesser visual quality, especially for the Lifter. Conversely, Sky Temple remained much greener in comparison and trichomes appeared to be well intact.

Image 1. Harvest date 1 pictures for harvested cola, flower pistils, and trichomes of Lifter, Elektra, and Sky Temple cultivars (pictured from left to right).

Image 2. Harvest date 3 pictures for harvested cola, flower pistils, and trichomes of Lifter, Elektra, and Sky Temple cultivars (pictured from left to right).

Image 3. Harvest date 6 pictures for harvested cola, flower pistils, and trichomes of Lifter, Elektra, and Sky Temple 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. Please refer to this https://www.ams.usda.gov/rules-regulations/hemp for detailed information on USDA hemp guidelines for production.

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. When looking at peak cannabinoid levels throughout all harvest dates (regardless of variety), highest levels were observed in the second and third harvest dates, however, the differences between each harvest date were slight. With the selected varieties for this year of study and the given harvest date sampling period, total cannabinoid concentrations remained relatively consistent over the six-week sampling period. Two of these varieties especially, Elektra and Lifter, have an earlier window of maturation and while the sampling period started a few weeks prior to "normal" harvest, each likely should have been sampled at earlier dates to observe the greatest increase in cannabinoid concentrations as the flowers matured. Compared to previous years, no significant differences were observed across the trial for interactions between harvest date and hemp variety, whereas in 2021, the four selected varieties showed much more variation in cannabinoid concentrations across the sampling period which started one week later and continued one week later into the fall.

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 and limits are in place for pre-harvest sampling and subsequent harvest window. 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.

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. While this study did not show fluctuations over time, it did show that despite disease pressure and drying down of flower over time, a crop could still be harvested that might provide desirable concentrations of cannabinoids within compliant levels for various market outlets. These are but a few items to consider 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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