NORTHWEST CROPS & SOILS PROGRAM

2019 Hemp Flower Variety Trial

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THE UNIVERSITY OF VERMONT EXTENSION

2019 HEMP FLOWER VARIETY 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 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. University of Vermont, in partnership with the CASE Institute (https://www.caseinstitute.org/), evaluated 20 different hemp varieties for their growth habit, pest tolerance, flower yields, and flower quality.

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 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/Industrial_Hemp_Rule_%20SOS_05172019.pdf for a detailed outline of proposed rules in Vermont. 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

Companies selling hemp seed suitable for the CBD market were solicited to participate in the variety evaluation program. Six companies submitted twenty unique hemp varieties for evaluation in the trial. The varieties were assessed for yield, quality and tolerance to pests at Borderview Research Farm in Alburgh, Vermont. 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 (Table 1). Treatments consisted of the 20 individual CBD hemp varieties (Table 2).

Clones were transplanted into black plastic mulch with drip tape. Fertility amendments were based on soil test results received from the University of Vermont Agricultural and Environmental Testing Laboratory (Burlington, VT). The field was fertilized with 120 lbs N ac^{-1} over the course of six weeks via fertigation. Nitrogen was applied in the form of ammonium nitrate plus sulfur (28-0-0) distributed evenly through 1000 gallons of water using a Dosatron unit. In addition, potassium chloride (0-0-62) was applied at a rate of 100 lbs ac^{-1} just following planting. Based on soil test results, no further nutrients were required for production of hemp.

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

Location	**Borderview Research Farm Alburgh, VT**
Soil type	Benson rocky silt loam, 3-5% slope
Previous crop	Organic corn
Plant spacing (ft)	5 x 5
Planting date	19-Jun, 26-Jun
Fertilization	120 lbs N ac^{-1}, 60 lbs K ac^{-1}

Table 2. Hemp varieties and variety source.

Variety	Source
AC/DC	Vermont Natural CBD
Alexa	Vermont Natural CBD
Apollo	Davis Farms of Oregon
Boax	Northern Roots Nursery
Boax Wine	Vermont Natural CBD
Ceiba	Northern Roots Nursery
Cherry Blossom	Kanape Collective
Cherry Ceiba	Northern Roots Nursery
Cherry Wine	Northern Roots Nursery
Cosmic	Vermont Natural CBD
Dave's Haze	Vermont Natural CBD
Eighty-Eight	Davis Farms of Oregon
Otakarek	Davis Farms of Oregon
Painted Lady	Davis Farms of Oregon
River Rock	Chimney Rock Hemp
RN13	GoFarmHemp
Skipper	Davis Farms of Oregon
Suzy Q	Vermont Natural CBD
VTCherry	Vermont Natural CBD
Wulf	Vermont Natural CBD

The plant material received from the companies comprised mainly of seeds or cuttings. Seed material was planted into 72-cell trays containing Fort Light potting mix (Vermont Compost Company, Montpelier, VT) on 9-Mar and placed in 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.*

Of the 72 seedlings, 12 were transplanted into 6" round pots from Dillen International (Twinsburg, OH) on 27-Mar and plugs were dusted with Blue Sky Organics Myco-Grow (Vernon, BC, Canada). On 18-Apr, 6 female plants per variety were selected and then transplanted into 9" pots from Nursery Supplies Inc. (Jacksonville, FL). At transplant, plant starts received supplemental fertility in the form of Greenhouse Feeding BioGrow (7-2-4) (Amsterdam-Zuidoost, Netherlands). On 7-May, seedlings were selected as mother plants for clonal propagation of each variety and were once again transplanted into #3 squat pots from Nursery Supplies Inc. (Jacksonville, FL), fertilized with BioGrow, and covered with Black Dirt Farm Vermicompost-Inoculated Mulch (Greensboro Bend, VT). On 1-Jun, cuttings were taken from each of the mother plants and allowed to soak in H_2O for 3-4 hours to increase turgidity before being introduced to the EZ-Clone aerocloner (Sacramento, CA). Aerocloners were filled with 12 gallons DI H_2O and 240 mL Clonex Liquid Solution (Lansing, MI). Cuttings were removed from H_2O soak, cut fresh at a 45-degree angle (approximately 1/4" below a node), and dipped up to 2" in Clonex Rooting Hormone Gel (Lansing, MI). Cuttings were placed in aerocloner with at least 2 nodes below neoprene collar and at least 3 leaves above. Pump was set on timer for 15 min ON / 15 min OFF continuously with T5 lighting (approximately 18" from cuttings) set for 18 hours ON / 6 hours OFF. For one week, cuttings were allowed to callus and begin root formation, with a reservoir temperature of approximately 75º F and pH between 5.6-6.0. After 7 days, reservoir was emptied, cleaned, and refilled with 12 gallons of fresh DI H_2O and 360 mL Clonex Liquid Solution. Pump, lighting, timers, temperature, and pH remained the same. After 14 days, cuttings were fully rooted (approximately 2" roots emerging from callused stem) and transplanted into Fort Light potting mix (Vermont Compost Company) in trays of 1801 pots.

On the 19-Jun, the clones were transplanted into the field at Borderview Research Farm in Alburgh, VT. The varieties Cherry Ceiba, Ceiba, and Cherry Wine were obtained directly from supplier as feminized seedlings and also planted on 19-Jun. The varieties Apollo, Skipper, Otakarek, Eighty-Eight, and Painted Lady were planted on 26-Jun (Table 3). These five varieties were entered into the trials late and hence were one-week behind in the propagation schedule. Irrigation was applied on a weekly basis at a rate of 8000 gallons of water per acre delivered via drip tape. Irrigation duration and amount was modified based on weekly rainfall.

Table 3. Planting, flowering, and harvest dates for CBD Hemp Variety Trial 2019. Alburgh, VT.

Variety	Planted material	Planting date	Approximate flowering date	Harvest date start	Harvest date end
AC/DC*	Clone	19-Jun	15-Aug	9-Oct	11-Oct
Alexa*	Clone	19-Jun	21-Jul	19-Sep	20-Sep
Apollo	Clone	26-Jun	25-Aug	22-Oct	23-Oct
Boax	Clone	19-Jun	20-Aug	22-Oct	23-Oct
Boax Wine	Clone	19-Jun	20-Aug	22-Oct	23-Oct
Ceiba	Seedling	19-Jun	20-Aug	22-Oct	23-Oct
Cherry Blossom	Clone	19-Jun	25-Aug	22-Oct	23-Oct
Cherry Ceiba	Seedling	19-Jun	25-Aug	22-Oct	23-Oct
Cherry Wine	Seedling	19-Jun	3-Sep	22-Oct	23-Oct
Cosmic	Clone	19-Jun	25-Aug	22-Oct	23-Oct
Dave's Haze*	Clone	19-Jun	5-Aug	30-Sep	4-Oct
Eighty-Eight	Clone	26-Jun	3-Sep	22-Oct	23-Oct

Otakarek	Clone	26-Jun	5-Sep	22-Oct	23-Oct
Painted Lady	Clone	26-Jun	25-Aug	22-Oct	23-Oct
River Rock*	Clone	19-Jun	20-Aug	11-Oct	14-Oct
RN13*	Clone	19-Jun	15-Aug	8-Oct	9-Oct
Skipper	Clone	26-Jun	25-Aug	22-Oct	23-Oct
Suzy Q	Clone	19-Jun	3-Sep	22-Oct	23-Oct
VTCherry*	Clone	19-Jun	16-Jul	16-Sep	17-Sep
Wulf*	Clone	19-Jun	21-Jul	23-Sep	30-Sep

* indicates plants harvested by hand with the remaining varieties harvested with assistance from mechanical buckers and trimmers.

Image 1. Munch Machine Mother Bucker (Toppenish, WA)

On a weekly basis, scouting took place from 13-Sep until 15-Oct. One plant per plot was scouted for insect pests and diseases. Three leaves per plant at low, medium, and high locations on each plant we counted for insect populations. Entire plant assessments were made for disease with total number of infected buds or stems counted and severity rated for gray mold *(Botrytis cinerea)*, white mold (*Sclerotinia sclerotiorum*), and powdery mildew (*Sphaerotheca macularis.* Severity was rated on a 1-5 scale, with a rating of 1 being least severe and a rating of 5 being most severe. Least severe cases were noted as single flower clusters showing degradation or infection, most severe cases would be indicative of entire stems or colas showing disease infection.

Plants matured at different rates with VT Cherry, Alexa, and Wulf reaching harvestable maturity a month or more before many of the other later maturing varieties. Prior to harvest, plant height and width was measured from all harvested plants in each plot. From each plot, flower samples were taken from the top 8" of colas and sent to ProVerde Laboratories (Milford, MA) to be analyzed for cannabinoids.

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

For each plant harvested the whole plant weight was recorded. Plants harvested prior to 22-Oct were processed entirely by hand. Plants harvested after 22-Oct were 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 Munch Machine Mother Bucker (Toppenish, WA) (Image 1) and remaining leaf material and buds were collected. Wet bud and leaf material was then processed 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. A subsample

of flower bud from each plot was dried in a small dehydrator and wet weights and dry weights were recorded in order to calculate the percent moisture of the flower buds. The percent moisture at harvest was used to calculate dry matter yields. Metrics were collected for each of the three harvested plants within each plot and a plot average was calculated.

Yield data and stand characteristics were analyzed using mixed model analysis using the mixed procedure of SAS (SAS Institute, 1999). Replications within the trial were treated as random effects, and treatments were treated as fixed. Treatment mean comparisons were made using the Least Significant Difference (LSD) procedure when the F-test was considered significant ($p<0.10$).

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. At the bottom of each table a p-value is presented for each variable that showed statistical significance (p-value ≤ 0.10). In this case, the difference between two treatments within a column is equal to or greater than the least significant difference (LSD) value and you can be sure that for 9 out of 10 times, there is a real difference between the two treatments. In this example, variety 3 is significantly different from variety 1 but not from variety 2. Variety 2 and variety 3 have share the same letter 'a' next to their yield value, to indicate that these results are statistically similar. The difference between variety 3 and variety 2 is equal to 1.5, which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between variety 3 and variety 1 is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The letter 'b' next to variety 1's yield value shows that this value is significantly different from variety 2 and variety 3, which have the letter 'a' next to their value.

Treatment	Yield
Variety 1	6.0 b
Variety 2	7.5a
Variety 3	**9.0**a
LSD (p-value ≤ 0.10)	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 4).

Table 4. Seasonal weather data collected in Alburgh, VT, 2019.

Alburgh, VT	June	July	August	September	October
Average temperature (°F)	69.2	73.5	68.3	60.0	50.8
Departure from normal	0.84	2.84	-0.53	-0.62	0.14
Precipitation (inches)	1.71	2.34	3.50	3.87	3.85
Departure from normal	0.33	-1.81	-0.41	0.23	1.88
Growing Degree Days	446	716	568	335	146
Departure from normal	-29	76	-13	17	146

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

The month of July was hot and dry when compared to the 30-year average, followed by a slightly cooler than normal August. June, July and October saw higher than normal temperatures whereas August and September were slightly below normal. July and August were below average precipitation amounts with the tail end of the season receiving a well above average amounts of precipitation. Overall, there were an accumulated 2211 Growing Degree Days (GDDs) this season, approximately 197 more than the historical average, with much of the heat coming mid-season. Hemp plants received supplemental irrigation to account for precipitation deficits throughout the growing season, as needed.

Image 3. Hemp aphid on underside of leaf. Alburgh, VT.

Arthropod pests were scouted towards the end of the growing season from 13-Sep until 10-Oct (Table 5). European corn borers, or other stem boring insects, were observed in four hemp varieties including AC/DC, Cherry Wine, Painted Lady, and Wulf. While the differences between varieties was not statistically significant, host specific hemp borers or crossover European corn borers could have the potential for causing crop losses depending on the location of entry along the stem and number of generations within a given year. During the observed scouting period, VT Cherry had the lowest populations of aphids (Image 3) at 0.17 aphids per leaf alongside top performers Alexa, Suzy Q, Dave's Haze, Cosmic, Cherry Blossom, River Rock, AC/DC, and Wulf. Cherry Wine had the greatest aphid populations at 16.9 aphids per leaf. Other observed insects included tarnished plant bugs, minute pirate bugs, flea beetles, and lady bugs among others. High populations of aphids led to similarly high population of lady bugs in various growth stages throughout the observation period.

Table 5. Impact of arthropods on hemp variety, Alburgh, VT, 2019.

Variety	Stem borer # plant^{-1}	Aphids # leaf^{-1}
AC/DC	0.25	2.82*
Alexa	0.00	0.20*
Apollo	0.00	6.85
Boax	0.00	3.80
Boax Wine	0.00	7.82
Ceiba	0.00	7.35
Cherry Blossom	0.00	2.45*
Cherry Ceiba	0.00	7.32
Cherry Wine	0.25	16.9
Cosmic	0.00	1.40*
Dave's Haze	0.00	0.87*
Eighty-Eight	0.00	7.27
Otakarek	0.00	8.82
Painted Lady	0.25	9.17
RN13	0.00	5.00*
River Rock	0.00	2.80*
Skipper	0.00	3.72*
Suzy Q	0.00	0.63*
VTCherry	0.00	**0.17**

Wulf	0.25	2.87*
LSD (0.10)	**NS**	**2.06**
Trial Mean	**0.05**	**4.91**

*Treatments with an asterisk are not significantly different from the top performer in **bold**.
LSD – Least significant difference.
NS – No significant difference between treatments.

Image 4. *Botrytis cinerea* in hemp. Alburgh, VT.

The two diseases, gray mold *(Botrytis cinerea)* (Image 4) and white mold (*Sclerotinia sclerotiorum*) (Image 5), were observed within the trial (Table 6). Gray mold was evaluated by the number of infected colas and white mold by the number of infected stems per plant prior to harvest. Disease present on plants was also rated for severity on a 1-5 scale, 1 being least severe and 5 being most severe. Within this study, Cosmic appeared to have the highest incidence of gray mold with an average of 5.5 infected colas per plant as well as the greatest severity at 2.75. Other varieties also experienced higher incidence of infection for gray mold including Ceiba, RN13, and Suzy Q, but were not statistically similar to Cosmic. AC/DC, Alexa, Apollo, Boax, Cherry Blossom, Dave's Haze, Eighty-Eight, Otakarek, Painted Lady, Skipper, VT Cherry, and Wulf were not infected with gray mold. White mold was also present, however, it did not appear to be as prevalent or severe as gray mold within these varieties. Ceiba showed the highest incidence of white mold at 1.00 stem per plant, with white mold also being present on Boax Wine, RN13, and VT Cherry. White mold disease severity for each of these varieties was statistically similar ranging from a rating of 0.75-1.00. Powdery mildew was also observed on the farm, however, it was not present within the trial. Varieties with no gray mold or white mold observed during the scouting period included AC/DC, Alexa, Apollo, Boax, Cherry Blossom, Dave's Haze, Eighty-Eight, Otakarek, Painted Lady, Skipper, and Wulf. These diseases also contributed to our overall "unmarketable wet flower yield" (Table 9), which also includes buds that suffered from mechanical damage or otherwise contaminated material.

Image 5. *Sclerotinia sclerotiorum* on hemp stem. Alburgh, VT.

Table 6. Impact of disease incidence and severity and hemp varieties, Alburgh, VT, 2019.

Variety	Gray mold incidence # infected colas plant^{-1}	Gray mold severity rating 1-5†	White mold incidence # infected stems plant^{-1}	White mold severity rating 1-5†
AC/DC	0.00	0.00	0.00	0.00
Alexa	0.00	0.00	0.00	0.00
Apollo	0.00	0.00	0.00	0.00
Boax	0.00	0.00	0.00	0.00
Boax Wine	0.75	0.75	0.75*	**1.00**
Ceiba	2.25	1.50	**1.00**	0.75*
Cherry Blossom	0.00	0.00	0.00	0.00
Cherry Ceiba	0.50	0.50	0.00	0.00
Cherry Wine	0.25	0.25	0.00	0.00
Cosmic	**5.50**	**2.75**	0.00	0.00
Dave's Haze	0.00	0.00	0.00	0.00
Eighty-Eight	0.00	0.00	0.00	0.00
Otakarek	0.00	0.00	0.00	0.00
Painted Lady	0.00	0.00	0.00	0.00
RN13	3.00	2.00*	0.75*	**1.00**
River Rock	0.50	0.50	0.00	0.00
Skipper	0.00	0.00	0.00	0.00
Suzy Q	2.25	1.50	0.00	0.00
VTCherry	0.00	0.00	0.25	**1.00**
Wulf	0.00	0.00	0.00	0.00
LSD (0.10)	**2.06**	**0.99**	**0.72**	**0.90**
Trial Mean	**0.75**	**0.49**	**0.14**	**0.19**

*Treatments with an asterisk are not significantly different from the top performer in **bold**.
LSD – Least significant difference.
NS – No significant difference between treatments.
† Rating of 1-5 where 1= least severe and 5=most severe.

Table 7. Hemp whole plant weight, height, and width, Alburgh, VT, 2019.

Treatment	Whole plant height in	Whole plant width in	Whole plant weight lbs plant^{-1}
AC/DC	63.7	67.2*	17.3*
Alexa	40.6	45.2	9.90
Apollo	66.8	67.7*	16.8*
Boax	55.3	66.0*	16.4*
Boax Wine	45.8	52.4	12.8
Ceiba	59.4	53.0	15.4*
Cherry Blossom	53.6	53.2	15.1*
Cherry Ceiba	62.3	51.0	10.9
Cherry Wine	68.6	55.6	17.0*
Cosmic	56.5	58.4	12.7
Dave's Haze	58.6	**75.8**	15.9*
Eighty-Eight	62.9	64.5	14.5
Otakarek	71.2*	68.5*	18.1*
Painted Lady	68.1	68.8*	**18.7**
River Rock	52.5	52.1	15.4*

RN13	53.8	53.7	10.7
Skipper	66.1	68.2*	13.8
Suzy Q	60.9	61.2	18.6*
VTCherry	46.7	30.3	5.05
Wulf	**75.3**	65.8*	10.6
LSD (0.10)	**6.2**	**11.2**	**3.9**
Trial Mean	**59.4**	**58.9**	**14.3**

*Treatments with an asterisk are not significantly different from the top performer in **bold**.
LSD – Least significant difference.
NS – No significant difference between treatments.

Within the variety trial, Wulf was the tallest plant at 75 inches with Otakarek being of comparable height (71 inches). Wulf has potential as a dual-purpose crop with higher CBD concentrations as well as a longer stem that could be processed more consistently and reliably for fiber. Plant widths showed a fair bit of variability with Dave's Haze being the widest at 76 inches and VT Cherry the smallest width at 30 inches. Based on plant size, these different varieties could benefit from greater or less space between plants to optimize land usage and yields for specific varieties. VT Cherry in particular, which was less than half the size of some other varieties, may benefit from a closer plant spacing. Painted Lady had the heaviest average plant weight at 18.7 lbs plant^{-1}, with more than half of the other varieties having comparable weights. Average heights, widths, and weights for the trial were 59.4 in, 58.9 in, and 14.3 lbs respectively (Table 7).

Total bud weight, leaf weight, and stem weight were measured at harvest to further evaluate growth characteristics of each variety (Table 8). Dave's Haze had the highest overall fresh bud weight per plant with AC/DC, Painted Lady, and River Rock having comparable bud weights. VT Cherry had the lowest bud weight per plant, but the bud weight accounted for the highest percentage of total plant weight within the trial. Otakarek had the highest total leaf weight per plant with Apollo, Boax, Boax Wine, Ceiba, Cherry Blossom, Cherry Wine, Painted Lady, and Suzy Q having comparable total leaf weights. Alexa had the greatest ratio of buds to stems alongside VT Cherry. These two plants were also the fastest maturing and were first to be harvested. While plants of Alexa and VT Cherry themselves were small, the proportion of buds to the other plant segments was highest for these two varieties.

The amount of total leaf or stem material can also greatly affect harvest time. While we were not able to record hand harvest times for each variety (as we switched to mechanical assisted harvest for later maturing varieties), a few were documented. VT Cherry was easily the quickest variety to harvest requiring approximately 45 minutes per plant to break down plants, remove fan leaves, and buck flowers from stems. This variety had one of the lowest leaf to stem ratios and highest bud to stem ratios on top of smallest leaf and stem weights. Alexa having the highest bud to stem ratio (comparable to VT Cherry), but more than triple the leaf material of the VT Cherry variety, required approximately 3 hours to fully process one plant. On the higher end of processing time, AC/DC required nearly 5 hours per plant and was among some of the heaviest varieties within the trial with substantial portions of leaf and stem material. Some other larger, later harvested varieties may require additional time to trim and harvest by hand. Amount of time required to harvest plants will vary drastically depending not only on selected cultivars but also desired end-product and intricacy of trimming, however all are important factors to take into consideration when selecting a variety.

Table 8. Hemp plant growth metrics, Alburgh, VT, 2019.

Treatment	Wet bud weight lbs plant-1	Wet bud weight % total	Leaf weight lbs plant^{-1}	Leaf weight % total	Stem weight lbs plant^{-1}	Stem weight % total	Bud:stem	Leaf:stem
AC/DC	7.70*	46.1	4.65	26.2	4.90*	27.7	1.7	1.0
Alexa	5.65	58.0*	2.60	24.5	1.65	17.5	**3.4**	1.5*
Apollo	5.25	31.7	5.90*	34.8*	5.65*	33.6*	1.0	1.0
Boax	6.10	37.7	5.68*	34.4	4.65*	27.9	1.5	1.3*
Boax Wine	4.30	34.1	5.40*	**40.7**	3.10	25.2	1.4	**1.7**
Ceiba	5.90	38.7	5.40*	34.9*	4.10	26.4	1.5	1.4*
Cherry Blossom	5.40	35.9	5.85*	37.7*	3.85	26.4	1.4	1.6*
Cherry Ceiba	4.15	38.4	3.95	35.3*	2.80	26.3	1.5	1.4*
Cherry Wine	5.10	30.4	5.85*	34.4	**6.00**	35.2*	1.0	1.0
Cosmic	3.65	29.1	4.35	34.6*	4.65*	**36.3**	0.8	1.0
Dave's Haze	**7.90**	50.0	4.25	26.8	3.70	23.2	2.2	1.2
Eighty-Eight	4.75	33.0	5.35	36.9*	4.35	30.2	1.1	1.2*
Otakarek	5.05	28.2	**7.20**	39.8*	5.80*	32.1*	0.9	1.2*
Painted Lady	6.90*	37.1	5.85*	31.4	5.90*	31.5*	1.2	1.0
River Rock	6.75*	43.7	5.25	34.5	3.35	21.8	2.0	1.6*
RN13	4.95	46.8	2.50	23.1	3.20	30.0	1.6	0.8
Skipper	4.50	33.3	4.75	33.6	4.55*	33.1*	1.1	1.1
Suzy Q	5.55	30.1	7.05*	38.0*	**6.00**	31.9*	1.0	1.2*
VTCherry	3.20	**63.4**	0.75	15.2	1.10	21.5	3.0*	0.7
Wulf	5.20	50.3	2.10	20.0	3.25	29.7	1.7	0.7
LSD (0.10)	**1.42**	**6.50**	**1.83**	**6.10**	**1.51**	**5.7**	**0.5**	**0.4**
Trial Mean	**5.40**	**39.8**	**4.73**	**31.8**	**4.13**	**28.4**	**1.5**	**1.2**

*Treatments with an asterisk are not significantly different from the top performer in **bold**.
LSD – Least significant difference.

At harvest a composite subsample of flower material was collected from each plot and dried down to determine flower dry matter and calculate dry matter flower yields (Table 9). Otakarek had the highest flower dry matter at 36.2% alongside Apollo, Alexa, Boax Wine, Cosmic, Eighty-Eight, Painted Lady, River Rock, and Skipper. The quantity of unmarketable flower was measured for each variety. Unmarketable flower included any flower that had suffered from disease, rot, soil contamination, or otherwise damaged flower material. The variety Eighty-Eight had the smallest amount of unmarketable material alongside Alexa, Apollo, Boax, Boax Wine, Ceiba, Cherry Blossom, Cherry Ceiba, Cherry Wine, Cosmic, Otakarek, Painted Lady, River Rock, Skipper, Suzy Q, VT Cherry, and Wulf.

Table 9. Hemp flower bud yield, Alburgh, VT, 2019.

Treatment	Flower dry matter %	Dry matter flower yield† lbs plant^{-1}	Unmarketable flower yield lbs plant^{-1}	Dry matter flower yield† lbs ac^{-1}	Yield at 8% moisture lbs ac^{-1}
AC/DC	21.6	1.67*	0.347	2911*	3164*
Alexa	31.0*	1.84*	0.013*	3200*	3478*
Apollo	34.8*	1.73*	0.067*	3019*	3281*
Boax	20.1	1.20	0.126*	2090	2271

Boax Wine	28.0*	1.11	0.122*	1933	2101
Ceiba	22.7	1.35*	0.213*	2347*	2551*
Cherry Blossom	20.3	1.10	0.088*	1909	2075
Cherry Ceiba	21.4	0.83	0.025*	1448	1574
Cherry Wine	22.2	1.13	0.032*	1974	2145
Cosmic	27.9*	1.02	0.157*	1770	1924
Dave's Haze	22.1	1.76*	0.638	3063*	3329*
Eighty-Eight	27.4*	1.35*	**0.005**	2359*	2563*
Otakarek	**36.2**	1.82*	0.053*	3164*	3439*
Painted Lady	27.8*	1.89*	0.068*	3293*	3579*
River Rock	27.3*	**1.98**	0.063*	**3453**	**3752**
RN13	20.9	1.04	0.274	1807	1964
Skipper	34.5*	1.58*	0.150*	2747*	2985*
Suzy Q	21.9	1.20	0.228*	2096	2278
VTCherry	24.9	0.79	0.075*	1381	1500
Wulf	24.8	1.29*	0.046*	2252*	2447*
LSD (0.10)	**11.1**	**0.73**	**0.229**	**1277**	**1388**
Trial Mean	**25.9**	**1.40**	**0.139**	**2411**	**2621**

*Treatments with an asterisk are not significantly different from the top performer in **bold**.

LSD – Least significant difference.

† Dry matter yield is reported at 0% moisture.

The flower yields of River Rock, Painted Lady, Alexa, Otakarek, Dave's Haze, Apollo, AC/DC, Skipper, Eighty-Eight, Ceiba, and Wulf were statistically similar. River Rock had the highest dry matter yield at 3453 lbs ac^{-1} whereas VT Cherry had the lowest dry matter yield at 1381 lbs ac^{-1}. Varieties within the trial had an average yield of 2411 lbs ac^{-1} (Table 9, Figure 1). Top performers for dry matter flower yield also had a wide range of harvest windows with the earliest, Alexa, harvested on 19-Sep and others, such as Otakarek, harvested as late as 23-Oct.

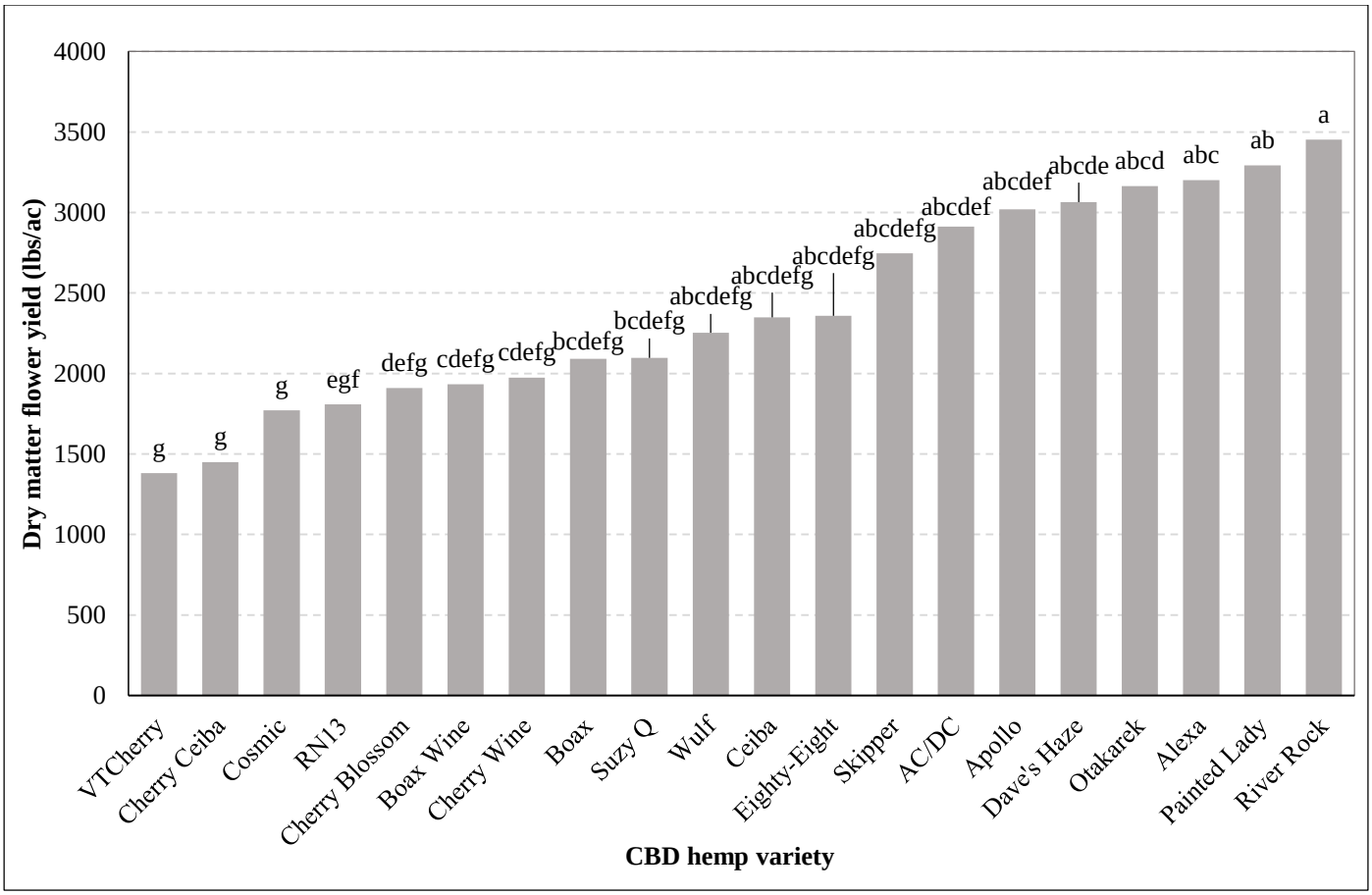

Figure 1. Dry matter flower yield of hemp varieties for the CBD market, 2019.
Similar letters indicate that these results are statistically similar.

Results for cannabinoids are on a dry matter basis (0% moisture). Total cannabinoids were highest in Alexa with other top performers including Ceiba, Cherry Blossom, Cherry Ceiba, Cherry Wine, Cosmic, Dave's Haze, Painted Lady, and VT Cherry (Table 10). Dave's Haze had the highest total potential CBD with other top performers including Cosmic, VT Cherry, Suzy Q, River Rock, Painted Lady, Cherry Wine, Cherry Blossom, and Alexa (Figure 2).

Of our tested varieties and under the given growing conditions, three varieties (Cherry Ceiba, Ceiba, and Cherry Wine) were not compliant with Vermont State regulations (https://agriculture.vermont.gov/sites/agriculture/files/documents/PHARM/hemp/Industrial_Hemp_Rule_%20SOS_05172019.pdf) for THC limits in the 2019 growing season. Acceptable potency for hemp in the State of Vermont is defined as one that has a Δ-9 THC concentration of 0.3% or less **and** a total potential THC concentration of 1.0% or less reported on a dry weight basis. While each of these three varieties were top performers for total cannabinoids and total potential CBD, they would not be considered a compliant crop and need to be destroyed. Aside from the three non-compliant varieties, each variety in the trial had a high ratio of CBD to THC with Skipper having the highest at 31:1. Each of the seventeen compliant varieties within this trial would fall under the Type III definition for cultivars of *Cannabis sativa* L. where cultivars are CBD dominate and have a CBD:THC that is at least 20:1 under definitions proposed under Vermont Hemp Program Rules (5/17/19).

Table 10. Total flower bud cannabinoids, cannabidiol, and tetrahydrocannabinol content, Alburgh, VT, 2019.

Treatment	Total cannabinoids % weight	Total potential CBD † % weight	Total potential THC ‡ % weight	CBD:THC
AC/DC	10.3	8.45	0.29*	29.6*
Alexa	**15.1**	12.1*	0.46*	26.6*
Apollo	8.26	6.25	0.67*	21.8
Boax	11.2	9.17	0.32*	28.7*
Boax Wine	6.27	5.27	0.21*	25.6*
Ceiba	14.4*	9.80	NC	NC
Cherry Blossom	12.2*	10.1*	0.34*	29.3*
Cherry Ceiba	**15.1**	8.76	NC	NC
Cherry Wine	14.3*	10.3*	NC	NC
Cosmic	14.4*	12.0*	0.41*	29.1*
Dave's Haze	14.7*	**12.2**	0.45*	27.4*
Eighty-Eight	8.28	6.77	0.24*	27.9*
Otakarek	8.60	6.99	0.25*	27.9*
Painted Lady	14.9*	11.6*	0.88*	23.9
RN13	6.36	5.16	0.19*	27.1*
River Rock	12.9	10.7*	0.38*	28.0*
Skipper	7.56	6.19	0.20*	**31.3**
SuzyQ	13.5	11.2*	0.41*	27.4*
VT Cherry	14.3*	11.4*	0.46*	25.0*
Wulf	5.52	4.41	**0.16**	27.4*
LSD (0.10)	**3.12**	**2.51**	**1.36**	**6.70**
Trial mean	**11.4**	**8.94**	**0.75**	**24.5**

*Treatments with an asterisk are not significantly different from the top performer in **bold**.

LSD – Least significant difference.

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

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

NC – Indicates variety did not meet state requirements of acceptable potency for hemp in the state of Vermont, defined as one that has a Δ-9 THC concentration of 0.3% or less **and** a total potential THC concentration of 1% or less reported on a dry weight basis.

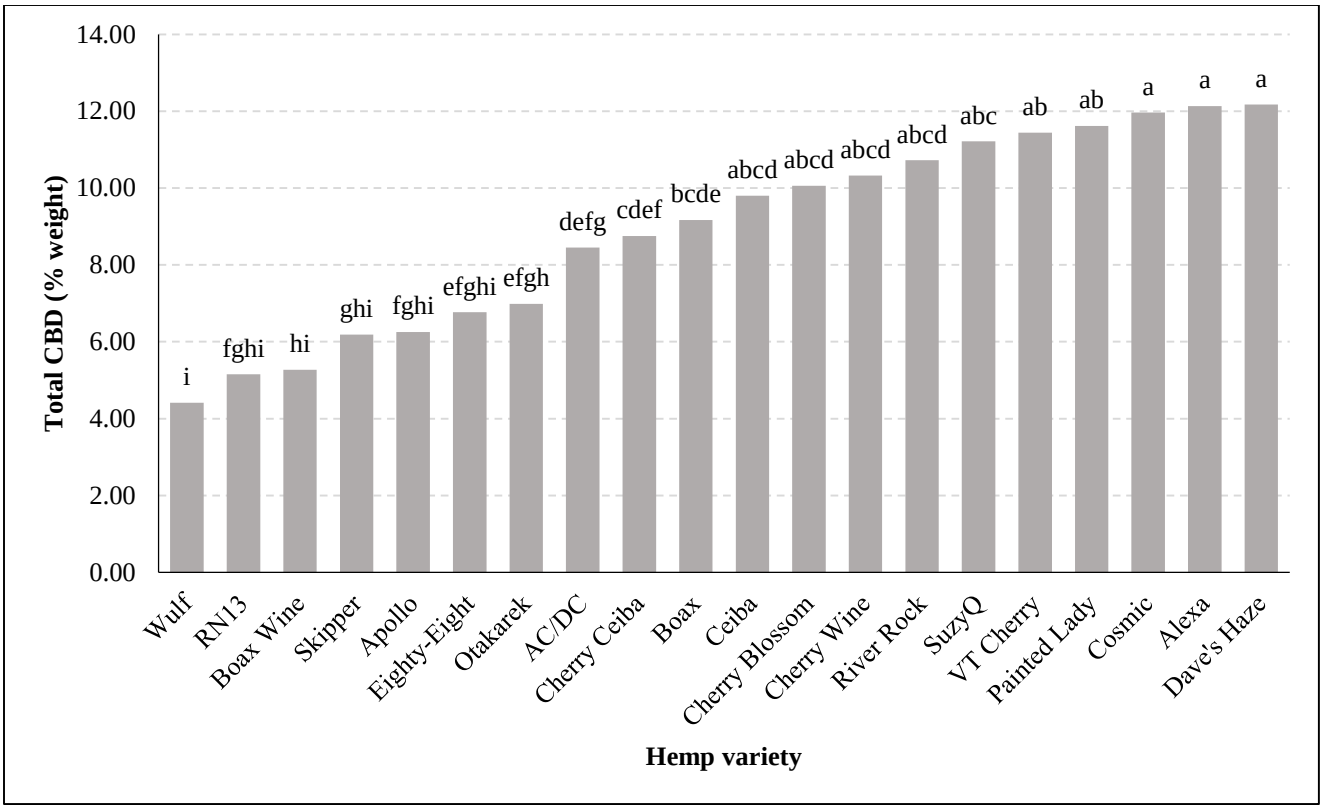

Figure 2. Total potential CBD for 20 hemp varieties grown for flower harvest, 2019.
Similar letters indicate that these results are statistically similar.

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 are one of many types of compounds found in hemp. Terpene profiles were determined in one replicate for each variety (Table 11). Results are included for 21 analyzed, unique terpenes, which have distinct chemical compositions and associated aromas that contribute to individual plant characteristics. 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.

Table 11. Total flower bud terpene profiles, Alburgh, VT, 2019†.

Treatment	Alpha-bisabolol ppm	Alpha-humulene ppm	Alpha-ocimene ppm	Alpha-phellandrene ppm	Alpha-pinene ppm	Alpha-terpinene ppm	Beta-caryophyllene ppm	Beta-myrcene ppm	Beta-pinene ppm	Camphene ppm
AC/DC	32.0	186	5.74	0.00	26.0	2.58	614	251	22.6	5.66
Alexa	17.3	305	0.00	293	3.81	959	363	85.9	7.46	14.8
Apollo	12.3	347	2.72	0.00	17.9	1.30	848	470	17.4	2.49
Boax	16.8	86.6	5.04	0.00	24.3	2.47	318	833	22.2	3.52
Boax Wine	6.87	108	19.8	0.00	33.0	0.00	403	138	11.6	0.00
Ceiba	8.67	230	0.77	0.00	23.8	0.89	565	156	24.6	5.26
Cherry Blossom	145	89.2	0.98	0.00	238	3.55	267	1250	82.6	4.83
Cherry Ceiba	195	366	7.92	0.00	20.4	4.09	1250	387	18.4	2.65
Cherry Wine	72.5	302	44.8	0.00	21.5	10.1	723	404	19.2	1.90
Cosmic	23.5	112	2.68	0.00	11.1	1.42	376	97.5	6.98	0.00
Dave's Haze	48.5	48.6	0.00	0.00	144	2.06	126	305	37.5	3.45
Eighty-Eight	113	215	3.44	0.00	248	1.05	696	553	107	3.92
Otakarek	77.0	109	9.56	0.00	142	1.55	397	655	52.6	3.64
Painted Lady	122	232	18.8	0.00	552	2.80	703	246	202	8.90
River Rock	53.0	158	0.90	0.00	181	3.79	379	803	63.8	4.24
RN13	43.6	203	3.31	0.00	21.2	2.76	621	1000	25.3	3.90
Skipper	86.1	155	15.5	0.00	199	1.34	504	770	66.8	5.05
SuzyQ	97.9	134	2.09	0.00	414	2.89	271	539	160	5.05
VT Cherry	87.0	282	0.49	0.00	18.7	2.63	733	74.3	14.2	4.75
Wulf	20.1	432	6.01	0.00	171	12.1	1540	107	34.3	0.00

†The above data represents only one replicate hence no statistical analysis was run on terpene profiles.

Table 11 cont. Total flower bud terpene profiles, Alburgh, VT, 2019. †

Treatment	Cis-beta-ocimene	D-limonene	Delta-3-carene	Eucalyptol	Gamma-terpinene	Geraniol	Guaiol	Linalool	P-cymene	Terpinolene	Trans-nerolidol
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
AC/DC	273	167	0.00	0.00	3.24	0.00	56.4	4.47	3.70	25.6	10.8
Alexa	74.7	3.55	110	18.6	4.35	12.0	11.0	0.00	1.97	9.51	0.00
Apollo	50.4	90.0	0.00	0.00	1.53	0.00	0.00	2.47	1.71	8.59	0.00
Boax	137	123	0.00	2.11	3.01	0.00	23.0	11.7	2.92	13.0	9.68
Boax Wine	107	13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.73	3.60	0.00
Ceiba	19.8	163	0.00	0.00	1.06	0.00	43.7	43.6	2.15	11.0	2.69
Cherry Blossom	31.9	81.6	0.00	1.37	3.82	0.00	74.0	17.8	2.79	13.1	3.61
Cherry Ceiba	83.2	107	0.00	31.9	5.80	0.00	0.00	0.00	2.61	9.60	5.68
Cherry Wine	251	73.5	3.29	18.9	13.2	0.00	0.00	0.00	4.20	135	3.09
Cosmic	14.8	52.2	0.00	18.1	2.44	0.00	23.2	0.00	1.76	3.85	0.00
Dave's Haze	12.5	31.4	0.00	19.8	3.28	0.00	15.1	8.34	2.98	6.64	0.00
Eighty-Eight	70.2	68.2	0.00	0.00	1.21	0.00	37.8	4.48	0.95	5.55	2.27
Otakarek	83.5	99.9	0.00	0.00	1.98	0.00	44.2	4.18	2.22	8.86	3.25
Painted Lady	107	121	0.00	0.00	1.74	0.00	41.0	0.00	2.09	6.65	0.00
River Rock	30.0	67.1	0.00	5.54	4.27	0.00	54.5	34.74	3.56	11.5	5.87
RN13	106	136	0.00	4.32	3.29	0.00	70.2	0.00	2.57	12.8	0.00
Skipper	101	98.4	0.00	0.00	1.74	0.00	43.2	0.00	1.96	7.90	3.15
SuzyQ	18.0	40.5	0.00	22.7	4.79	0.00	48.4	0.00	1.91	5.18	0.00
VT Cherry	7.69	80.2	0.00	0.00	2.97	0.00	76.9	58.9	1.96	16.6	25.28
Wulf	44.5	11.7	0.00	106	20.2	0.00	10.1	0.00	1.97	9.51	0.00

†The above data represents only one replicate hence no statistical analysis was run on terpene profiles.

DISCUSSION

Each variety within the trial appeared to perform well in our Northeast climate. However, there were some stark differences in growth habits and quality across the board. Based on growth habit alone, there is potential to adjust plant spacing of any given variety to optimize per acre yields while also maintaining adequate spacing for air flow and thus disease control. While not largely prevalent, there were noticeable instances of disease across the numerous different varieties, which primarily included white mold, gray mold, and powdery mildew at various severities across cultivars. Major pest problems could potentially be mitigated by cultural practices such as proper plant spacing and varietal selection as we obtain more information on varietal resistances moving forward. Various growth characteristics can be especially important when looking at the potential for high disease pressure leading up to harvest when we may experience wet conditions conducive for major pathogen growth and potential crop losses. Few species of arthropod pests were found on hemp plants this year with aphids being most prevalent. In addition to problems associated with feeding damage, there is also potential for sooty mold growth on leaves as a result of high aphid populations, reducing quality of flower. Other pests may begin to develop as a greater concern, such as stem borers, which were seen in greater populations in other parts of the region.

RN13 and Dave's Haze had the highest amounts of unmarketable flower material largely as a result of disease pressure or soil contamination later in the season, becoming most prevalent in the week prior to harvest for each of these varieties. Initial labor and efficiency constraints limited the ability to timely harvest some varieties, as these two hemp varieties appeared as if they could have benefit from an earlier harvest period, which may have impacted disease pressure and thus the amount of unmarketable material. River Rock, Painted Lady, Alexa, Otakarek, Dave's Haze, Apollo, AC/DC, Skipper, Eighty-Eight, Ceiba, and Wulf were all high flower yielding varieties. Dave's Haze, Cosmic, VT Cherry, Suzy Q, River Rock, Painted Lady, Cherry Blossom, and Alexa were all top performers for total CBD and were compliant with current state regulations for THC levels. Of our tested varieties and under the given growing conditions, three varieties (Cherry Ceiba, Ceiba, and Cherry Wine) were not compliant with Vermont State regulations for THC limits in the 2019 growing season. Hemp must be grown in compliance with state and federal regulations. Please check with your state to determine rules and regulations required for hemp production.

Terpene profiles and concentrations of hemp may also become increasingly important as new markets are developed for the crops. While many of these compounds contribute to the vast array of aromatics and can exhibit distinct aroma profiles across cultivars, many of these compounds may also be important for their purported health benefits and synergistic effects with other compounds when consumed in hemp and hemp related products.

The twenty varieties within our research trial only begins to scratch the surface of the multitude of hemp cultivars that are now commercially available. With such wide scale variations in growth habits, yield, and quality of various cultivars, it will be increasingly important to continue research and evaluation of those available cultivars to provide region specific information to optimize farmer yields within the Northeast.

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