Evaluation of High-CBD Cultivars in New York State – Results of 2020 Cornell Hemp Field Trials

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Introduction

The rapid advancement of the high-cannabinoid hemp market since the 2014 Farm Bill has highlighted the urgent need to characterize high-CBD hemp cultivars. During the 2020 growing season, the Cornell Hemp research team evaluated 40 high-CBD hemp entries in field trials, including cultivars from commercial sources and selected lines from the Cornell Hemp Breeding Program. Consistent with previous cultivar evaluation trials we measured height and surveyed flowering time weekly throughout the growing season. Additionally, we rated disease severity of powdery mildew, downy mildew, and *Bipolaris* leaf spot. We collected shoot tip samples at one, three, and five weeks after terminal flowering and measured wet biomass for all plants in the trial. Additionally, we divided one plant per plot into sections for post-harvest dry biomass and cannabinoid measurements.

Materials and Methods

Plant material

Forty hemp cultivars (Table 1) from 11 commercial sources and the Cornell hemp breeding program were established in a peat-based soilless media (Lambert LM111) in the second week of May 2020. In accordance with techniques employed by commercial cultivators, plants were propagated from dioecious (male and female) seed, 'feminized' (all female) seed, or via vegetative cuttings (Table 2). Cuttings were rooted using Clonex® rooting hormone (Hydrodynamics International, Lansing, MI). Seedlings and cuttings were maintained in the greenhouse at 18 light:6 dark until transplant in the first week of June. Dioecious cultivars were screened at the seedling stage with the CSP-1 Y chromosome-specific molecular marker in order to select females for transplant to the field (Toth et al. 2020).

Field preparation and maintenance

Trials were planted at two Cornell University field sites: Geneva, NY (McCarthy Farm: 42.895426, -77.005467) and Ithaca, NY (Bluegrass Lane Turf and Ornamental Farm: 42.461478, -76.462679). See the NEWA website for weather data (http://newa.cornell.edu/). Each site was cultivated and raised beds with drip irrigation and black plastic mulch were prepared every 6 feet on center. Fertilizer (19-19-19, Phelps Supply Inc., Phelps, NY) equivalent to 85 lb. N A^{-1}, was spread under the plastic mulch in Geneva and was broadcast pre-planting in Ithaca. Landscape fabric was used to control weeds in the alleys. Each entry was planted in five-plant plots in a randomized complete block design with four complete blocks at each site with 32 cultivars replicated on both sites. Eight entries were planted only in Geneva and were randomized separately in 4 rows between the replicate blocks of the other 32 cultivars. Seedlings and rooted cuttings were transplanted into raised beds on June 11, 2020 (Geneva) and June 12, 2020 (Ithaca). Plants were spaced 4 feet apart within rows. After transplanting, the plots were irrigated using in-bed drip irrigation as needed throughout the season to maintain optimal soil moisture. HOBOnet 10HS soil moisture sensors (Onset, Bourne, MA) were installed and used to assess when irrigation was necessary. Fertilizer (Jack's 12-4-16 Hydro FeED RO, 11.3 kg per treatment) was included in the irrigation on two occasions in early and late July.

*Table 1. Sources of high-CBD cultivars in field trials in Geneva (all 40) and Ithaca (32). Cultivars were started from seed (dioecious or feminized) or vegetative cuttings. Germination of seeded lines was rated 8 days post planting. *Cultivar only trialed at Geneva site*

Cultivar/ID	Propagation (cutting/seed)	Source	Germination
19-1191	Seed (feminized)	Cornell Hemp Program	87%
19-1091	Seed (dioecious)	Cornell Hemp Program	95%
20-1030	Seed (dioecious)	Cornell Hemp Program	90%
19-1064-003	Cutting	Cornell Hemp Program	-
19-1068-003	Cutting	Cornell Hemp Program	-
19-1066-001	Cutting	Cornell Hemp Program	-
19-1067-001	Cutting	Cornell Hemp Program	-
19-1077-008	Cutting	Cornell Hemp Program	-
TJ's CBD	Cutting	Stem Holdings Agri	-
FL 49	Cutting	Sunrise Genetics	-
FL 58	Cutting	Sunrise Genetics	-
FL 70	Cutting	Sunrise Genetics	-
CJ 2	Cutting	Sunrise Genetics	-
SB 1	Cutting	Sunrise Genetics	-
Z 25	Cutting	Sunrise Genetics	-
NS52	Seed (feminized)	Phytonyx	100%
SR-1	Seed (feminized)	Industrial Seed Innovations	90%
Umpqua	Seed (feminized)	Industrial Seed Innovations	98%
Rogue	Seed (feminized)	Industrial Seed Innovations	70%
The Grand	Seed (feminized)	Boring Hemp	92%
CSG Berry Blossom	Seed (feminized)	Castetter Sustainability Group	99%
Sweetened	Seed (feminized)	Ryes Creek	80%
Carolina Dream	Seed (dioecious)	Ryes Creek	88%
BaOx	Seed (dioecious)	Ryes Creek	78%
Hybrid #5	Cutting	Front Range Biosciences	-
Hybrid #9	Cutting	Front Range Biosciences	-
Early Pearly	Cutting	Front Range Biosciences	-
Lindorea	Seed (feminized)	Charlotte's Web	91%
CW EM-18	Seed (feminized)	Charlotte's Web	100%
CW EM-28	Seed (feminized)	Charlotte's Web	98%
CW EM-31	Seed (feminized)	Charlotte's Web	87%
CW EM-73	Seed (feminized)	Charlotte's Web	90%
Hot Blonde*	Seed (feminized)	Blue Forest Farms	-
Cloud Berry*	Seed (feminized)	Blue Forest Farms	-
Queen Dream*	Seed (feminized)	Blue Forest Farms	-
Cinderella Story*	Seed (feminized)	Blue Forest Farms	-

Berry Blossom*	Seed (feminized)	Wessels' Farm	89%
Cherry Blossom*	Seed (feminized)	Wessels' Farm	84%
Merlot*	Seed (feminized)	Wessels' Farm	78%
Zion*	Seed (feminized)	Boring Hemp	-

Measuring height and growth rate

The heights of the middle three plants of each five-plant plot were measured weekly after transplant until all plants in a plot did not grow for two consecutive weeks. Growth rate was calculated using the formula in Table 3. Height and growth rate were modeled using local polynomial regression. All statistical analyses and modeling were conducted using R statistical software version 3.6.1 (R Core Team). After modeling, data points were sampled from all of the models and used to conduct a *k*-means clustering analysis to group similar models. The Hartigan and Wong algorithm was used to assign the clusters and the elbow method to select the optimal number of clusters (Hartigan and Wong 1979).

Flowering surveys

All plants were surveyed weekly for evidence of flowering. Each plant was assessed for the presence of female flowers presenting pistils and whether the plant had initiated terminal flowering. Plants were marked as 'terminally flowering' when clusters of female flowers were observed at shoot apices. Terminal flowering is distinct from sparse, solitary flowers developing in the axils of the leaves (Spitzer-Rimon et al. 2019). Any plants that produced staminate flowers were immediately removed from the field to avoid pollination. Staminate flowers were observed on 19-1091, 19-1191, 20-1030, 'CW EM-28', and 'Zion.'

Foliar disease ratings

During the growing season, all of the plants at both sites were visually rated for severity of powdery mildew infection (Fig.1) and *Bipolaris* leaf spot based on a continuous scale of 0-100% leaf area showing disease symptoms. Additionally, the plants were rated at the Ithaca site for downy mildew (Fig. 1) using the same method. Powdery mildew ratings were conducted on 9/9 (Ithaca) and 9/15 (Geneva). *Bipolaris* leaf spot was rated on 8/27 (Geneva) and 8/28 (Ithaca). Downy mildew was rated in Ithaca on 8/28.There was no downy mildew observed at the Geneva site. For each field site, ratings for the plants within each plot were averaged.

Cannabinoid time series

Shoot tips of the 32 multi-site cultivars were sampled from every plot starting one week after terminal flowering and re-sampling three and five weeks after terminal flowering. In accordance with current regulatory standard in New York State, the top 10 cm of the shoot tips were sampled for the time series. Shoot tip samples were dried in a climate-controlled room (~30% RH and below 33°C) and , then milled to a fine powder in a Ninja® Pro blender (SharkNinja, Needham,

Figure 1. Leaf with no visible powdery mildew adjacent to a leaf covered in powdery mildew at the Geneva site **(L)**. Symptoms of downy mildew on leaves of 'NS52' at the Ithaca site **(R)**.

MA). Milled samples were stored at 4°C prior to high pressure liquid chromatography (HPLC) analysis following the methods described by Stack et al. (2021). The following cannabinoids were quantified for each sample: tetrahydrocannabinolic acid (THCA), Δ^9-tetrahydrocannabinol (THC), cannabidiolic acid (CBDA), cannabidiol (CBD), cannabichromenic acid (CBCA), cannabichromene (CBC), cannabigerolic acid (CBGA), cannabigerol (CBG), cannabinol (CBN), tetrahydrocannabivarin (THCV), tetrahydrocannabivarinic acid (THCVA), cannabidivarin (CBDV), cannabidivarinic acid (CBDVA), cannabicyclol (CBL), cannabicyclolic acid (CBLA), and Δ^8-tetrahydrocannabinol (Δ^8-THC). Samples were kept below 35°C at all times to avoid decarboxylation of acid-form cannabinoids. To control for potential variation in decarboxylation of acid-form cannabinoids, the analysis was conducted based on the total potential cannabinoid percentages. See Table 3 in Stack et al. (2021) for formulas used to calculate total potential cannabinoids. A two-way ANOVA test was used to determine whether a cultivar or site had a significant effect on cannabinoid samples five-weeks after terminal flowering. In the cases where the interaction term was not significant, the interaction was dropped from the model and the *p*-values of the main effects are reported. The mean total cannabinoid percentage for each cultivar at each time point was used to conduct a *k*-means clustering analysis to group similar accumulation rates. The Hartigan and Wong algorithm was used to assign the clusters and the elbow method to select the optimal number of clusters (Hartigan and Wong 1979).

End of season biomass

At harvest, the stems were cut at soil level and the total wet biomass of each plant in a plot was measured. The middle plant in each five-plant plot was divided into five equal sections based on the length of the main stem. The sections were air-dried in a greenhouse with industrial fans, then total dry biomass (whole plant) and dry stripped biomass (floral tissue stripped from the plant) were measured for each section. Stripped biomass per area was calculated by dividing the

stripped biomass by the area of a circle with the same diameter as the width of the plant. Cannabinoids will be quantified by HPLC for each section, following the methods above, using a subsample of the stripped biomass. A two-way ANOVA test was used to determine whether a cultivar or site had a significant effect on biomass. In the cases where the interaction term was not significant, the interaction was dropped from the model and the *p*-values of the main effects are reported.

Results and Discussion

Height and Growth Rate

Similar to the results found in the 2019 Cornell CBD cultivar field trials (Stack et al. 2021), the growth rate curves clustered into five groups based on the maximum growth rate and point in the season that the maximum growth rate occurred (Fig. 2). These measurements were based on the height of the main stem, so they do not account for any lateral growth on branches. Some of the plants were as much as two times wider as they were tall. In addition, many of the cultivars were segregating for flowing time, which strongly impacts the growth rate and maximum height of the plants.

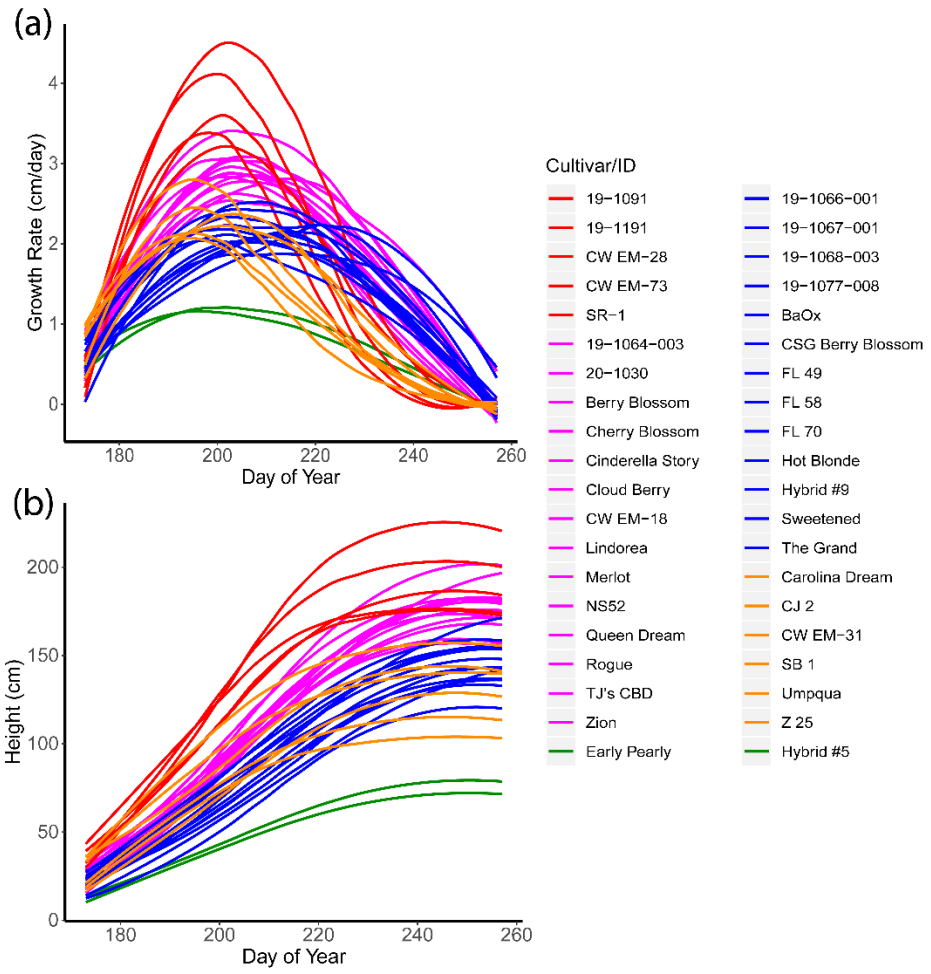

Figure 2. Time series measurements of growth rate (a) and height (b) for 40 hemp cultivars. Average height and daily growth rate measured weekly from transplant until the plants stopped growing. Curves were modeled using local polynomial regression. Groups assigned were based on *k*-means clustering.

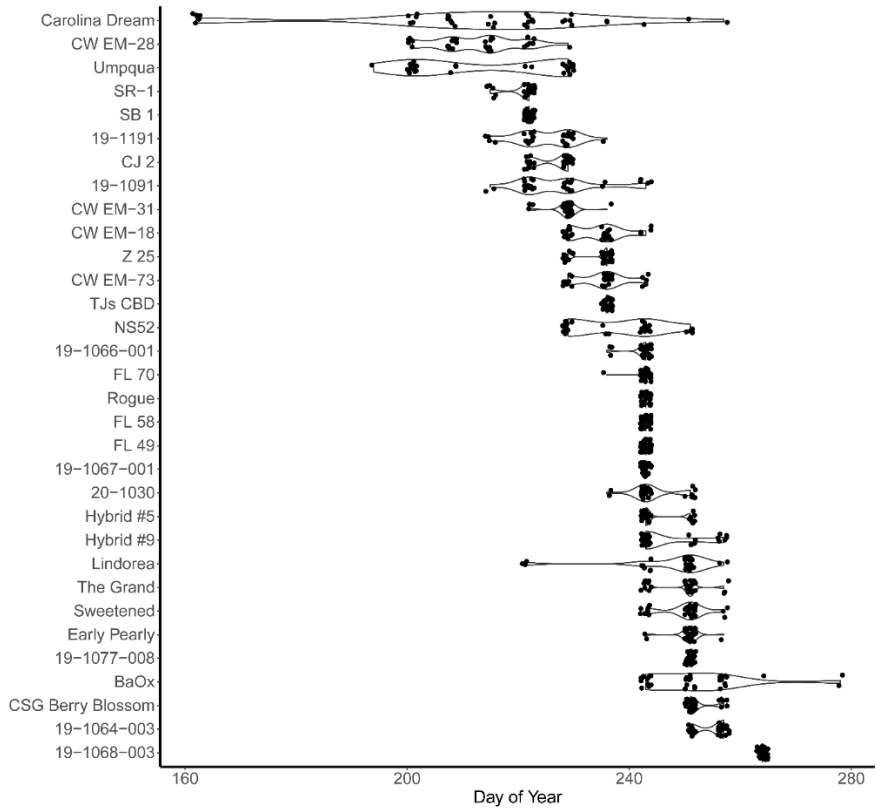

Figure 3. Distribution of hemp cultivar flowering time for 32 hemp cultivars grown at two sites in New York State. Jittered points indicate the week an individual plant was marked as terminally flowering. Flowering was surveyed weekly. Violin plots show the distribution of flowering times for each cultivar during the growing season.

Flowering Time

Segregation for flowering time within cultivars was observed in nearly all seeded cultivars. Cultivars propagated from cuttings were more uniform in flowering (Fig. 3). One cultivar, 'Carolina Dream,' had some individuals that flowered in the greenhouse before transplant. Similar to the 2019 trial, 'Umpqua' segregated equally into two flowering time groups, as did 'NS52.' However, not all seeded cultivars were consistent between years. 'Rogue' flowered early in the 2019 trial and was segregating for flowering time, whereas it flowered uniformly much later in the 2020 trial. Very late flowering cultivars are riskier to grow in New York as they can be damaged by early frost. Anecdotally, frost seems to damage vegetative plants more than plants that have transitioned to flowering.

Cannabinoid Accumulation

The majority of cultivars displayed increases in total cannabinoid concentration across consecutive sampling weeks (Fig. 4). The clustering analysis parsed three clusters: cultivars with rapid accumulation rates (green), moderate accumulation rates (blue), and slow accumulation rates (orange). We have not completed the cannabinoid analysis of the whole plant stripped floral

samples to date, but in the 2019 trial there were cultivar-specific differences in the cannabinoid concentration in shoot tip samples compared with whole plant biomass samples.

Disease Ratings

Mean disease severity by cultivar and site was rated for three pathogens (Fig. 5). Similar to the 2019 trial there were very high levels of powdery mildew at both sites. Again, 'Umpqua' was one of the most susceptible cultivars at both sites and 'FL 58' had extremely low ratings of powdery mildew at both sites. In addition, *Bipolaris* leaf spot was rated at both sites. Overall disease severity was very low, though 19-1067-001 consistently had greater mean severity of *Bipolaris* leaf spot. In the Ithaca trial, downy mildew was identified and rated as well. Most of the downy mildew inoculum appears to have moved in from one side of the field so the ratings of plants on that edge tend to be much higher. Despite this, all of the 'NS52' plots had noticeable levels of downy mildew at the Ithaca site.

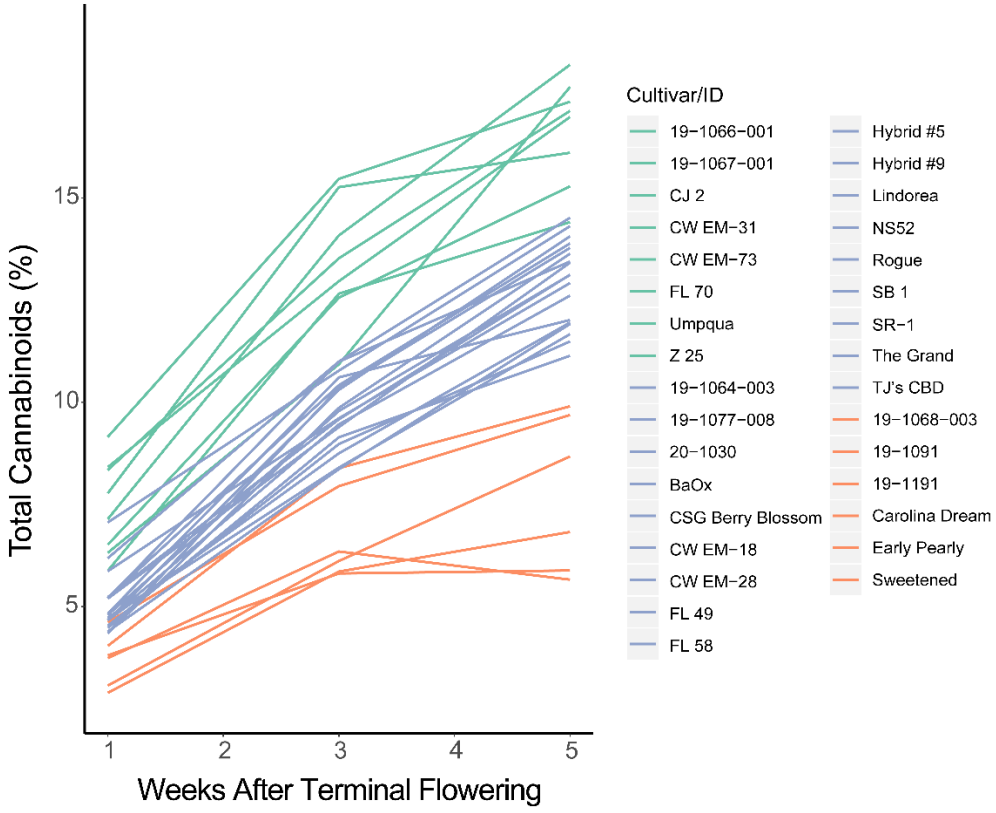

Figure 4. Accumulation of total cannabinoids in 10 cm floral shoot tips sampled 1,3, and 5 weeks after terminal flowering. Cannabinoids were quantified by HPLC. Accumulation rate groups were assigned were based on *k*-means clustering.

Biomass Weights and Proportions

There was significant variability between and within cultivars for wet, dry and stripped biomass (Tables 2 & 4). On a per plant basis, 'Lindorea' had the greatest wet, stripped, and dry biomass of the cultivars replicated at two sites. 'Merlot' had the greatest mean wet biomass at the Geneva site and the heaviest plant was 'Berry Blossom' at 17.46 kg. Most cultivars were approximately 25% dry matter with slight variation by cultivar and site. This could be partly attributed to variation in water content at harvest as plants were harvested on different dates based on when they started to flower. Generally, plants with lower biomass had a greater proportion of stripped biomass, with some exceeding 70% of total dry biomass. When considering yield on a per unit area basis 'Carolina Dream,' 'CW EM-28,' 'The Grand,' and 'SR-1' were the top performers at over 0.5 kg per m^2. Yield per unit area was related to plant architecture, planting density, and of course cannabinoid content in the biomass, so additional research is needed to determine optimal growing conditions to maximize yield per acre and profitability.

Harvest Time Cannabinoid Sampling

Additional data about the concentration of cannabinoids in whole plant stripped biomass will be available in the coming months. In lieu of those data, the cultivar means from shoot tips at five weeks post terminal flowering are reported (Tables 3 & 4). Twenty-four of the 32 cultivars trialed at both sites had mean total THC that exceeded 0.3%. The CBD:THC ratios were generally greater than 25:1 with some cultivars exceeding 30:1. The cultivar with the greatest mean CBD and total cannabinoid content was 'FL 70.' Three cultivars averaged over 1.5% total CBC, with Cornell line 19-1067 exceeding 3% total CBC. A few of the individuals in Cornell line 19-1091 had appreciable content (>1% w/w) of varin (propyl) cannabinoids, though most cultivars averaged below 0.1%. One cultivar, 'Zion,' had several chemotype II individuals that produced >3% total THC.

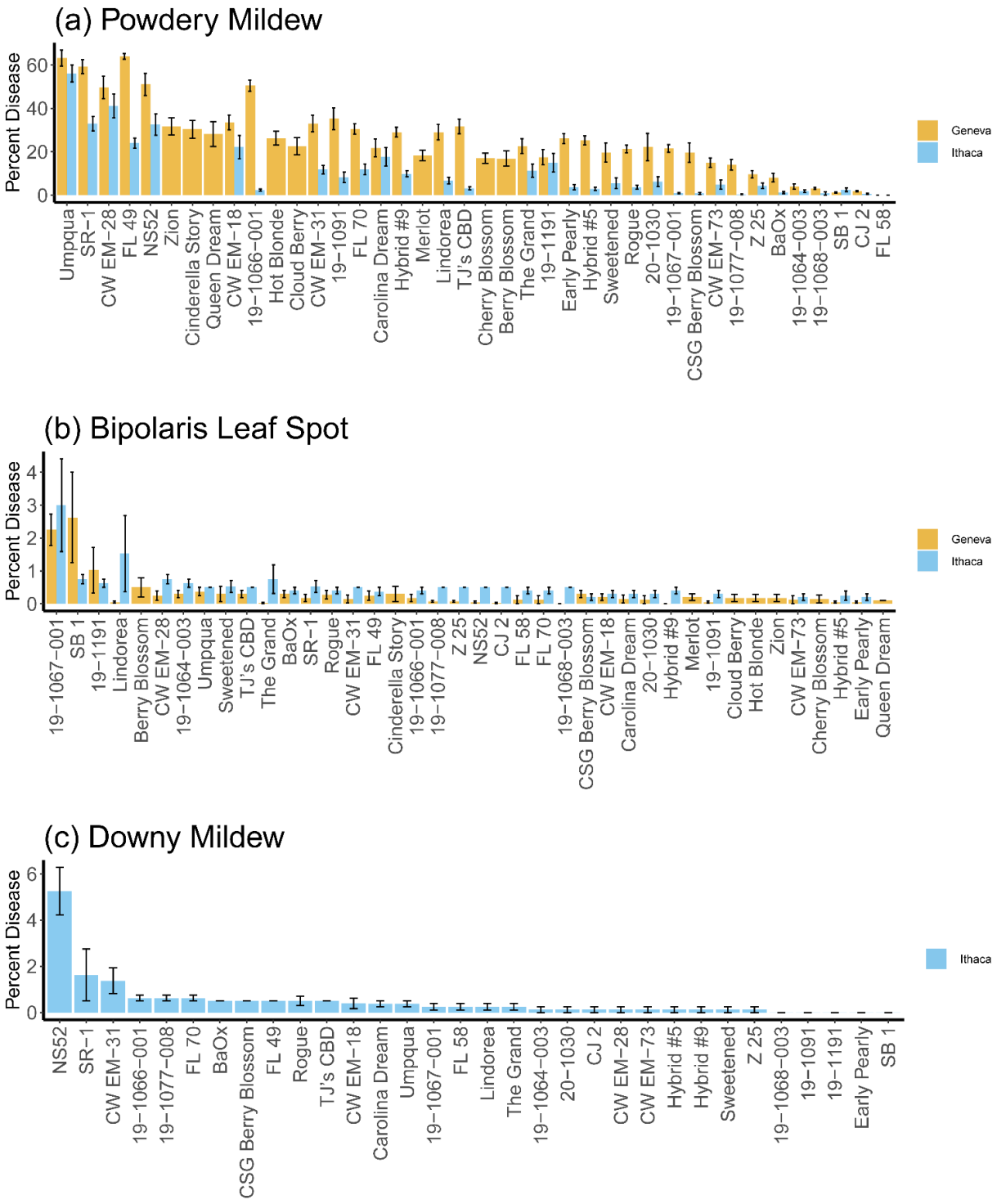

Figure 5. Mean disease severity for 40 high-CBD hemp cultivars in field trials in Geneva and Ithaca. All ratings are on a scale of 0-100% leaf area diseased. Powdery mildew ratings were conducted on 9/9 (Ithaca) and 9/15 (Geneva). *Bipolaris* leaf spot was rated on 8/27 (Geneva) and 8/28 (Ithaca). Downy mildew was rated in Ithaca on 8/28.

*Table 2. Biomass data from 32 hemp cultivars grown on two sites (Ithaca, NY and Geneva, NY) in 2020. Plants were harvested five weeks after terminal flowering. * $p<0.05$, ** $p<0.01$, *** $p<0.001$, n. s. is not significant*

Cultivar/ID	Wet Biomass (kg)	Dry Biomass (g)	Stripped Biomass (g)	% Dry Matter	% Stripped Biomass	Stripped Biomass per Area (g/m^2)
19-1064-003	8.7	2555.0	1060.5	28.6%	43.8%	337.8
19-1066-001	8.3	2255.8	1086.2	27.4%	48.4%	217.1
19-1067-001	9.2	2528.1	1131.4	27.9%	45.2%	292.7
19-1068-003	7.9	1846.0	684.7	22.8%	38.9%	165.9
19-1077-008	8.7	2397.0	874.4	27.5%	35.7%	234.0
19-1091	5.6	1648.8	782.5	29.4%	49.9%	198.9
19-1191	4.4	1429.4	843.8	32.0%	59.4%	389.3
20-1030	8.5	2352.2	1075.5	27.7%	48.1%	321.8
BaOx	7.3	1913.3	902.0	25.9%	48.6%	303.2
Carolina Dream	6.2	1570.1	953.0	24.7%	64.6%	560.4
CJ 2	3.9	986.7	691.9	25.3%	70.5%	225.6
CSG Berry Blossom	6.7	1789.6	763.0	27.0%	43.0%	265.5
CW EM-18	10.3	2355.2	1278.3	23.8%	54.4%	381.8
CW EM-28	5.2	1290.3	881.2	24.9%	69.0%	554.5
CW EM-31	6.6	1783.3	1053.8	27.2%	60.4%	379.0
CW EM-73	8.7	2070.0	1092.6	24.4%	53.4%	324.3
Early Pearly	2.5	625.4	406.9	24.5%	65.0%	286.5
FL 49	6.8	1614.7	776.5	24.2%	47.5%	294.1
FL 58	6.9	1587.4	778.5	23.0%	48.8%	318.3
FL 70	6.6	1647.6	793.9	25.0%	49.4%	310.2
Hybrid #5	3.0	659.5	485.3	22.2%	73.7%	363.5
Hybrid #9	4.8	1198.2	672.2	24.8%	55.2%	298.8
Lindorea	10.3	2741.1	1312.4	27.0%	47.9%	361.8
NS52	8.2	2024.4	1101.7	24.5%	56.4%	445.5
Rogue	9.6	2643.6	1139.5	28.1%	42.6%	351.4
SB 1	4.9	1326.9	887.3	26.4%	70.5%	324.2
SR-1	6.1	1598.3	1026.8	26.3%	64.1%	500.2
Sweetened	8.4	2315.7	932.8	27.6%	41.7%	235.5
The Grand	6.5	1546.2	857.9	23.8%	56.4%	513.4
TJs CBD	8.6	1949.7	1067.3	23.3%	54.6%	421.5
Umpqua	4.3	1025.1	661.6	23.2%	68.5%	482.3
Z 25	5.5	1425.5	868.5	25.6%	64.5%	293.5
Overall Mean	**6.9**	**1769.8**	**906.3**	**25.8%**	**54.6%**	**343.1**
Site	n. s.	*	n. s.	***	**	***
Cultivar	***	***	***	***	***	***
Site:Cultivar	n. s.	n. s.	n. s.	**	n. s.	n. s.

Table 3. Cannabinoid data from shoot tips sampled five weeks after terminal flowering. Samples were air dried at 30% RH for at least 2 weeks prior to milling and cannabinoid quantification by HPLC. * $p<0.05$, ** $p<0.01$, *** $p<0.001$, n. s. is not significant

Cultivar/ID	Total THC	Total CBD	Total CBC	Total CBG	Total THCV	Total CBDV	Total CBL	Total Cannab-inoids	CBD:THC
19-1064-003	0.26%	8.41%	1.38%	0.20%	0.00%	0.02%	0.00%	11.67%	32.23
19-1066-001	0.40%	11.97%	2.36%	0.22%	0.00%	0.03%	0.01%	16.98%	29.70
19-1067-001	0.34%	11.31%	3.19%	0.24%	0.00%	0.03%	0.00%	17.13%	32.85
19-1068-003	0.17%	5.07%	0.56%	0.17%	0.00%	0.02%	0.03%	6.83%	30.59
19-1077-008	0.36%	10.49%	0.46%	0.47%	0.00%	0.03%	0.01%	13.42%	28.92
19-1091	0.24%	4.10%	0.21%	0.15%	0.08%	0.36%	0.04%	5.88%	24.19
19-1191	0.17%	4.29%	0.20%	0.22%	0.00%	0.06%	0.04%	5.66%	25.69
20-1030	0.27%	8.18%	0.93%	0.32%	0.00%	0.09%	0.03%	11.14%	30.79
BaOx	0.37%	10.52%	0.76%	0.39%	0.00%	0.09%	0.00%	13.78%	28.69
Carolina Dream	0.28%	7.30%	0.56%	0.20%	0.01%	0.23%	0.04%	9.69%	25.68
CJ 2	0.41%	11.19%	0.47%	0.52%	0.00%	0.04%	0.07%	14.41%	27.28
CSG Berry Blossom	0.33%	9.31%	0.52%	0.39%	0.00%	0.02%	0.00%	12.01%	28.46
CW EM-18	0.39%	10.43%	0.98%	0.35%	0.01%	0.21%	0.03%	14.06%	27.01
CW EM-28	0.36%	9.03%	0.38%	0.28%	0.00%	0.03%	0.06%	11.49%	25.04
CW EM-31	0.49%	12.65%	0.62%	0.33%	0.00%	0.05%	0.07%	16.10%	26.04
CW EM-73	0.46%	11.97%	0.64%	0.30%	0.00%	0.05%	0.05%	15.28%	25.91
Early Pearly	0.24%	6.65%	0.41%	0.15%	0.00%	0.18%	0.00%	8.67%	27.15
FL 49	0.37%	10.81%	0.56%	0.28%	0.00%	0.02%	0.01%	13.64%	28.93
FL 58	0.36%	10.95%	0.59%	0.32%	0.00%	0.03%	0.02%	13.89%	30.10
FL 70	0.50%	14.31%	0.74%	0.47%	0.00%	0.07%	0.03%	18.26%	28.83
Hybrid #5	0.40%	11.32%	0.57%	0.28%	0.00%	0.05%	0.02%	14.31%	28.61
Hybrid #9	0.33%	9.50%	1.55%	0.21%	0.00%	0.02%	0.01%	13.12%	29.15
Lindorea	0.34%	9.79%	0.58%	0.26%	0.00%	0.14%	0.00%	12.61%	28.91
NS52	0.45%	11.27%	0.63%	0.42%	0.00%	0.03%	0.03%	14.51%	25.48
Rogue	0.37%	9.81%	0.68%	0.41%	0.01%	0.10%	0.01%	12.92%	26.24
SB 1	0.40%	10.25%	0.49%	0.32%	0.00%	0.04%	0.06%	13.12%	25.48
SR-1	0.44%	10.52%	0.50%	0.30%	0.00%	0.03%	0.05%	13.44%	23.85
Sweetened	0.25%	7.29%	0.80%	0.27%	0.00%	0.06%	0.06%	9.90%	29.12
The Grand	0.34%	9.36%	0.58%	0.25%	0.00%	0.02%	0.00%	11.95%	27.83
TJs CBD	0.37%	9.27%	0.49%	0.25%	0.00%	0.08%	0.03%	11.92%	25.09
Umpqua	0.54%	14.01%	0.59%	0.40%	0.00%	0.04%	0.06%	17.71%	26.10
Z 25	0.52%	13.78%	0.63%	0.31%	0.00%	0.03%	0.05%	17.35%	26.63
Overall Mean	**0.36%**	**9.90%**	**0.77%**	**0.30%**	**0.00%**	**0.07%**	**0.03%**	**12.97%**	**27.71**
Site	n. s.	**	***	n. s.	*	n. s.	**	***	***
Cultivar	***	***	***	***	**	***	***	***	***
Site:Cultivar	n. s.	n. s.	***	*	n. s.	n. s.	n. s.	n. s.	n. s.

Table 4. Wet biomass, flowering date, and cannabinoid data from eight cultivars grown only in Geneva, NY. Flowering date is the date that most individuals terminally flowered; if there were two distinct flowering groups two dates are listed. Cannabinoid data from shoot tips sampled five weeks after terminal flowering. Samples were dried at 30% RH for at least 2 weeks prior to milling and cannabinoid quantification by HPLC. None of the cultivars had >0.1% of total THCV or CBL. ^ indicates cultivars with chemotype II and III plants, all others are only chemotype III

Cultivar/ID	Total THC	Total CBD	Total CBC	Total CBG	Total CBDV	Total Cannab-inoids	CBD: THC	Wet Biomass (kg)	Flowering Date(s)
Hot Blonde	0.29%	8.26%	0.45%	0.23%	0.02%	10.50%	28.52	8.4	9/8, 9/14
Cloud Berry	0.32%	9.34%	0.64%	0.43%	0.10%	12.28%	29.27	9.7	9/8, 9/14
Queen Dream	0.37%	10.62%	0.81%	0.37%	0.09%	13.90%	28.85	8.6	9/8, 9/14
Cinderella Story	0.34%	9.25%	0.69%	0.30%	0.10%	12.10%	27.54	10.2	9/8, 9/14
Berry Blossom	0.40%	11.11%	0.61%	0.33%	0.14%	14.30%	27.76	9.0	9/8, 9/14
Cherry Blossom	0.35%	9.96%	0.65%	0.29%	0.14%	12.95%	28.17	10.6	9/8
Merlot	0.35%	10.30%	0.78%	0.37%	0.19%	13.61%	29.12	11.0	9/8, 9/14
Zion^	1.50%	8.16%	0.53%	0.31%	0.26%	12.27%	20.43	9.3	8/31, 9/8

Table 5. Site means for biomass and cannabinoid traits measured for the 32 cultivars trialed at both the Ithaca and Geneva sites. Cannabinoid data from shoot tips sampled five weeks after terminal flowering. Samples were dried at 30% RH for at least 2 weeks prior to milling and cannabinoid quantification by HPLC.

	Ithaca		Geneva		
	Mean	**SE**	**Mean**	**SE**	***p*-value**
Wet Biomass (kg)	6.69	0.24	7.04	0.31	0.59
Dry Biomass (g)	1837.25	69.86	1700.58	79.73	**0.040**
Stripped Biomass (g)	924.45	29.08	887.83	34.65	0.18
% Dry Matter	27.35	0.27	24.16	0.27	**<0.001**
% Stripped Biomass	53.50	1.16	55.64	1.05	**0.007**
Stripped Biomass per Area (g/m^2)	365.69	13.15	320.15	13.04	**<0.001**
Total THC %	0.351	0.010	0.368	0.010	0.08
Total CBD %	9.587	0.260	10.287	0.256	**0.002**
Total CBC %	0.709	0.047	0.845	0.070	**<0.001**
Total CBG %	0.301	0.013	0.308	0.013	0.80
Total THCV %	0.001	0.000	0.002	0.001	**0.048**
Total CBDV %	0.057	0.006	0.084	0.019	0.06
Total CBL %	0.032	0.003	0.024	0.003	**0.007**
Total Cannabinoids %	12.512	0.334	13.513	0.330	**<0.001**
CBD:THC Ratio	27.498	0.233	28.127	0.228	**<0.001**

Impact of Site on Biomass and Cannabinoids

There was a significant effect of site on some of the biomass and cannabinoid measurements (Table 5). For most measurements where there was a significant difference, the magnitude of the difference was very small. For example, there was a significant effect of site on CBD:THC ratio, but the ratio was only 2% higher at the Geneva site than the Ithaca site. Of note, the mean concentration of total cannabinoids was 8% greater and concentration of CBC was 20% greater at the Geneva site as compared to the Ithaca site.

Acknowledgements

We are grateful to the research teams from the L. Smart, C. Smart, Viands, Rose, and Bergstrom labs for their excellent technical assistance on this project, especially Emily McFadden, Lauren Carlson, Colin Day, Garrett Giles, Dr. Heather Grab, Nicholas Kaczmar, Jesse Chavez, Ryan Crawford, Jason Schiller, Johanna Gertin and the farm crews at Cornell AgriTech and the CUAES campus area farms. We are also grateful to Stem Holdings Agri, Sunrise Genetics, Phytonyx, Industrial Seed Innovations, Castetter Sustainability Group, Ryes Creek, Front Range Biosciences, Charlotte's Web, Blue Forest Farms, Wessels' Farm, and Boring Hemp for contributing cultivars. This trial was funded by a sponsored research agreement with Pyxus International and grants from New York State Dept. of Agriculture and Markets through the Empire State Development Corporation.

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