

2021 UW Madison - Wisconsin Hemp Cultivar Trial Cannabinoid Production

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Introduction

Hemp has been legal to grow in Wisconsin since 2018, however, there is still substantial uncertainty regarding agronomic practices and markets, including such basic information as what varieties should be grown. To address this lack of information a replicated high cannabinoid cultivar trial was conducted in the summer of 2021 at the University of Wisconsin Madison Arlington Agricultural Research Station in collaboration with the Midwestern Hemp Database Team. The main objective of the cultivar trial was to obtain data on how high cannabinoid hemp cultivars perform in different upper midwestern locations. Farmers can use this data to help choose the best cultivars to plant, and breeders to decide on key traits in need of improvement. The University of Wisconsin Madison evaluated 29 different hemp cultivars for plant height, uniformity, flowering time, biomass yield, and cannabinoid content in this trial. As a result, the information synthesized from these trials will help refine and expand the existing knowledge base and increase the successful adaptation of hemp as a viable option for Midwestern farmers.



Hemp producers and processors 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. Regulations are subject to change from year to year with the development and approval of proposed program rules. It is important to note that these regulations may vary across state lines and may be impacted by pending federal regulations. In 2021, hemp production was licensed under the WI Department of Agriculture Trade and Consumer Protection (https://datcp.wi.gov/Pages/Programs_Services/Hemp.aspx). In 2022, hemp production is licensed under the U.S Domestic Hemp Production Program. Please see (<https://www.ams.usda.gov/rules-regulations/hemp>) for current rules and regulations regarding hemp production in Wisconsin.

2021 Growing Season

Weather data at the Arlington Agricultural Research Station in Arlington, Wisconsin indicated that June was slightly warmer than average, and July had less than average rainfall (Table 1). The total precipitation was the highest in August (4.18 inches). The lowest precipitation was in the month of October (2.21 inches). Relative humidity was between 59% and 99.5% during the growing season. The soil tests showed that the soil was silt loam texture with 18% sand, 58% silt and 24% clay. Soil organic matter was around 3.5%. The pH was 6.9 where CEC was 13 meq/100g.

Table 1. Average monthly weather data for Arlington, Wisconsin in 2021.

	Jun.	Jul.	Aug.	Sept.	Oct.
Max Average Temp (°F)	82.5	82.5	83.7	76.1	65.5
Average Temp (°F)	71.2	71.2	71.5	63.7	56.0
Min average Temp (°F)	59.9	59.9	59.4	51.2	46.5
Total Precipitation (in)	3.51	1.28	4.18	2.41	2.21
Max RH* (%)	95.1	99.4	99.9	99.8	99.5
Min RH* (%)	45.7	54.3	53.9	46.1	59.0

Data retrieved from National Centers for Environmental Information (NOAA).

*Data retrieved from Enviro-weather formerly Michigan Automated Network (MAWN)



Experimental Location and Design

The hemp cultivar trial was conducted at the University of Wisconsin Madison Arlington Agricultural Research Station. A total of 29 cultivars were evaluated including three day-neutral cultivars and 26 photoperiod-sensitive cultivars. The trial was established as a randomized complete block design with three replications. Day-neutral plots consisted of 12 plants per replication at 1 ft in-row spacing and 5 ft centers. Photoperiod sensitive plots consisted of five plants per replication with 4 ft in-row spacing and 5 ft centers. Photoperiod sensitive feminized seeds were planted on May 10th in the greenhouse and transplanted on June 10th. Day-neutral seeds were planted on May 24th in the greenhouse and transplanted on June 10th. Weeds were managed by hand weeding and cultivation throughout the season. No irrigation or fertilization was applied.

Trait Evaluation

Plant Height

Plant height was measured from the base of the plant to the tip of the tallest inflorescence. Plants were measured when growth stopped at approximately week 5 of flowering. The data collected is reported in inches using the average of 15 plants.

Flowering Time

Flowering data was recorded every week after planting. A cultivar reached 50% flowering when half of the plants showed extruding stigma located at the terminal inflorescence or apical bud/cola (Figure 1). Flowering data is presented as number of days after transplanting.



Figure 1. Flower initiation with a yellow arrow pointing at the extruding stigmas.

Cannabinoid Composition

Approximately 3 inches of floral tissue was collected from the top third of 15 plants for each cultivar. Floral material was sent to Rock River Laboratory (Watertown, WI) for analysis of cannabinoid potency using high-performance liquid chromatography (HPLC). Flower samples were collected at three, five, and seven weeks after the cultivar reached 50% flowering. Total THC = Δ^9 THC + (THCA*0.877), Total CBD = CBD + (CBDA*0.877), Total CBG = CBG + (CBGA*0.878).

Whole Plant Dry Yield and Biomass Yield

One representative plant per replication (three plants per cultivar total) was selected for drying and yield data. Hemp plants were harvested seven weeks after flowering by hand-cutting plants at the base and hanging whole plants in a greenhouse for approximately three weeks. Whole plant dry weight was taken for each plant. Next, each cultivar was stripped to remove flower/bud and leaf matter from the stem. Flower bud and leaf material were then bagged and weighed to estimate floral biomass.

Statistical Analysis of Data

The tables on the following pages have been prepared with the entries listed in alphabetical order. Height, flowering, and yield data were analyzed in R with the program agricolae, with mean separation performed using the Fisher's Protected LSD (Least Significant Difference) test. All analyses used a mixed model with treatment as a fixed effect and replicates as a random effect with an alpha level of 0.05 to determine significance. Cultivars that are within the range of the value listed for LSD are not significantly different from each other at the five percent level of probability.

Results

Several significant differences in flowering date, plant height, whole plant dry weight yield, whole plant wet weight yield, stripped biomass yield, and cannabinoid composition were found for day-neutral cultivars (Table 2, 4, and 5) and photoperiod sensitive cultivars (Table 3, 6, and 7). Many cultivars remained compliant for THC at week 5 after flowering but not at harvest (week 7) (Figure 2). This aligns well within the 30-day testing period granted by the USDA Final Rule. Most cultivars continue to accumulate cannabinoids (THC, CBD, CBG, CBDV) until harvest (Figure 2, 3, 4, and 5). The ratio of CBD to THC ranged from 20:1 to 35:1 (Figure 6).

Table 2. Planting date, average days to flowering, 50% flowering and harvest date for day-neutral cultivars. There is no significant difference between cultivars sharing the same letter assignment.

Cultivar	Source	Planting Date	Av. Flowering (day)	50% Flowering	Harvest Date
Dr. Chunk	Kayagene	6/10/2021	18.67 ^a	6/25/2021	8/19/2021
118 Early Harvest	7-Mile Farms, LLC	6/10/2021	17.33 ^a	6/25/2021	8/19/2021
Auto Blunami	Beacon Hemp	6/10/2021	19.33 ^a	6/25/2021	8/19/2021
Mean			18.44		
LSD (p=0.05)			6.58		



Table 3. Planting date, average days to flowering, 50% flowering and harvest date for photoperiod sensitive cultivars. There is no significant difference between cultivars sharing the same letter assignment. An asterisk indicates there were not enough viable plants to evaluate.

Cultivar	Source	Planting Date	Transplant Date	Avg. Flowering (day)	50% Flowering	Harvest Date
Badger	WCIC	5/10/2021	6/10/2021	61.33 ^{c-i}	8/19/2021	10/7/2021
Bubbatonic	Kayagene	5/10/2021	6/10/2021	57.0 ^{g-j}	8/13/2021	9/30/2021
Buffalo Soldier	KifCure	5/10/2021	6/10/2021	53.0 ^{h-k}	7/30/2021	9/16/2021
Early Cherry	Beacon Hemp	5/10/2021	6/10/2021	62.33 ^{b-i}	8/13/2021	9/30/2021
Early Nueve	Beacon Hemp	5/10/2021	6/10/2021	45.33 ^{jk}	7/23/2021	9/10/2021
Early Remedy	Beacon Hemp	5/10/2021	6/10/2021	59.67 ^{e-i}	8/6/2021	9/23/2021
Forbidden V*	Oregon CBD	5/10/2021	6/10/2021		8/19/2021	10/7/2021
Hot Blonde	Blue Forest Farm	5/10/2021	6/10/2021	74.67 ^{a-c}	8/25/2021	10/14/2021
Lifter	Oregon CBD	5/10/2021	6/10/2021	58.33 ^{g-j}	8/6/2021	9/23/2021
Lifter Seedless	Oregon CBD	5/10/2021	6/10/2021	69.67 ^{a-g}	8/19/2021	10/7/2021
Oregon Guava	East Fork Cultivars	5/10/2021	6/10/2021	74.0 ^{a-d}	8/19/2021	10/7/2021
Oregon Sweetgum	East Fork Cultivars	5/10/2021	6/10/2021	67.67 ^{a-g}	8/19/2021	10/7/2021
Panakeia	Tesoro Genetics	5/10/2020	6/10/2021	42.0 ^k	7/23/2021	9/10/2021
Pine Walker*	Oregon CBD	5/10/2021	6/10/2021		8/19/2021	10/7/2021
Queen Dream	Blue Forest Farms	5/10/2021	6/10/2021	72.67 ^{a-e}	8/19/2021	10/7/2021
Rogue	Arcadia	5/10/2021	6/10/2021	73.0 ^{a-e}	8/25/2021	10/14/2021
Santiam	Arcadia	5/10/2021	6/10/2021	71.67 ^{a-f}	8/19/2021	10/7/2021
71x71	Industrial Hemp Genetics	5/10/2021	6/10/2021	71.0 ^{a-f}	8/19/2021	10/7/2021
Cultivar 1	Trilogene Seeds	5/10/2021	6/10/2021	75.67 ^{ab}	8/25/2021	10/14/2021
Suver Haze	Oregon CBD	5/10/2021	6/10/2021	60.67 ^{d-i}	8/13/2021	9/30/2021
Suver Haze Seedless	Oregon CBD	5/10/2021	6/10/2021	70.33 ^{a-g}	8/19/2021	10/7/2021
Tahiti Green	Infinite Tree	5/10/2021	6/10/2021	65.0 ^{a-h}	8/13/2021	9/30/2021
Cultivar 2	Trilogene Seeds	5/10/2021	6/10/2021	76.67 ^a	8/25/2021	10/14/2021
Umpqua	Arcadia	5/10/2021	6/10/2021	50.33 ^{i-k}	8/6/2021	9/23/2021
White CBG	Oregon CBD	5/10/2021	6/10/2021	49.67 ^{i-k}	7/23/2021	9/10/2021
White CBG Seedless*	Oregon CBD	5/10/2021	6/10/2021		8/13/2021	9/30/2021
Mean				63.55		
LSD (p=0.05)				13.98		

Table 4. Plant height, wet whole plant weight, dry whole plant weight and stripped biomass for day-neutral cultivars. There is no significant difference between cultivars sharing the same letter assignment.

Cultivar	Source	Plant Height (in)	Wet Whole Plant Weight (lb)	Dry Whole Plant Weight (lb)	Stripped Biomass (lb)
Dr. Chunk	Kayagene	16.67 ^a	0.60 ^a	0.2 ^a	0.17 ^a
118 Early Harvest	7-Mile Farms, LLC	12.67 ^b	0.77 ^a	0.2 ^a	0.17 ^a
Auto Blunami	Beacon Hemp	19.33 ^a	1.37 ^a	0.4 ^a	0.33 ^a
Mean		16.22	0.91	0.27	0.22
LSD (p=0.05)		3.69	1.08	0.34	0.26

Table 5. Cannabinoid composition for day-neutral cultivars at 7 weeks after flowering. Red indicates cultivars with more than 0.3% THC.

Cultivar	Source	CBD (%)	CBG (%)	CBDV (%)	THC (%)
Dr. Chunk	Kayagene	7.43	0.30	0.17	0.33
118 Early Harvest	7-Mile Farms, LLC	6.38	0.32	0.17	0.31
Auto Blunami	Beacon Hemp	6.33	0.40	0.17	0.28

Table 6. Plant height, dry whole plant weight and stripped biomass for photoperiod sensitive cultivars. There is no significant difference between cultivars sharing the same letter assignment. An asterisk indicates there were not enough viable plants to evaluate.

Cultivar	Source	Plant Height (in)	Dry Whole Plant Weight (lb)	Stripped Biomass (lb)
Badger	WCIC	54.33 ^{a-e}	3.20 ^{ab}	1.53 ^a
Bubbatonic	Kayagene	62.67 ^{a-c}	4.93 ^a	2.20 ^a
Buffalo Soldier	KifCure	37.67 ^e	2.93 ^{ab}	1.10 ^a
Early Cherry	Beacon Hemp	46.33 ^{a-e}	3.17 ^{ab}	2.03 ^a
Early Nueve	Beacon Hemp	43.67 ^{b-e}	2.30 ^{ab}	1.37 ^a
Early Remedy	Beacon Hemp	47.0 ^{a-e}	3.53 ^{ab}	1.83 ^a
Forbidden V*	Oregon CBD			
Hot Blonde	Blue Forest Farm	50.0 ^{a-e}	3.97 ^{ab}	2.20 ^a
Lifter	Oregon CBD	42.0 ^{c-e}	3.40 ^{ab}	2.20 ^a
Lifter Seedless	Oregon CBD	65.33 ^a	4.03 ^{ab}	1.80 ^a
Oregon Guava	East Fork Cultivars	56.33 ^{a-e}	3.77 ^{ab}	1.77 ^a
Oregon Sweetgum	East Fork Cultivars	64.33 ^{ab}	3.37 ^{ab}	1.90 ^a
Panakeia	Tesoro Genetics	49.67 ^{a-e}	2.03 ^b	1.40 ^a
Pine Walker*	Oregon CBD			
Queen Dream	Blue Forest Farms	57.33 ^{a-e}	3.53 ^{ab}	1.53 ^a
Rogue	Arcadia	62.33 ^{a-c}	4.33 ^{ab}	1.77 ^a
Santiam	Arcadia	60.0 ^{a-c}	3.63 ^{ab}	1.53 ^a
71x71	Industrial Hemp Genetics	44.67 ^{a-e}	3.17 ^{ab}	1.70 ^a
Cultivar 1	Trilogene Seeds	57.67 ^{a-e}	4.27 ^{ab}	1.93 ^a
Suver Haze	Oregon CBD	60.67 ^{a-c}	4.56 ^{ab}	2.57 ^a
Suver Haze Seedless	Oregon CBD	59.33 ^{a-d}	3.80 ^{ab}	2.07 ^a
Tahiti Green	Infinite Tree	60.33 ^{a-c}	4.43 ^{ab}	2.43 ^a
Cultivar 2	Trilogene Seeds	52.67 ^{a-e}	3.77 ^{ab}	1.77 ^a
Umpqua	Arcadia	56.0 ^{a-e}	3.23 ^{ab}	2.13 ^a
White CBG	Oregon CBD	38.33 ^{de}	2.63 ^{ab}	1.33 ^a
White CBG Seedless*	Oregon CBD			
Mean		53.42	3.57	1.83
LSD (p=0.05)		21.38	2.70	1.63

Table 7. Cannabinoid composition for photoperiod sensitive cultivars at 5 weeks after flowering. Green indicates cultivars with more than 8% CBD, blue indicates cultivars with more than 4% CBG, orange indicates cultivars with more than 1% CBDV, and red indicates cultivars with more than 0.3% THC.

Cultivar	Source	CBD (%)	CBG (%)	CBDV (%)	THC (%)
Badger	WCIC	5.98	0.24	0.13	0.18
Bubbatonic	Kayagene	9.13	0.30	0.10	0.34
Buffalo Soldier	KifCure	0.01	6.01	0.03	0.03
Early Cherry	Beacon Hemp	10.11	0.64	0.07	0.37
Early Nueve	Beacon Hemp	8.02	0.71	0.11	0.36
Early Remedy	Beacon Hemp	5.11	1.37	0.04	0.18
Forbidden V	Oregon CBD	2.18	0.11	1.81	0.05
Hot Blonde	Blue Forest Farm	7.93	0.27	0.04	0.29
Lifter	Oregon CBD	8.53	0.38	0.10	0.32
Lifter Seedless	Oregon CBD	7.43	0.25	0.07	0.27
Oregon Guava	East Fork Cultivars	5.80	0.18	0.04	0.19
Oregon Sweetgum	East Fork Cultivars	8.19	0.35	0.09	0.30
Panakeia	Tesoro Genetics	0.02	7.18	0.04	0.02
Pine Walker	Oregon CBD	1.92	0.14	2.08	0.04
Queen Dream	Blue Forest Farms	7.02	0.32	0.04	0.24
Rogue	Arcadia	8.14	0.58	0.12	0.32
Santiam	Arcadia	5.06	0.38	0.03	0.19
71x71	Industrial Hemp Genetics	6.93	0.26	0.06	0.24
Cultivar 1	Trilogene Seeds	6.51	0.14	0.12	0.23
Suver Haze	Oregon CBD	10.30	0.31	0.09	0.37
Suver Haze Seedless	Oregon CBD	11.39	0.51	0.14	0.44
Tahiti Green	Infinite Tree	8.33	0.25	0.16	0.30
Cultivar 2	Trilogene Seeds	6.63	0.15	0.06	0.23
Umpqua	Arcadia	7.31	0.21	0.07	0.27
White CBG	Oregon CBD	0.02	6.97	0.05	0.05
White CBG Seedless	Oregon CBD	0.02	8.30	0.03	0.04

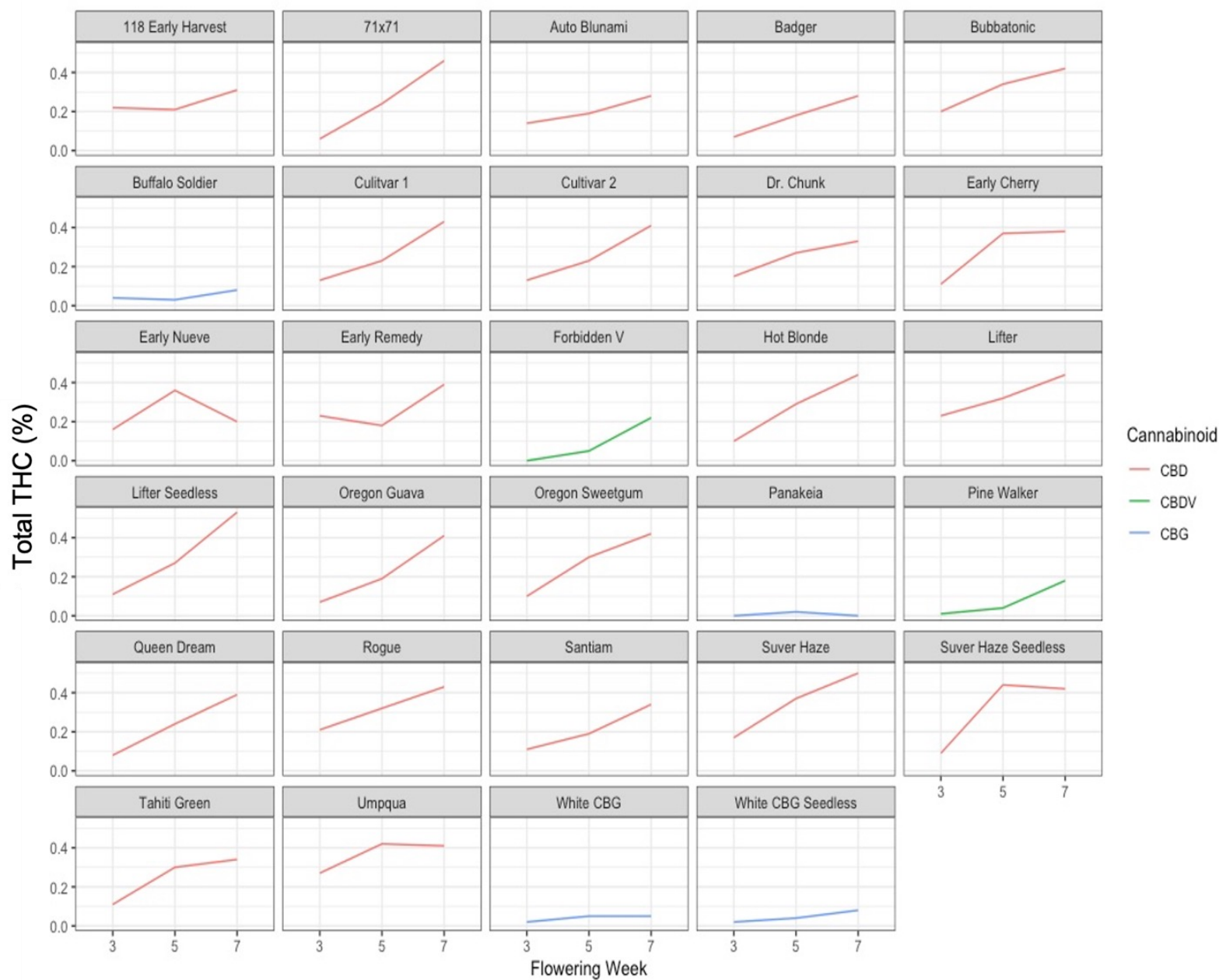
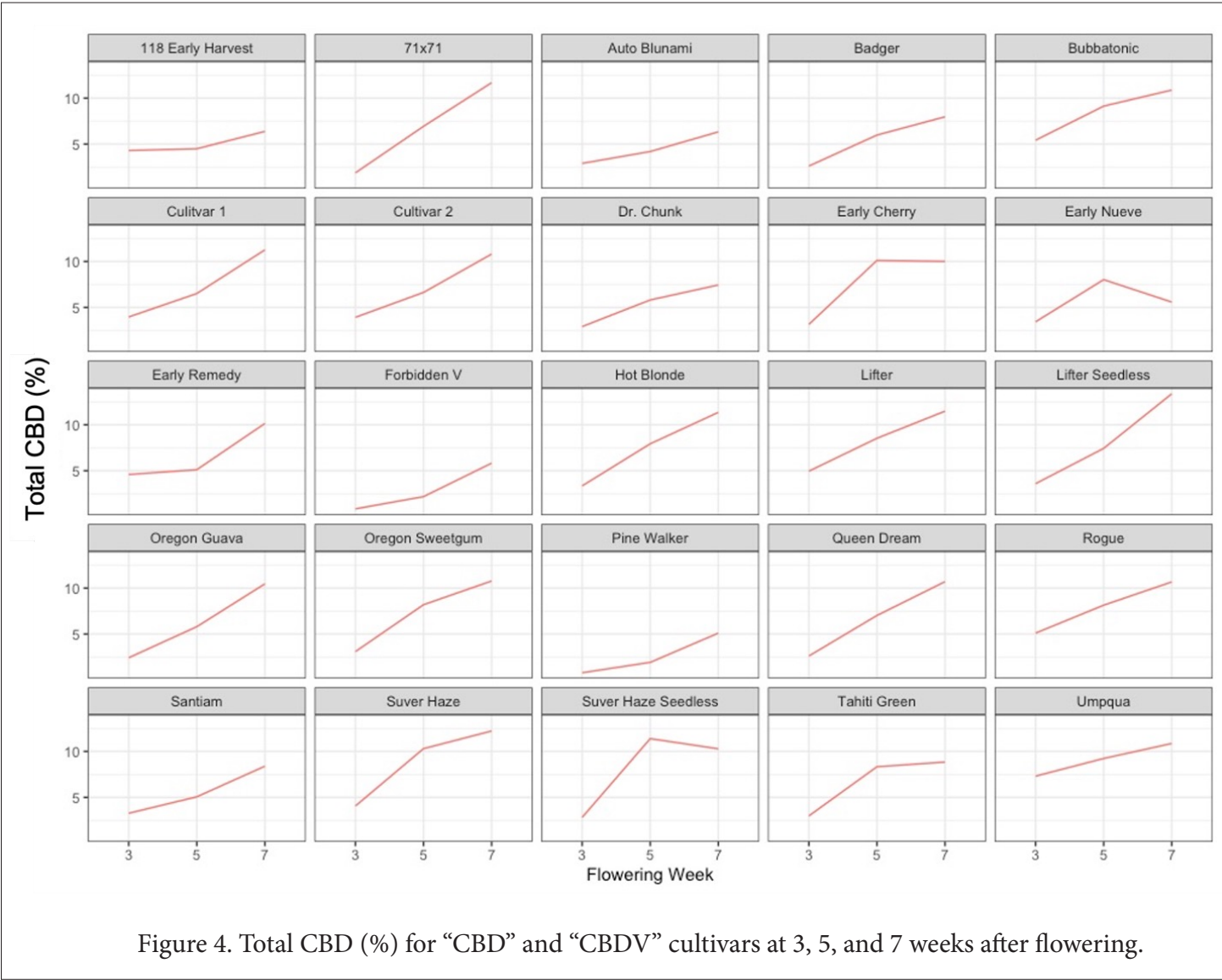
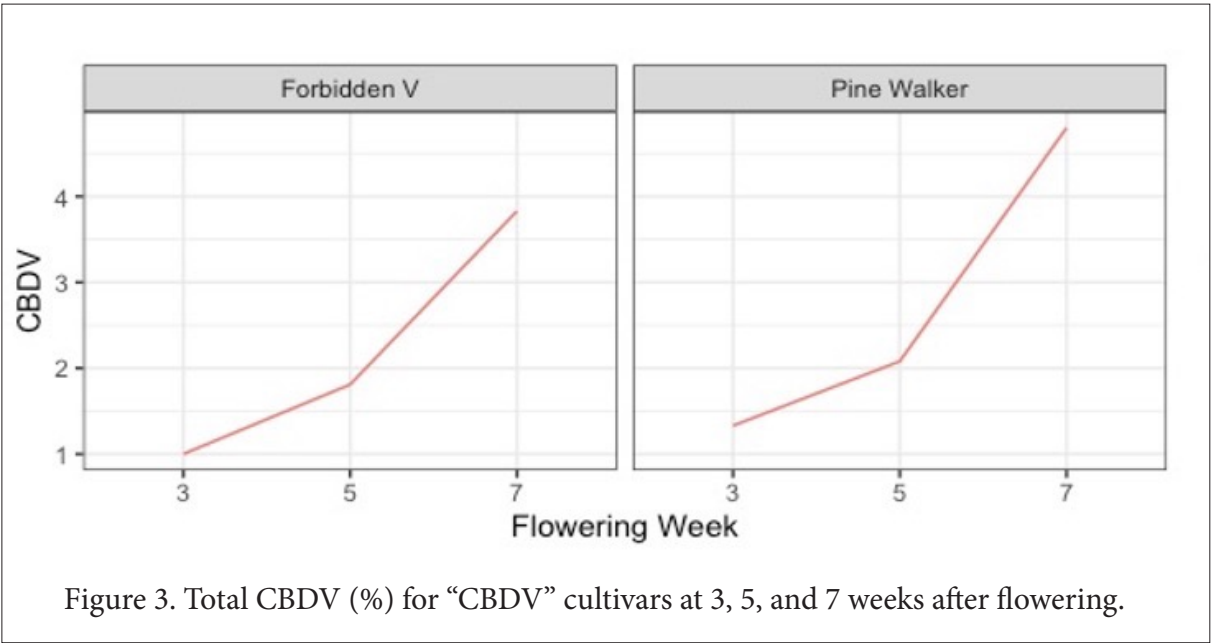


Figure 2. Total THC (%) for “CBG” (blue), “CBD” (red), and “CBDV” (green) cultivars at 3, 5, and 7 weeks after flowering.



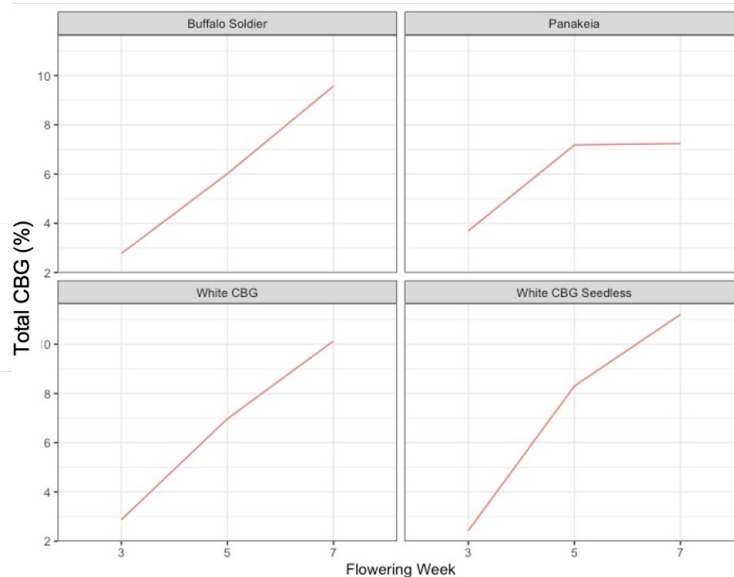


Figure 5. Total CBG (%) for “CBG” cultivars at 3, 5, and 7 weeks after flowering.

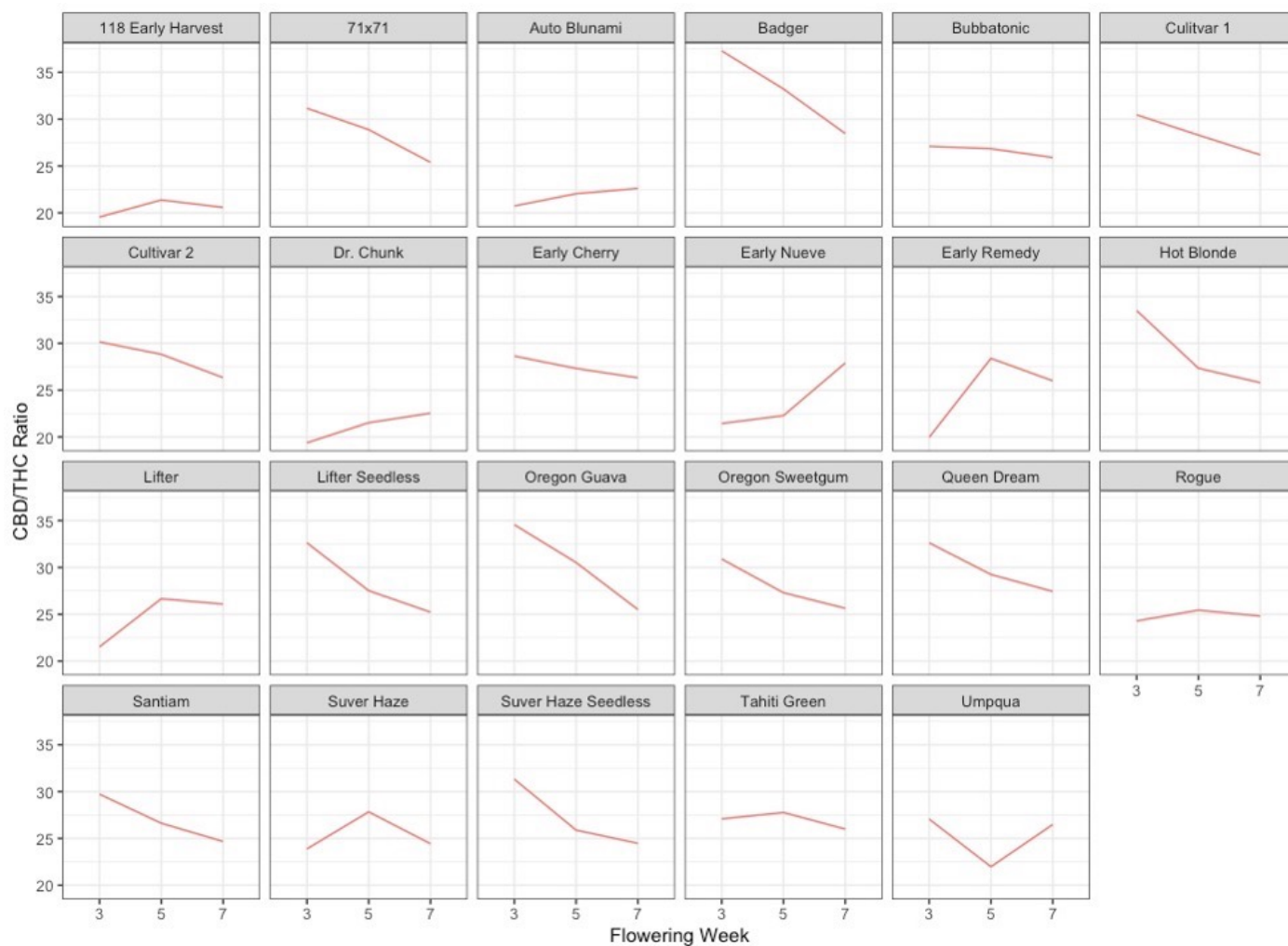


Figure 6. Total CBD (%) for “CBD” and “CBDV” cultivars at 3, 5, and 7 weeks after flowering.

Recommendations

The Midwest Hemp Database project uses the following criteria to identify CBD hemp cultivars with “good potential” in our region:

- Minimum of 15 distinct samples submitted for each source*cultivar combination
- Flowering initiated prior to August 30th
- Average Total THC for all samples below .3%
- Average Total CBD for all samples above 5%
- CBD:THC > 25

We encourage everyone to access the [Midwestern Hemp Database](#) for the best information available on high cannabinoid hemp cultivar performance in the Midwest.

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