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2020 UW Madison - Wisconsin Hemp Cultivar Trial

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Introduction

The practice of growing industrial hemp in Wisconsin terminated in the 1950s after decades of serving as an important crop for the region. The rebirthed hemp industry is seeing a dramatic increase in producers, but there is still substantial uncertainty regarding agronomic practices and markets, including such basic information as what cultivars grow well in the region. To address this lack of information a replicated CBD/CBG cultivar trial was conducted in the summer of 2020 at the University of Wisconsin, Madison Arlington Agricultural Research Station, Michael Fields Agricultural Institute (MFAI) and Michigan State University UPREC-Chatham. The main objective of the cultivar trial was to obtain data on how currently available 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. At the University of Wisconsin, Madison location, 44 different hemp cultivars were evaluated for plant height, uniformity, flowering time, biomass yield, and cannabinoid content. As a result, the information synthesized from these trials will help refine and expand the knowledge base and increase the successful adaptation of hemp as a viable option for Midwestern farmers.

Hemp producers and processers 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 the 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. Please refer to the Department of Agricultural, Trade, and Consumer Protection Hemp Research Program (https://hemp.wi.gov) for rules and regulations regarding producing hemp in the state of Wisconsin.

Experimental Location and Design

The hemp cultivar trial was conducted at the University of Wisconsin, Madison Arlington Agricultural Research Station. A total of 44 cultivars were evaluated including 4 day-neutral (autoflowering) cultivars, 22 transplanted seedling cultivars, and 14 transplanted clonal cultivars. The trial was established as a randomized complete block design with three replications. Day-neutral plots consisted of 12 plants per rep at 1 ft in-row spacing and 9 ft centers. Photoperiod sensitive plots consisted of six plants per rep with 4 ft in-row spacing and 9 ft centers. Feminized seeds for the seedling trial were planted on May 12th, 2020 and transplanted on June 15th, 2020. Clones were transplanted on June 23th, 2020. Feminized day-neutral cultivars were direct seeded on June 25th, 2020. No additional fertility or irrigation was added. Weeds were managed by hand weeding and cultivation throughout the season.

2020 Growing Season

Weather data at the Arlington Agricultural Research Station in Arlington, Wisconsin indicated that the average max temperature was observed in July (74.2˚F) and the lowest average temperature was observed in October (44.1˚F) (Table 1). The total precipitation was the highest in July (5.39 inches). The lowest precipitation was in the month of August (3.58 inches). Relative humidity was between 41.5% and 98% during the growing season. The soil tests showed that the soil was silty clay loam twexture with 15% sand, 58% silt and 27% clay. Soil organic matter was approximately 2.9%. The pH was 6.6 where CEC was 11 meq/100g.

Table 1. Average monthly weather data for Arlington, Wisconsin in 2020

	Jun.	Jul.	Aug.	Sept.	Oct.
Average Temp (˚F)	68.7	74.2	69.6	59.6	44.1
Total Precipitation (in)	4.37	5.39	3.58	4.34	4.00
Max RH* (%)	95.3	97.9	98	97.9	96.6
Min RH* (%)	51	54.7	52.4	57.4	41.5

Data retrieved from National Centers for Environmental Information (NOAA)
*Data retrieved from Enviro-weather formerly Michigan Automated Network (MAWN)

Trait Evaluation

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 top 1/3 of the plant (Figure 1). Flowering data is presented as number of days after transplanting for clones and seedlings and direct planting for day-neutral types.

Figure 1. Flower initiation with yellow arrows pointing at the extruding stigma.

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 was collected in cm and is reported in inches using the average of 18 plants for seedling and clonal cultivars and 10 plants for day-neutral cultivars.

Cannabinoid Composition

Approximately 3 inches of floral tissue was collected from the top third of 14-18 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 seven weeks after the cultivar reached 50% flowering. THC is calculated using the equation: Total THC = THC + (THCa*0.877).

Whole Plant Dry Yield and Biomass Yield

One representative plant per replication was selected for drying and yield data for a total of three plants per cultivar. Hemp plants were harvested after seven weeks of flowering by hand-cutting plants at the base and hanging whole plants in a greenhouse for approximately three weeks. The resulting plants had between 10% and 15% moisture content. Whole plant dry weight was taken for each plant. Next, each cultivar was stripped to remove flower and leaf matter from the stem. Flower and leaf material were then bagged and weighed.

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 separations 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 same letter range as determined by the value listed for LSD are not significantly different from each other at the five percent level of probability.

Results

Significant differences in flowering date, plant height, whole plant dry weight yield, stripped biomass yield, cannabinoid composition and survivability were found for day-neutral cultivars (Table 2, 5, Figure 2), clonally propagated cultivars (Table 3, 6, and Figure 2) and seed propagated cultivars (Table 4, 7, and Figure 2).

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

Cultivar	Source	Planting Date	Av. Flowering (day)	50% Flowering	Harvest Date
199ENO	Beacon Hemp	6/25/2020	**40.5[a]**	8/3/2020	9/21/2020
Maverick	Kayagene	6/25/2020	**34.1[a]**	7/23/2020	9/14/2020
Pipeline	Kayagene	6/25/2020	**38.4[a]**	7/24/2020	9/14/2020
Socati	Boring Hemp	6/25/2020	**37.9[a]**	7/25/2020	9/14/2020
Mean			38.2		
LSD (p=0.05)			7.5		

Table 3. Planting date, average days to flowering, 50% flowering and harvest date for cultivars produced by clonal propagation (clones). Values in bold indicate the earliest flowering cultivars. There is no significant difference between cultivars sharing the same letter assignment.

Cultivar	Source	Transplanting Date	Av. Flowering (day)	50% Flowering	Harvest Date
Anna Lee	Front Range Biosciences	6/23/2020	60.5[bc]	8/17/2020	10/5/2020
CJ2	Sunrise Genetics	6/23/2020	41.4[d]	8/3/2020	9/21/2020
FL49	Sunrise Genetics	6/23/2020	66.0[b]	8/24/2020	10/12/2020
FL58	Sunrise Genetics	6/23/2020	66.6[ab]	8/24/2020	10/12/2020
FL70	Sunrise Genetics	6/23/2020	66.5[b]	8/24/2020	10/12/2020
FL71	Sunrise Genetics	6/23/2020	74.0[a]	8/31/2020	10/19/2020
FL80	Sunrise Genetics	6/23/2020	74.0[a]	8/31/2020	10/19/2020
Hybrid 5	Front Range Biosciences	6/23/2020	**40.9[de]**	7/27/2020	9/14/2020
Hybrid 9	Front Range Biosciences	6/23/2020	58.3[c]	8/17/2020	10/5/2020
Panakeia	Front Range Biosciences	6/23/2020	**33.7[e]**	7/20/2020	9/7/2020
Pure CBD	PureGene	6/23/2020	58.3[c]	8/24/2020	10/12/2020
Pure CBG	Front Range Biosciences	6/23/2020	53.6[c]	8/10/2020	9/28/2020
Pure CBG	PureGene	6/23/2020	54.7[c]	8/10/2020	9/28/2020
SB1	Sunrise Genetics	6/23/2020	44.4[d]	8/3/2020	9/21/2020
Mean			56.6		
LSD (p=0.05)			7.4		

Table 4. Planting date, average days to flowering, 50% flowering and harvest date for cultivars produced by seed propagation (seedlings). Values in bold indicate the earliest flowering cultivars. There is no significant difference between cultivars sharing the same letter assignment.

Cultivar	Source	Planting Date	Transplant Date	Av. Flowering (day)	50% Flowering	Harvest Date
198 MUY	Beacon Hemp	5/12/2020	6/15/2020	57.4^{d-i}	8/10/2020	9/28/2020
202 EVY	Beacon Hemp	5/12/2020	6/15/2020	**42.4^{j}**	8/3/2020	9/21/2020
Angie*	Front Range Biosciences	unknown	6/23/2020	55.7^{f-i}	8/10/2020	9/28/2020
BaOx Hybrid	Infinite Tree	5/12/2020	6/15/2020	58.1^{d-h}	8/10/2020	9/28/2020
Buffalo Soldier	KifCure	5/12/2020	6/15/2020	52.0^{hi}	8/3/2020	9/21/2020
C2 (Stellar Cherry)	Boring Hemp	5/12/2020	6/15/2020	76.4^{a}	8/31/2020	10/19/2020
Cherry Wine S1	Eastern Plains Hemp	5/12/2020	6/15/2020	66.4^{bc}	8/17/2020	10/5/2020
CWS1 x EPG	Eastern Plains Hemp	5/12/2020	6/15/2020	58.2^{d-g}	8/10/2020	9/28/2020
Eighty Eight	Davis Farms of Oregon	5/12/2020	6/15/2020	62.9^{d-b}	8/17/2020	10/5/2020
EPG	Eastern Plains Hemp	5/12/2020	6/15/2020	56.7^{e-i}	8/3/2020	9/21/2020
FL71	Sunrise Genetics	5/12/2020	6/15/2020	80.0^{a}	8/31/2020	10/19/2020
Florence	Infinite Tree	5/12/2020	6/15/2020	61.0^{c-f}	8/10/2020	9/28/2020
Hempress 3	Seedified	5/12/2020	6/15/2020	51.8^{i}	8/3/2020	9/21/2020
Hot Blonde	Blue Forest Farms	5/12/2020	6/15/2020	58.7^{d-g}	8/10/2020	9/28/2020
Hybrid 5*	Front Range Biosciences	unknown	6/23/2020	60.4^{c-f}	8/10/2020	9/28/2020
OTTO II	KifCure	5/12/2020	6/15/2020	57.1^{d-i}	8/3/2020	9/21/2020
Painted Lady	Davis Farms of Oregon	5/12/2020	6/15/2020	66.0^{bc}	8/17/2020	10/5/2020
Prairie Wine	Eastern Plains Hemp	5/12/2020	6/15/2020	60.6^{c-f}	8/10/2020	9/28/2020
Pure CBD lite*	PureGene	unknown	6/23/2020	65.5^{bc}	8/27/2020	10/5/2020
Pure CBG*	PureGene	unknown	6/23/2020	55.9^{f-i}	8/3/2020	9/21/2020
Queen Dream	Blue Forest Farms	5/12/2020	6/15/2020	62.6^{b-e}	8/10/2020	9/28/2020
Ruby 1	Green Lynx Farms	5/12/2020	6/15/2020	58.2^{d-g}	8/3/2020	9/21/2020
Silver Lining	Eastern Plains Hemp	5/12/2020	6/15/2020	68.5^{b}	8/24/2020	10/12/2020
Stormy	Blue Forest Farms	5/12/2020	6/15/2020	55.9^{f-i}	8/3/2020	9/21/2020
T1	Green Lynx Farms	5/12/2020	6/15/2020	52.7^{g-i}	8/3/2020	9/21/2020
The Grand	Boring Hemp	5/12/2020	6/15/2020	60.9^{c-f}	8/10/2020	9/28/2020
Mean				60.1		
LSD (p=0.05)				6.1		

*Indicates samples that were sent as seedling liners and planted 8 days later.

Table 5. Plant height, dry whole plant weight, striped biomass and cannabinoid composition for day-neutral cultivars. Values in bold indicate the largest and highest yielding cultivars. There is no significant difference between cultivars sharing the same letter assignment. Green indicates cultivars with more than 8% CBD, blue indicates cultivars with more than 4% CBG, and red indicates cultivars with more than 0.4% THC (non-compliant in Wisconsin in 2020).

Cultivar	Source	Plant Height (in)	Dry Whole Plant Weight (lb)	Stripped Biomass (lb)	CBD (%)	CBG (%)	THC (%)	CBD:THC Ratio
199ENO	Beacon Hemp	**24.1^{a}**	**0.40^{ab}**	**0.31^{ab}**	4.40	0.27	0.20	22.00
Maverick	Kayagene	**25.8^{a}**	**0.73^{a}**	**0.62^{a}**	6.98	0.34	0.26	26.85
Pipeline	Kayagene	**22.7^{a}**	0.24^{b}	0.21^{b}	4.69	0.20	0.21	22.33
Socati	Boring Hemp	**19.0^{a}**	0.37^{b}	0.29^{b}	5.44	0.30	**0.59**	9.22
Mean		22.9	0.42	0.35				
LSD (p=0.05)		8.3	0.35	0.31				

Table 6. Plant height, dry whole plant weight, striped biomass and cannabinoid composition for clonally propagated (clone) cultivars. Values in bold indicate the largest and highest yielding cultivars. There is no significant difference between cultivars sharing the same letter assignment. Green indicates cultivars with more than 8% CBD, blue indicates cultivars with more than 4% CBG, and red indicates cultivars with more than 0.4% THC (non-compliant in Wisconsin in 2020).

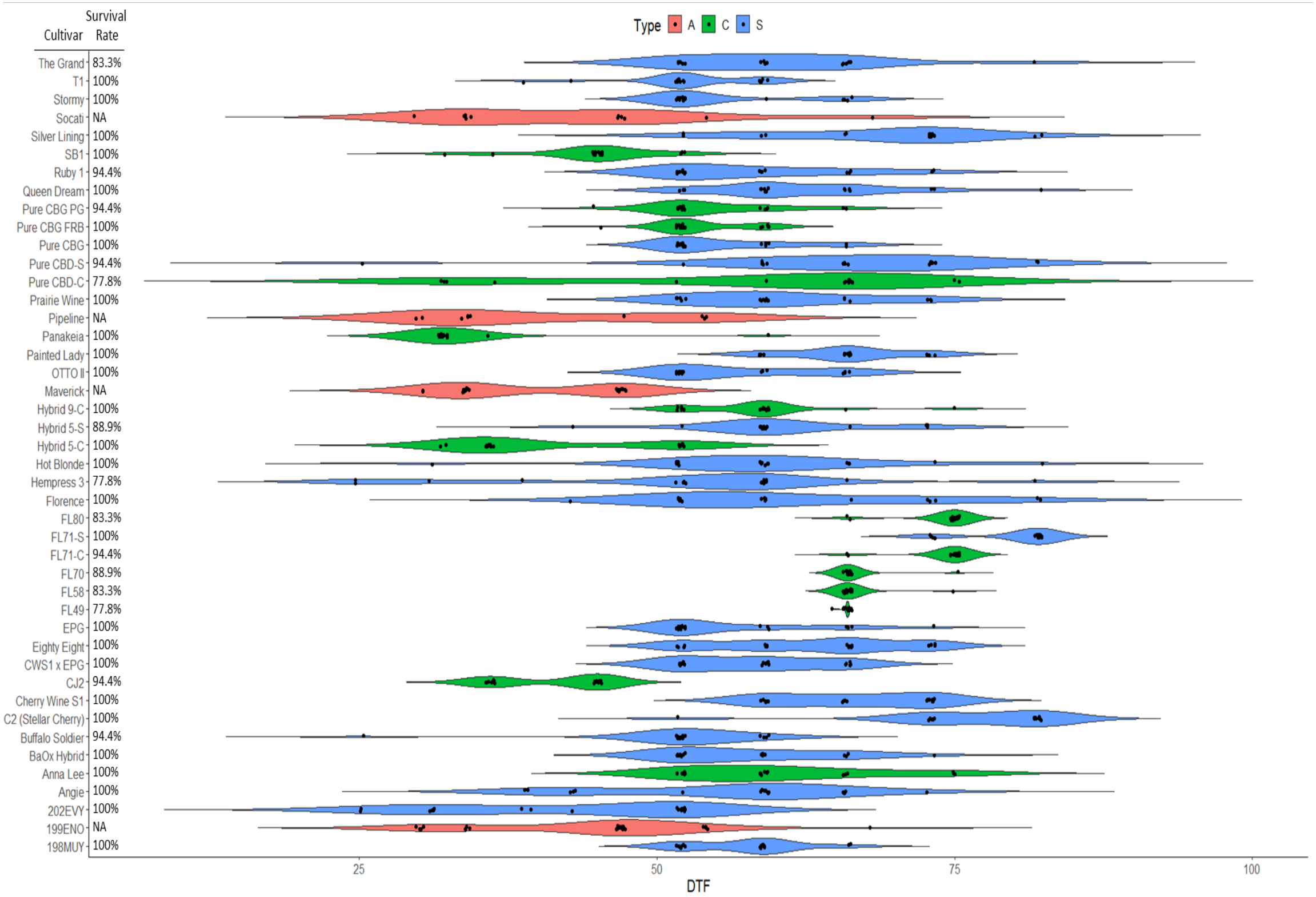
Cultivar	Source	Plant Height (in)	Dry Whole Plant Weight (lb)	Stripped Biomass (lb)	CBD (%)	CBG (%)	THC (%)	CBD:THC Ratio
Anna Lee	Front Range Biosciences	**35.2^{ab}**	**1.5^{a-e}**	0.9^{b-e}	**8.15**	0.44	0.26	31.35
CJ2	Sunrise Genetics	33.6^{bc}	1.2^{ef}	0.8^{c-e}	**8.96**	0.58	0.34	26.35
FL49	Sunrise Genetics	26.7^{g}	1.0^{ef}	0.7de	**11.80**	0.26	**0.41**	28.78
FL58	Sunrise Genetics	23.5^{gh}	1.3^{d-f}	0.9^{b-e}	**10.10**	0.44	0.35	28.86
FL70	Sunrise Genetics	27.8^{ef}	1.4^{b-e}	0.6^{e}	**13.70**	0.55	**0.48**	28.54
FL71	Sunrise Genetics	28.0^{d-f}	**1.8^{a-c}**	0.9^{b-e}	**9.76**	0.23	0.33	29.58
FL80	Sunrise Genetics	31.4^{cd}	1.3^{d-f}	0.6^{e}	**9.26**	0.43	0.32	28.94
Hybrid 5	Front Range Biosciences	20.6^{h}	0.7^{f}	0.8^{c-e}	5.09	0.23	0.19	26.79
Hybrid 9	Front Range Biosciences	28.2^{d-f}	**1.5^{a-e}**	**1.0^{a-c}**	8.82	0.40	0.30	29.4
Panakeia	Front Range Biosciences	**37.9^{a}**	1.3^{c-e}	0.7^{c-e}	0.00	**6.44**	0.03	0.00
Pure CBD	PureGene	29.3^{d-f}	**1.9^{ab}**	**1.2^{ab}**	**11.43**	0.61	0.38	30.08
Pure CBG	Front Range Biosciences	30.8^{c-e}	**2.0^{a}**	**1.3^{a}**	0.00	3.35	0.04	0.00
Pure CBG	PureGene	26.5^{fg}	**1.8^{a-d}**	**0.9^{a-d}**	0.00	2.68	0.03	0.00
SB1	Sunrise Genetics	30.8^{c-e}	**1.5^{a-e}**	**1.0^{a-c}**	6.34	0.29	0.24	26.42
Mean		29.1	1.5	0.9				
LSD (p=0.05)		3.4	0.7	0.4				

Table 7. Plant height, dry whole plant weight, striped biomass and cannabinoid composition for seed propagated (seedling) cultivars. Values in bold indicate the largest and highest yielding cultivars. There is no significant difference between cultivars sharing the same letter assignment. Green indicates cultivars with more than 8% CBD, blue indicates cultivars with more than 4% CBG, and red indicates cultivars with more than 0.4% THC (non-compliant in Wisconsin in 2020).

Cultivar	Source	Plant Height (in)	Dry Whole Plant Weight (lb)	Stripped Biomass (lb)	CBD (%)	CBG (%)	THC (%)	CBD:THC Ratio
198 MUY	Beacon Hemp	51.7^{d-g}	3.5^{b-f}	**2.2^{ab}**	**12.89**	0.54	**0.44**	29.30
202 EVY	Beacon Hemp	50.5^{g-h}	2.9^{e-h}	**1.8^{a-e}**	**8.07**	0.48	0.32	25.22
Angie*	Front Range Biosciences	42.7^{i-k}	1.0^{j}	0.4^{i}	5.59	0.10	0.22	25.41
BaOx Hybrid	Infinite Tree	54.8^{c-f}	3.9^{b-e}	1.3^{d-h}	6.98	0.39	0.28	24.93
Buffalo Soldier	KifCure	54.3^{d-g}	3.1^{e-g}	**1.7^{a-e}**	0.57	**4.25**	0.23	2.48
C2 (Stellar Cherry)	Boring Hemp	45.8^{h-j}	3.7^{b-e}	**1.8^{a-e}**	**10.72**	0.20	0.37	28.97
Cherry Wine S1	Eastern Plains Hemp	53.3^{c-g}	**3.7^{a-d}**	1.6^{b-f}	7.29	0.37	0.27	27.00
CWS1 x EPG	Eastern Plains Hemp	57.4^{b-d}	4.1^{b-e}	**1.9^{a-d}**	5.69	0.64	0.20	28.45
Eighty Eight	Davis Farms of Oregon	**63.3^{a}**	3.5^{b-f}	1.6^{b-f}	6.94	0.29	0.23	30.17
EPG	Eastern Plains Hemp	**58.1^{a-c}**	**4.5^{a-c}**	**2.3^{a}**	7.67	0.68	**0.57**	13.46
FL71	Sunrise Genetics	42.2^{jk}	2.4^{f-i}	1.0^{f-i}	6.74	0.14	0.24	28.08
Florence	Infinite Tree	**58.1^{a-c}**	**5.4^{a}**	**2.1^{a-c}**	5.95	0.42	0.19	31.32
Hempress 3	Seedified	49.7^{f-h}	**4.6^{ab}**	**2.2^{ab}**	7.41	0.43	0.30	24.70
Hot Blonde	Blue Forest Farms	51.2^{e-h}	3.2^{d-g}	1.5^{c-g}	6.80	0.10	0.26	26.15
Hybrid 5*	Front Range Biosciences	39.6^{k}	1.5^{ij}	0.9^{hi}	**9.04**	0.35	0.37	24.43
OTTO II	KifCure	48.3^{g-i}	4.0^{b-e}	**1.8^{a-e}**	2.11	0.16	0.09	23.44
Painted Lady	Davis Farms of Oregon	**61.2^{ab}**	3.3^{c-f}	**1.8^{a-e}**	7.22	0.34	0.25	28.88
Prairie Wine	Eastern Plains Hemp	56.4^{b-e}	4.1^{b-e}	**1.9^{a-d}**	7.24	0.12	0.27	26.81
Pure CBD*	PureGene	49.7^{f-h}	1.8^{h-j}	0.9^{g-i}	**11.13**	0.42	**0.41**	27.15
Pure CBG*	PureGene	50.3^{f-h}	2.1^{gj}	1.3^{e-h}	0.00	**4.52**	0.09	0.00
Queen Dream	Blue Forest Farms	54.7^{c-f}	3.4^{bf}	**1.7^{a-e}**	6.52	0.24	0.22	29.64
Ruby 1	Green Lynx Farms	54.2^{c-f}	3.7^{b-e}	1.5^{c-h}	6.15	0.41	0.24	25.63
Silver Lining	Eastern Plains Hemp	**63.3^{a}**	**4.6^{ab}**	**1.8^{a-e}**	**12.19**	0.58	**0.40**	30.475
Stormy	Blue Forest Farms	54.4^{c-f}	3.7^{b-e}	**1.8^{a-e}**	3.81	0.31	0.15	25.40
T1	Green Lynx Farms	**60.7^{ab}**	**4.6^{ab}**	**2.1^{a-c}**	6.61	0.42	0.22	30.05
The Grand	Boring Hemp	41.7^{jk}	1.5^{ij}	1.3^{d-h}	**8.18**	0.30	0.29	28.21
Mean		52.5	3.4	1.6				
LSD (p=0.05)		5.7	1.3	0.7				

*Indicates samples that were sent as seedling liners and planted 8 days later.

Figure 2. Distribution of days to flowering (DTF) for each of the 44 cultivars. Day neutrals are shown in red, clones are shown in green and seedlings are shown in blue. Survival rate is indicated as the percentage of plants that survived until harvest for a given cultivar.



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