

Hemp Production

**Dr. Heather Darby, Agronomist
University of Vermont**

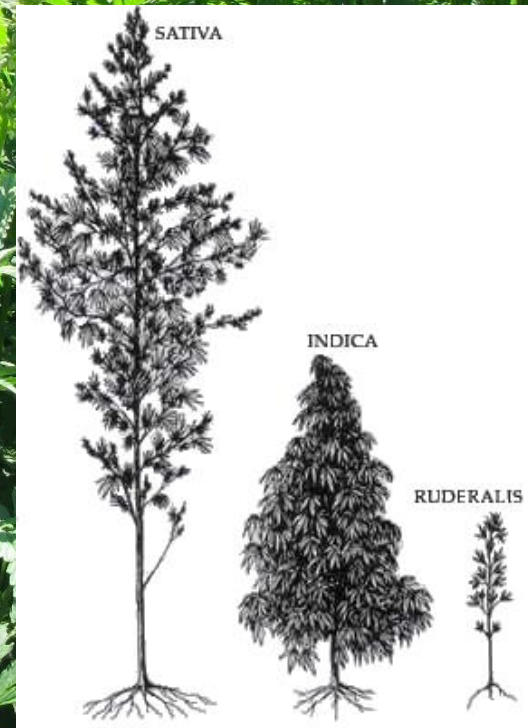


Cannabaceae Family

- Hemp - Cannabis
- Hops – Humulus
- Hackberries - Celtis



Hemp is an erect,
bushy, annual, herb.



Industrial Hemp

- THC 0.30% or below
 - Grain
 - Fiber
 - Phytocannabinoids like CBD



Hemp

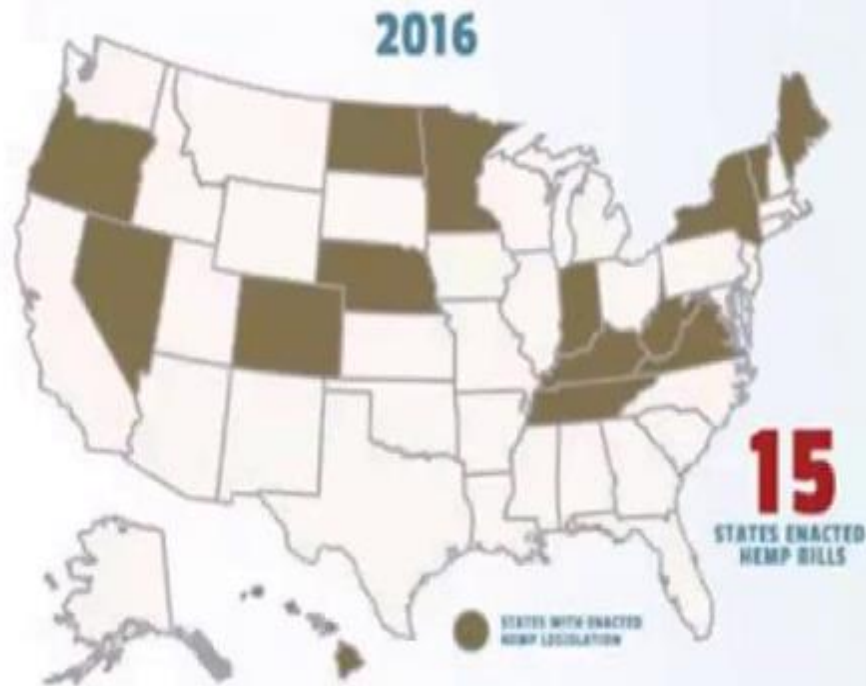
- Found in all regions of North America.
- It is a dioecious plant.
- It is photoperiod sensitive.



>40 states have legalized research

Rapid expansion

Twenty-six U.S. States have enacted hemp legislation since 2016.



9,770 ACRES OF HEMP GROWN



25,713 ACRES OF HEMP GROWN

*IN 2017

SOURCE: HEMP POLICY



Agriculture Improvement Act 2018

- 2018 Farm Bill authorized the production of hemp.
- Removed hemp and hemp seeds from DEA's Schedule of Controlled Drug List.
- Directed USDA to issue regulation and guidance.
- Establishment of hemp has allowed the way for participation in other USDA programs.
- <https://www.ams.usda.gov/rules-regulations/hemp>



Risk Management Agency
1400 Independence Ave. SW
Washington, DC 20250

Contact: FPAC Press Desk
FPAC.BC.Press@usda.gov

News Release

USDA Announces Pilot Insurance Coverage for Hemp Growers

WASHINGTON, D.C., Dec. 23, 2019 – USDA’s Risk Management Agency (RMA) today announced a new crop insurance option for hemp growers in select counties of 21 states in 2020. The pilot insurance program will provide Actual Production History (APH) coverage under 508(h) Multi-Peril Crop Insurance (MPCI) for eligible producers in certain counties in Alabama, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Maine, Michigan, Minnesota, Montana, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, Pennsylvania, Tennessee, Virginia, and Wisconsin.

The MPCI coverage is for hemp grown for fiber, grain or CBD oil for the 2020 crop year. It is in addition to the Whole-Farm Revenue Protection coverage available to hemp growers announced earlier this year.

“We are excited to offer coverage to certain hemp producers in this pilot program,” said RMA Administrator Martin Barbre. “Since this is a pilot program, we look forward to feedback from producers on the program in the coming crop year.”

The 2018 Farm Bill amended the Controlled Substances Act to address how industrial hemp is to be defined and regulated at the federal level, and those modifications cleared the way for the Federal Crop Insurance Corporation to offer policies for it. The Farm Bill defines hemp as containing 0.3 percent or less tetrahydrocannabinol (THC) on a dry-

2019 Hemp Explosion

- Prices dropped just Towards harvest.
- Estimated 8% over Production of CBD.
- Only approximate 4,000 growers in 2018.



511,442

Acres of hemp licensed nationally



34

States licensed hemp cultivation



16,877

State growers licenses issued

Source: Vote Hemp, www.VoteHemp.com

Hemp Prices

Biomass Spot Pricing - April 2019

Source: PanXchange

Region	Midpoint	Low	High
Colorado (per % CBD Content/lb.)	\$ 3.90	\$ 3.30	\$ 4.50
Kentucky (per % CBD Content/lb.)	\$ 4.16	\$ 3.66	\$ 4.65
Oregon (per % CBD Content/lb.)	\$ 4.08	\$ 3.75	\$ 4.40

Refined Product Pricing - April 2019

Product	Midpoint	Low	High
Colorado Winterized Crude (per kg)	\$ 2,050.00	\$ 1,800.00	\$ 2,300.00
Colorado Isolate (per kg)	\$ 6,350.00	\$ 5,200.00	\$ 7,500.00

Source: PanXchange, Inc.

Hemp Prices

Biomass Spot Pricing - December 2019

Source: PanXchange

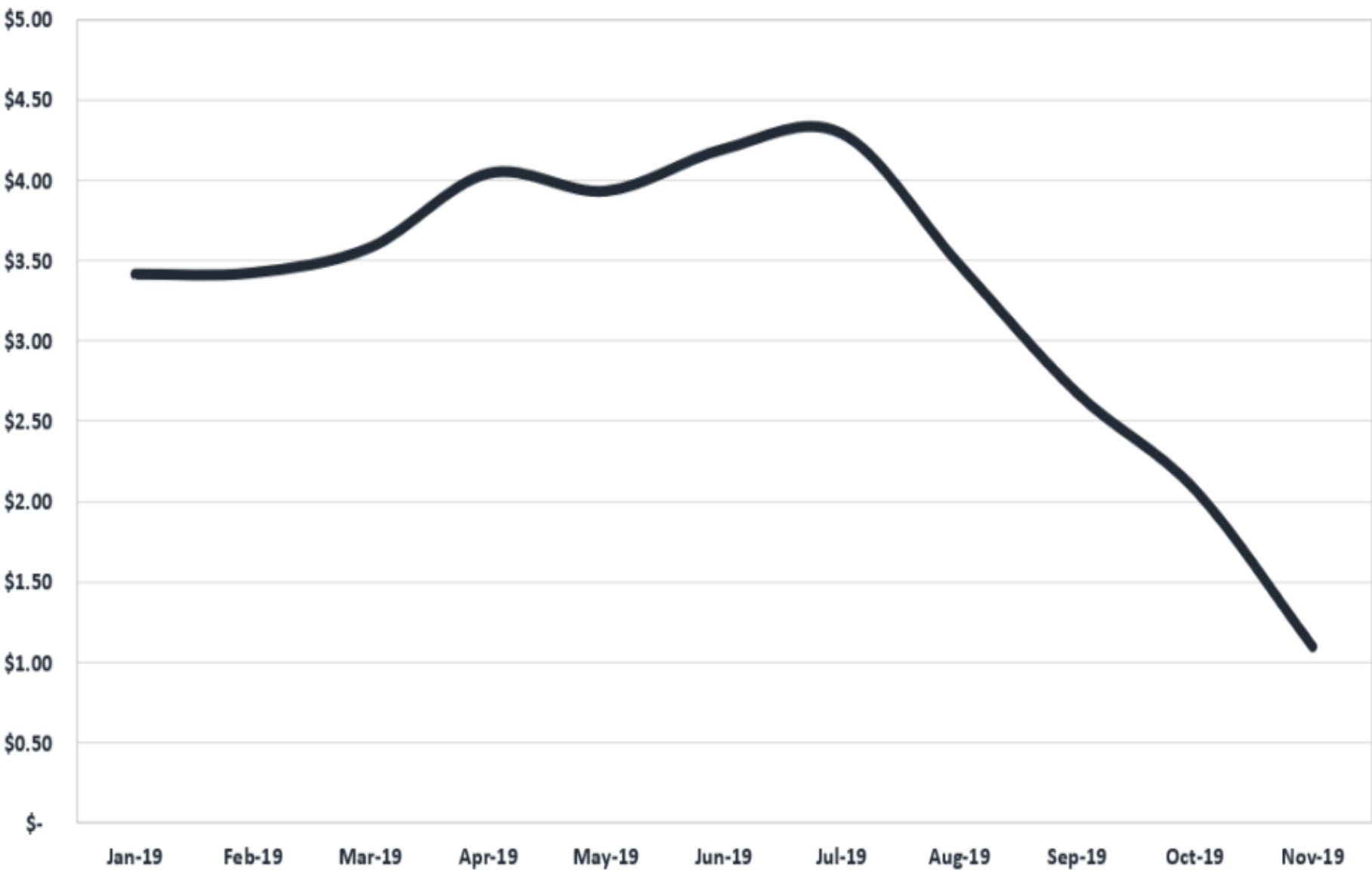
Region	Midpoint ▲	Low	High
Colorado (per % CBD Content/lb.)	\$ 0.98 -14%	\$ 0.75	\$ 1.20
Kentucky (per % CBD Content/lb.)	\$ 0.95 -7%	\$ 0.85	\$ 1.05
Oregon (per % CBD Content/lb.)	\$ 0.85 -24%	\$ 0.60	\$ 1.10

Refined Product Pricing - December 2019

Product	Midpoint ▲	Low	High
Colorado Winterized Crude (per kg.)	\$ 800 -22%	\$ 600	\$ 1,000
Colorado Full Spectrum Distillate (per kg.)	\$ 2,200 -15%	\$ 1,900	\$ 2,500
Colorado Broad Spectrum Distillate (per kg.)	\$ 4,050 -9%	\$ 3,400	\$ 4,700
Colorado Isolate (per kg.)	\$ 2,250 -6%	\$ 1,700	\$ 2,800

Source: PanXchange, Inc.

***Midpoint Biomass Spot Price (per % CBD Content/lb)
PanXchange Average Price Index (CO,KY,OR)***



Impacts

- Only approximate 50% of acreage planted reports of only 50 to 60% harvested.
- 30 to 60% of crops compliant.
- 50 to 70% farmers reporting product not sold.
 - No market to begin with
 - Contracts terminated or cancelled

Hemp Enterprise Budgets

CBD Plasticulture Model							
		Quant.	Unit	Price			Total
Gross Returns Per Acre							
	CBD%	10%					
	Price Per %	\$4.00					
	Dry Matter Yield	1,200	lbs	\$40.00			\$48,000.00
Total Revenue							\$48,000.00
Variable Costs Per Acre							
Total Variable Costs Per Acre							\$10,405.68
Return Above Variable Costs Per Acre							\$37,594
<i>Breakeven Yield at \$40 /lb of CBD</i>							
		9	/lb per acre to cover variable costs				
<i>Breakeven Cost at 1200 lbs of CBD</i>							
		\$260.14	/lb to cover variable costs				
Sensitivity Analysis							
	Price per % CBD		Total Revenue		Returns Above Variable Costs		
	\$6		\$72,000		\$61,594		
	\$5		\$60,000		\$49,594		
	\$4		\$48,000		\$37,594		
	\$3		\$36,000		\$25,594		
	\$2		\$24,000		\$13,594		
	\$1		\$12,000		\$1,594		

Hemp Enterprise Budgets

CBD Plasticulture Model							
		Quant.	Unit	Price			Total
Gross Returns Per Acre							
	CBD%	10%					
	Price Per %	\$1.14					
	Dry Matter Yield	1,200	lbs	\$11.40			\$13,680.00
Total Revenue							\$13,680.00
Variable Costs Per Acre							
Total Variable Costs Per Acre							\$10,405.68
Return Above Variable Costs Per Acre							
							\$3,274
<i>Breakeven Yield at \$11.4 /lb of CBD</i>		9	<i>/lb per acre to cover variable costs</i>				
<i>Breakeven Cost at 1200 lbs of CBD</i>		\$912.78	<i>/lb to cover variable costs</i>				
Sensitivity Analysis							
Price per % CBD		Total Revenue		Returns Above Variable Costs			
\$6		\$72,000		\$61,594			

Hemp Enterprise Budgets

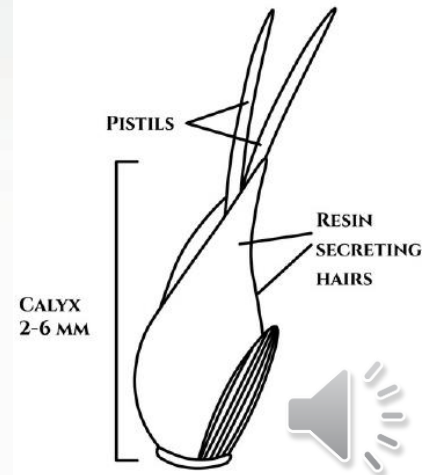
Hemp Grain							
		Quant.	Unit	Price			Total
Gross Returns Per Acre							
	Hemp Grain	1,200	lbs	\$0.70			\$840.00
Total Revenue							\$840.00
Variable Costs Per Acre							
Total Variable Costs Per Acre							\$795.06
Return Above Variable Costs Per Acre							\$45
<i>Breakeven Yield at \$0.7 /lb</i>		1136	lb per acre to cover variable costs				
<i>Breakeven Cost at 1200 lbs</i>		\$0.66	/lb to cover variable costs				

Sensitivity Analysis

Price per # Hemp Grain	Total Revenue	Returns Above Variable Costs
\$1.00	\$1,200	\$405
\$0.90	\$1,080	\$285
\$0.80	\$960	\$165

Female Plants

- Flowers in axillary inflorescences.
- Flowers congested.
- Stigmas are long and covered with receptive papillae.



Male Plants

- 10 to 15% taller and less robust.
- Die after shedding pollen.
- Specialized for pollen dispersal by wind.
- Bees (many types) are present at flowering but do not visit female flowers.



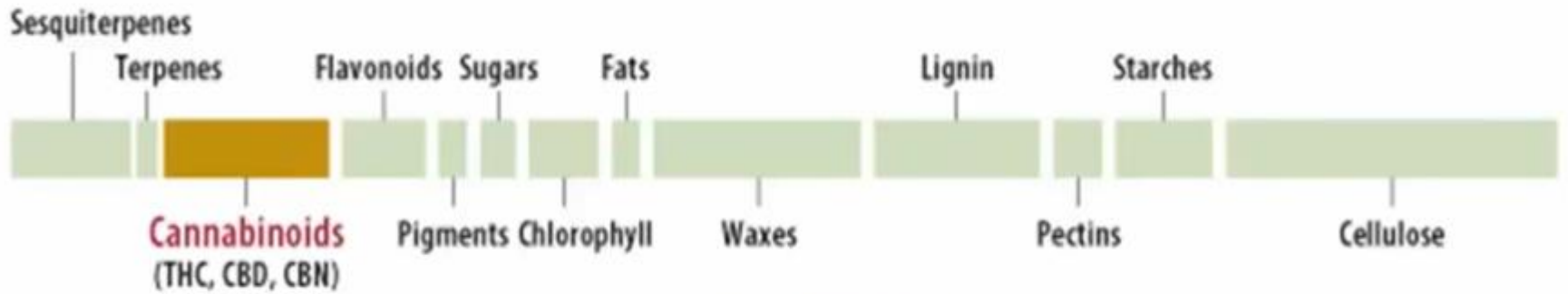


Trichomes

- Produce secondary chemicals
- Three classes in Cannabis
 - Sessile
 - Capitate
 - Bulbous



Chemicals in Cannabis



Cannabinoids

- 100 types identified.
- Largest quantities – CBD.
- Clinical trials ongoing.
- Also terpenes and phenolics

Table 1. Ongoing USA Clinical Trials and Orphan Medical Conditions for Which CBD Has Been Approved

Medical condition ^a	Phase I	Phase II	Phase III	Orphan drug designation ^b
Amphetamine addiction	n.d.	Yes	n.d.	n.d.
Anxiety	n.d.	Yes	n.d.	n.d.
Autistic disorder	n.d.	Yes	n.d.	n.d.
Cannabis use disorder	n.d.	Yes	n.d.	n.d.
Cocaine dependence	n.d.	Yes	n.d.	n.d.
Dravet syndrome	n.d.	n.d.	Yes	Designated
Drug-resistant epilepsy	Yes	Yes	n.d.	n.d.
Epileptic encephalopathy	Yes	n.d.	n.d.	n.d.
Fatty liver	n.d.	Yes	n.d.	n.d.
Fragile X syndrome	n.d.	n.d.	n.d.	Designated
Glioblastoma multiforme	Yes	n.d.	n.d.	Designated
Glioma	n.d.	n.d.	n.d.	Designated
Graft versus host disease	Yes	Yes	n.d.	Designated
Graft versus host disease – prevention	n.d.	n.d.	n.d.	Designated
Infantile spasms	n.d.	Yes	Yes	Designated
Lennox–Gastaut syndrome	n.d.	n.d.	Yes	Designated
Neonatal hypoxic ischemic encephalopathy	n.d.	n.d.	n.d.	Designated
Lung cancer	Yes	n.d.	n.d.	n.d.
Opiate addiction	Yes	Yes	n.d.	n.d.
Pediatric intractable epilepsy	Yes	Yes	n.d.	n.d.
Pediatric schizophrenia	n.d.	n.d.	n.d.	Designated
Posttraumatic stress disorder	n.d.	Yes	n.d.	n.d.
Prader–Willi Syndrome	n.d.	Yes	n.d.	n.d.
Schizophrenia	Yes	Yes	n.d.	n.d.
Solid tumor	n.d.	Yes	n.d.	n.d.
Sturge–Weber Syndrome	Yes	Yes	n.d.	n.d.
Treatment-resistant seizures	Yes	n.d.	Yes	n.d.
Tuberous sclerosis complex	n.d.	n.d.	Yes	Designated
Ulcerative colitis	Yes	Yes	n.d.	n.d.

Abbreviations: n.d., no data.

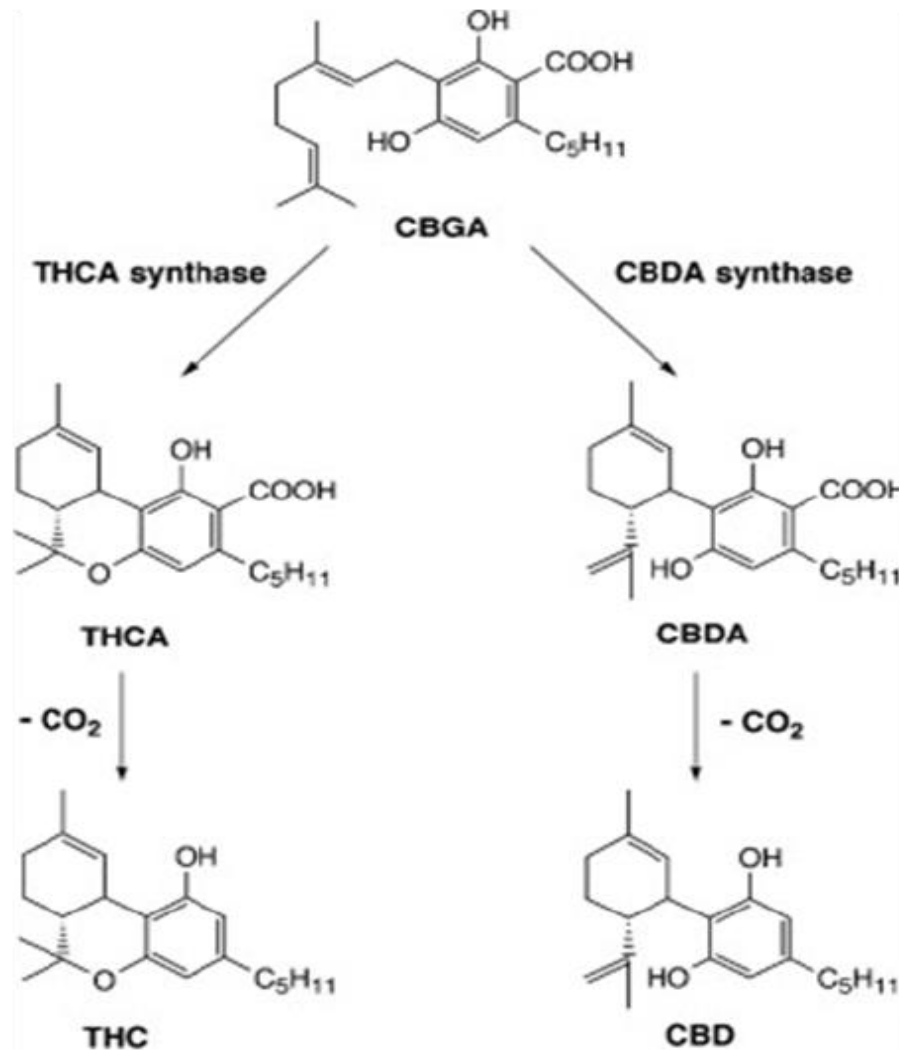


Figure 2: Biogenesis of THC and CBD adapted from Taura et al. (2007)
 THCA synthase and CBDA synthase catalyze oxidative cyclization of the monoterpene moiety of CBGA to form THCA and CBDA, respectively. THC and CBD are generated from THCA and CBDA by non-enzymatic decarboxylation. [11]

Cannabis chemicals

α -Pinene appears to be a broad-spectrum antibiotic



Fitoterapia

Volume 81, Issue 5, July 2010, Pages 413–419



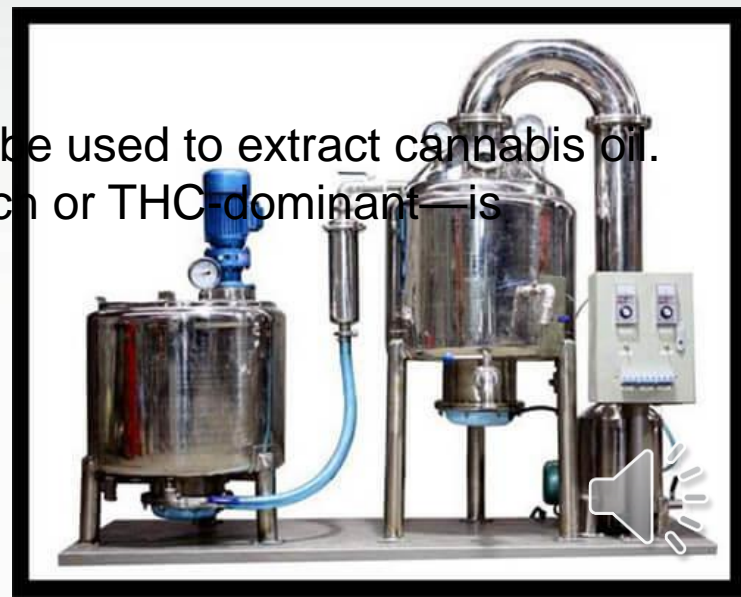
Characterization and antimicrobial activity of essential oils of industrial hemp varieties (*Cannabis sativa* L.)

Lorenzo Nissen^a,  , Alessandro Zatta^b, Ilaria Stefanini^a, Silvia Grandi^b, Barbara Sgorbati^a, Bruno Biavati^a, Andrea Monti^b

- Does α -Pinene in three hemp cultivars have an inhibitory activity of microbial growth?
- Yes, results demonstrate α -Pinene (in hemp essential oils) significantly inhibits microbial growth
 - Gram (+ and -) bacteria
 - Yeasts
- Conclusion: industrial hemp essential oils applications could control spoilage, food-borne pathogens, and phytopathogen microorganisms.

Extraction of Essential Oils

- CO₂ extraction.** The supercritical (or subcritical) CO₂ method uses carbon dioxide under high pressure and extremely low temperatures to isolate, preserve, and maintain the purity of the medicinal oil. This process requires expensive equipment and a steep operational learning curve. But, when done well the end product is safe, potent, and free of chlorophyll.
- Ethanol.** High-grade grain alcohol can be used to create high-quality cannabis oil appropriate for vape pen cartridges and other products. But this extraction method destroys the plant waxes, which may have health benefits that are favored by some product-makers.
- Olive oil.** Extra virgin or otherwise, olive oil can also be used to extract cannabis oil. However, cannabis-infused olive oil—whether CBD-rich or THC-dominant—is perishable and should be stored in a cool, dark place.



Isolation Distances

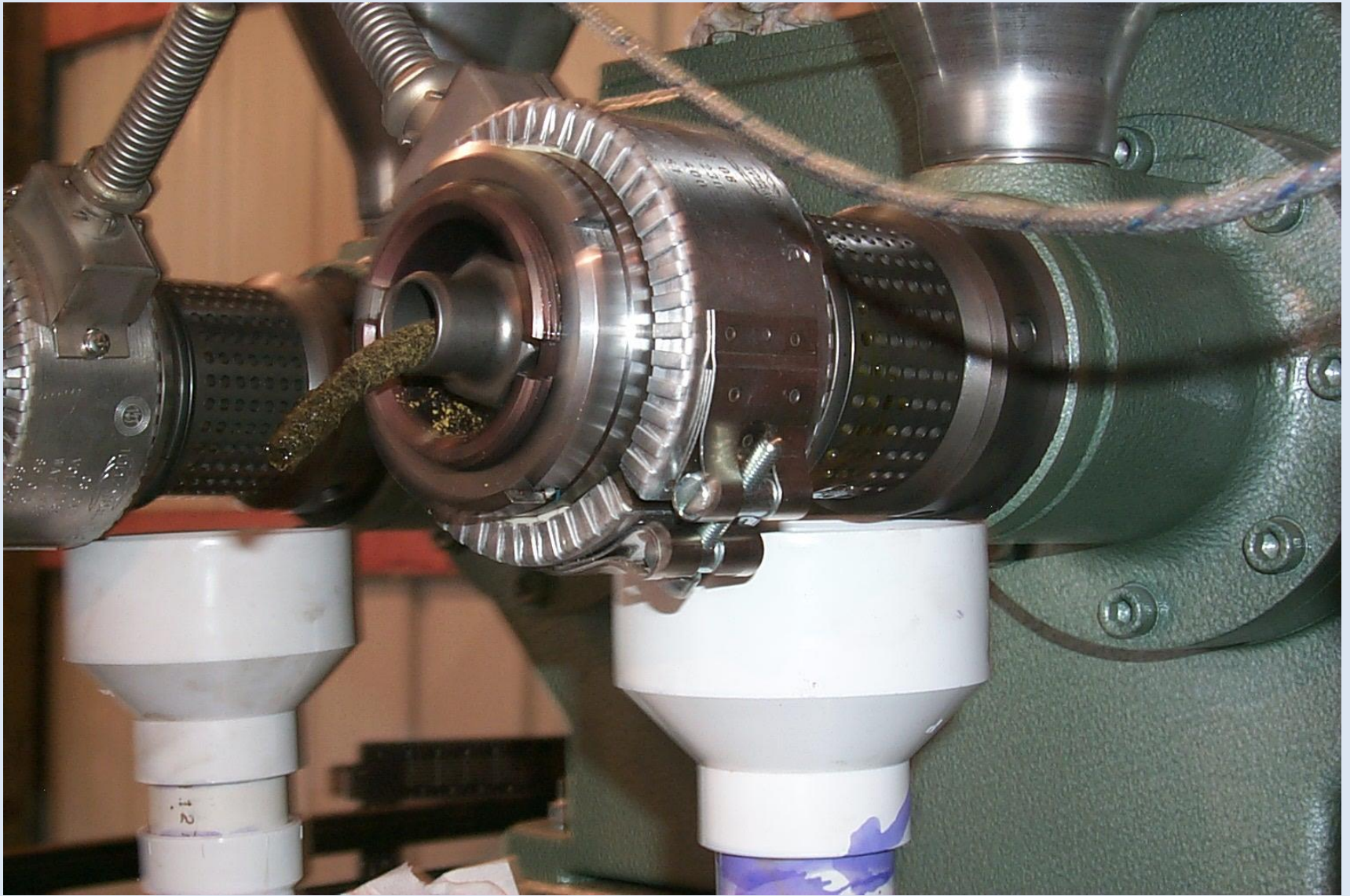
Several states have already developed isolation distances for hemp seed production.

The required distance for a certified seed crop is 3 miles.

The required distance from marijuana fields is 15 miles.







Hemp Seed Oil

- 30% protein, 25% starch, 30% oil.
- 90% polyunsaturated oils.
- High in omega-3 fatty acids.
- Food, fuel, cosmetics, etc.
- Cake – used for food and animal feed.



Hemp Fibers



Photo courtesy of <http://www.hemptrade.ca/eguide/>



Hemp Fiber

- Bast fiber – high quality
 - Clothing, rope, etc.
- Hurd – lower quality but..
 - Animal bedding
 - Hemp crete
 - Plastics





<https://www.youtube.com/watch?v=GJKnz9hlB3Q&t=2s>

YouTube

Double Crop Opportunities



Temperature, Water, Light

- Adapt to region – fairly cold tolerant.
- Tolerant of hot and arid conditions provided roots can reach water.
- Does not tolerate water logged soils.
- Thrive in full sun.



Water Requirements

- Hemp requires at least 20-30 inches of rainfall during the growing period
- Abundant moisture is needed during the germination period.
- The absorption of water increases until flowering begins.
- Then the uptake of water decreases considerably, with a slight increase at late flowering and during seed formation.





Soil Limitations

- Grows best on sandy loams.
- 40% or more clay not generally good.
- Adequate pH
 - over 6.0 (requires calcium).
- Nutrient loving especially N-P-K.



Fertility Requirements

Potassium (2.5 to 3.0%)

65 – 70 lbs per acre

Phosphorus (0.5 – 0.6%)

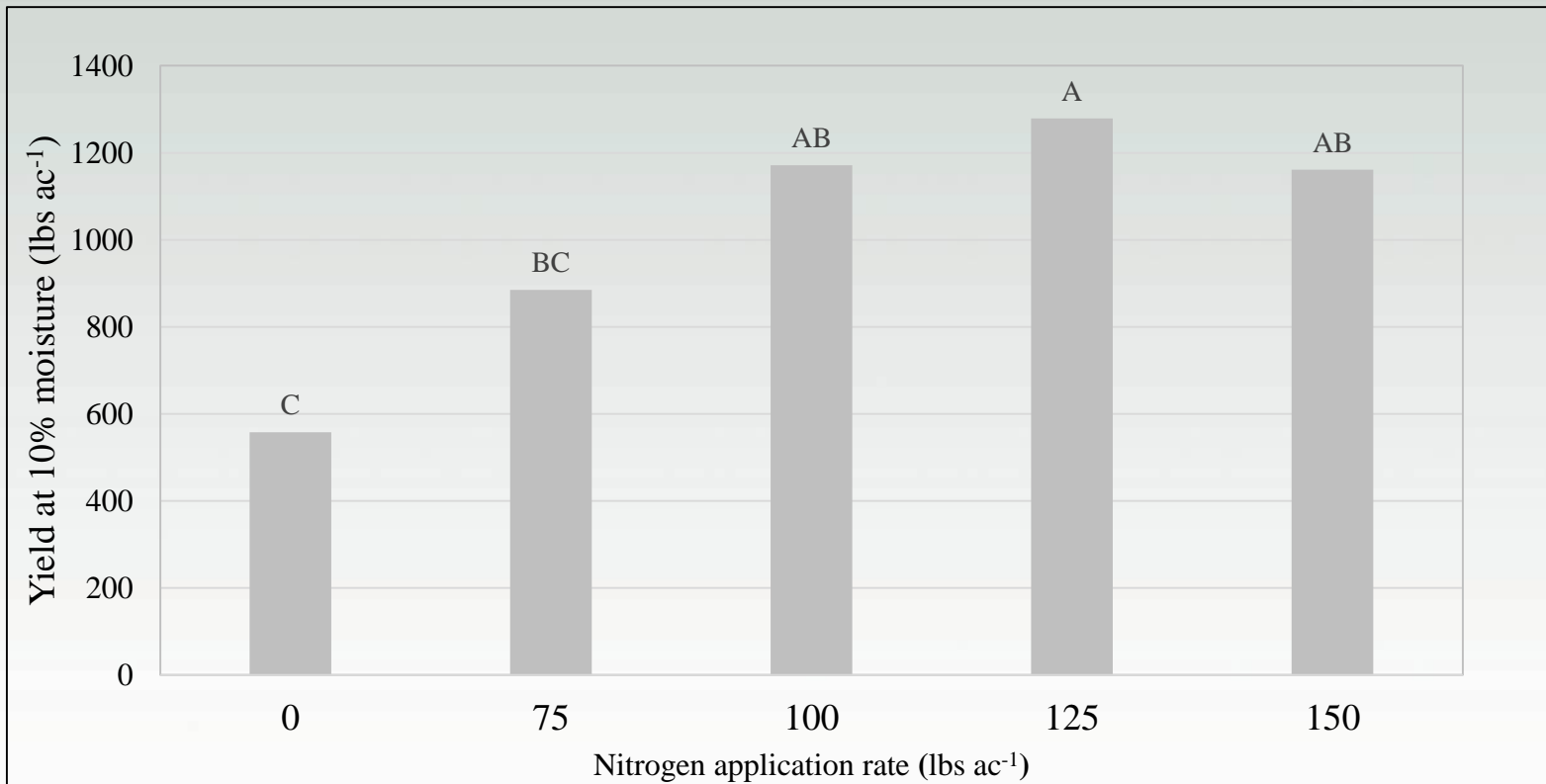
50 to 70 lbs per acre

Nitrogen (5 to 6%)

100 to 200 lbs per acre



Industrial grain hemp & nitrogen fertility



Pest pressure

- What we saw:
 - Aphids
 - Tarnish plant bugs



Hop aphids



Tarnished plant bugs

- What else may be out:
 - Hemp borer
 - Spider mites
 - Bertha armyworm
 - Cutworms



Bertha armyworm



Hemp borer



Cutworms

Corn Borer



Disease

- Sclerotinia
- Botrytis
- Alternaria
- Fusarium



Sclerotinia, 2016

White Mold



Botrytis – Grey Mold

- Limit irrigation during and after bloom.
- In greenhouses, maintain the relative humidity below 50%, temperatures warm, and high light intensity.
- Avoid over-fertilization with nitrogen.
- Canopy management is the best preventive method.



Crop Rotation

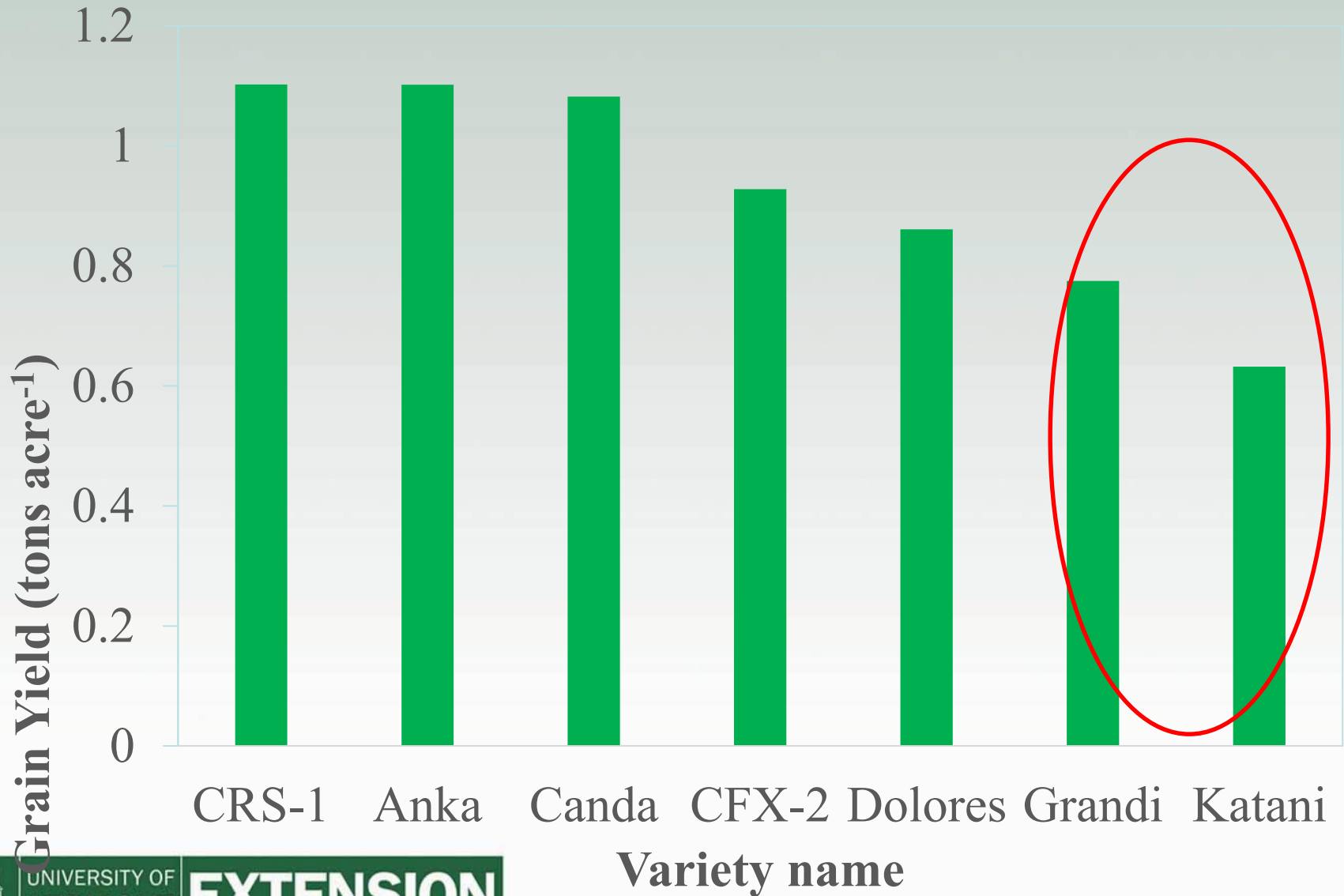
- Hemp is susceptible to many diseases.
- Hemp should be rotated ideally to a new spot every 1 to 2 years.
- To minimize disease build-up would recommend a 4 to 6 year rotation.

Seed Purchase

- Grain & Fiber – male & female seeds
- CBD
 - male & female seed
 - feminized seed
- CBD Clones
 - female plants
- CBD Starts
 - Gender typed
 - Mixed male & female plants

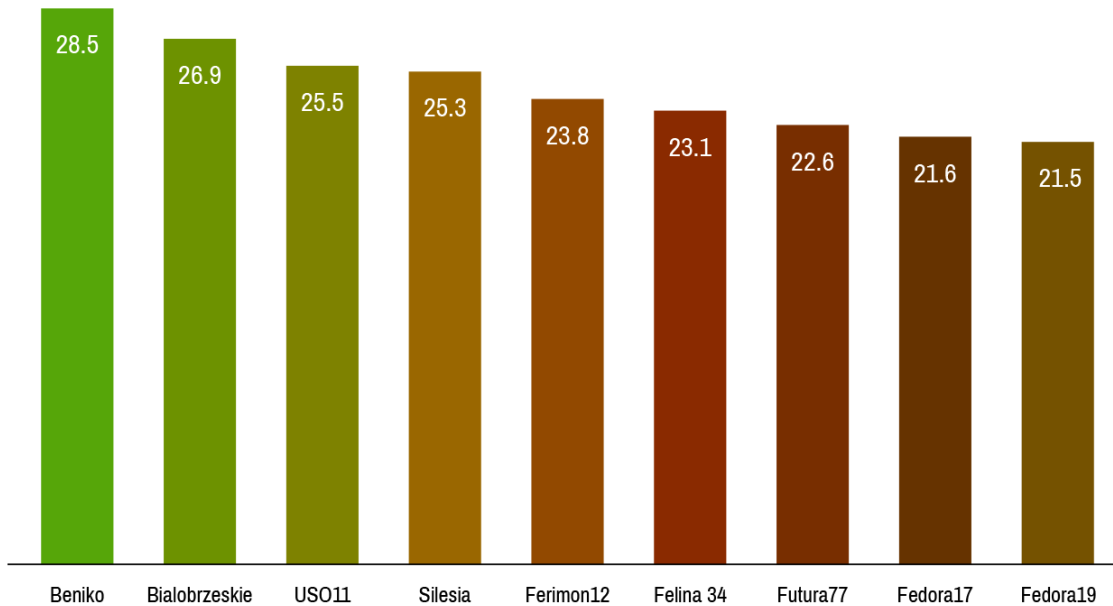


Grain Varieties



Variety Selection

Bast Fibre Content (%)



Certificate of Analysis

Risky Business

Proven Genetics/Companies

COA

Grower Testimonies

State List Compliant Varieties

MW Labs
724 S Central Ave STE 202
Medford OR 97501
(541) 499-6300
License: 1008606C050

Certificate of Analysis
Sample ID: HEMPRESS2
Report ID: TR- HEMPRESS2

Client Name: CBDINC
License No: N/A
Address: N/A

Date Sampled: Submitted on 2/20/2019
Sampled by: Client
Sample Name: HEMPRESS2
Sample Type: FLOWER
Sample Weight: N/A

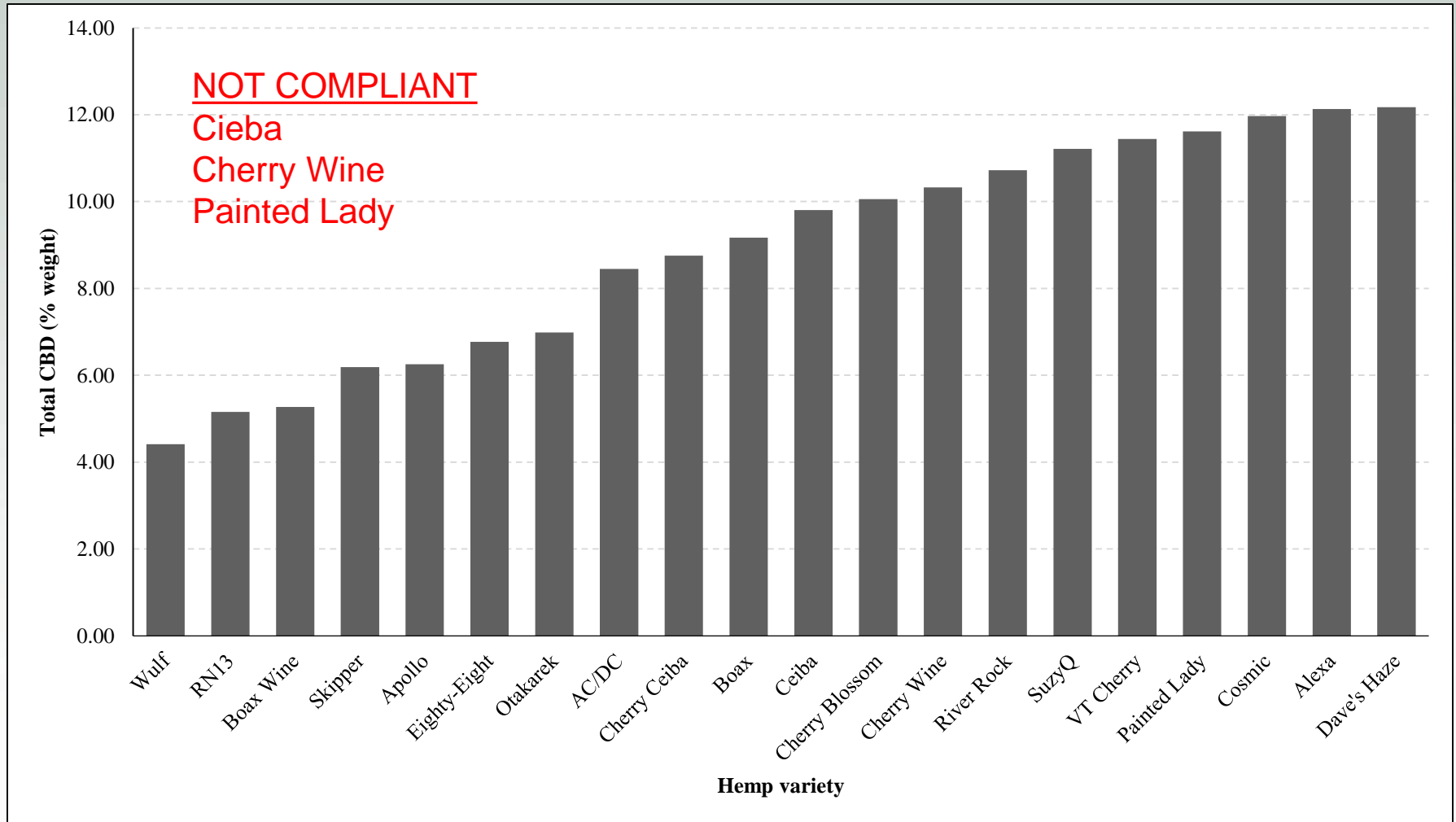
Description of the sample and environmental conditions at the time of sampling. Interpretation of the results is based on the sample and environmental conditions at the time of sampling.
Sample appeared normal for environmental conditions at the time of sampling.

Summary of Test Results

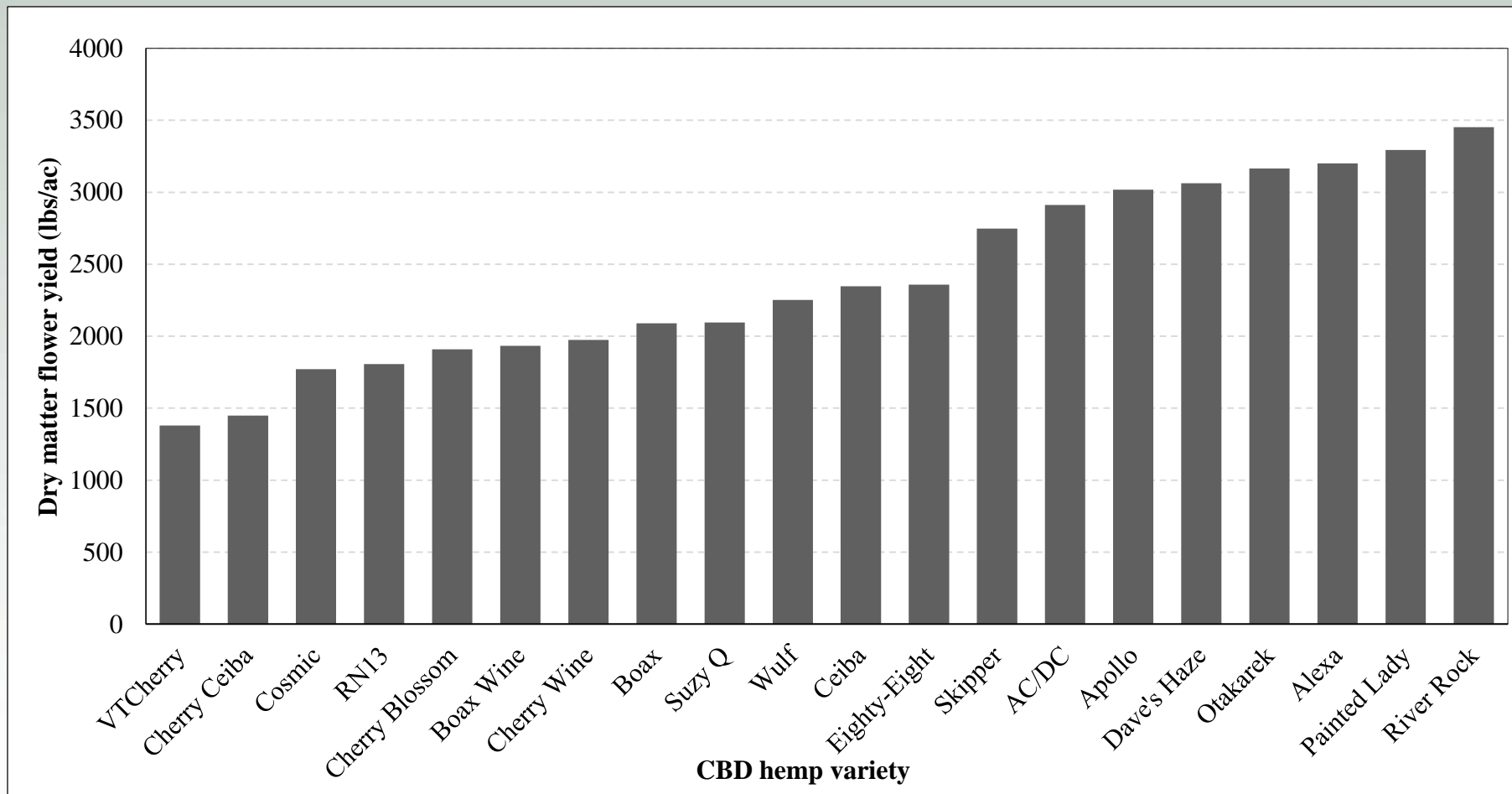
Items	Value
Total THC:	0.29 %
Total CBD:	17.1 %



2019 CBD Variety Trial – Total CBD



CBD Variety Trial - Yields



Growing Grain & Fiber

- Planting date
 - May through mid-June ideal
- Seeding depth: 2-3cm
- Seeding rate:
 - 20-25 lbs acre⁻¹ for grain
 - 40-50 lbs acre⁻¹ for fiber



Seeding Rate Trial - Pennsylvania

Seeding Rate	Yield (lb/ac)	Plants/ac	Height (in)
15	1281	102128	58
20	1526	96809	48
25	1662	154255	48
30	1704	163830	44
45	1700	286170	45
Mean	1575	160638	49
LSD(0.1)	176	92680	



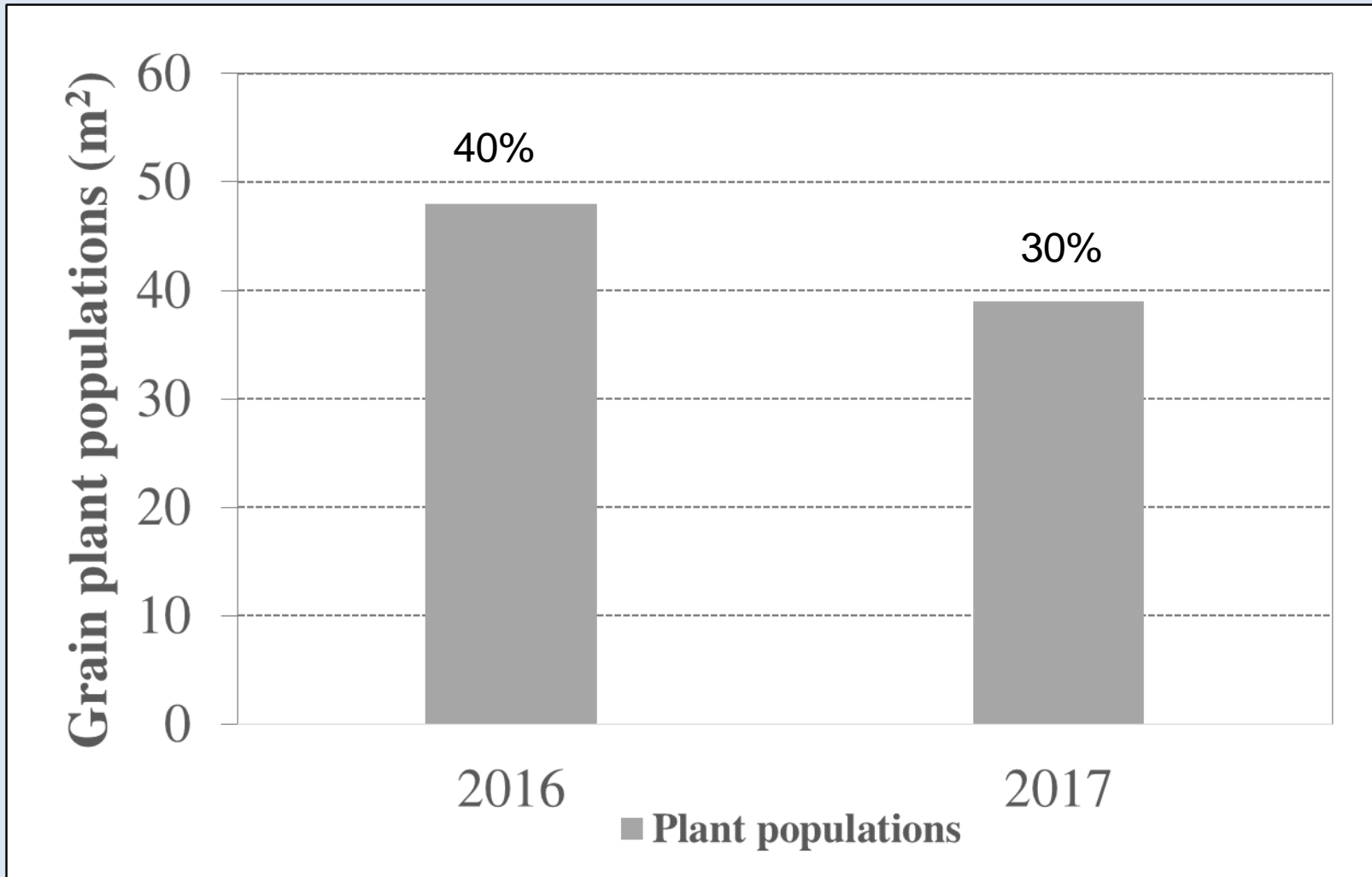


Figure 2. Average hemp grain population comparisons from the 2016 and 2017 variety trials.





Weed control trial

- Standard row – Average height 177 cm, significantly lower than other treatments.
- Weed cover ranged from 7.03 – 17.1%, no significant differences.
- No significant yield differences, 1444 kg/ha.



Percent weed cover assessment in industrial hemp, Alburgh, VT, 2016

Weed Control trial

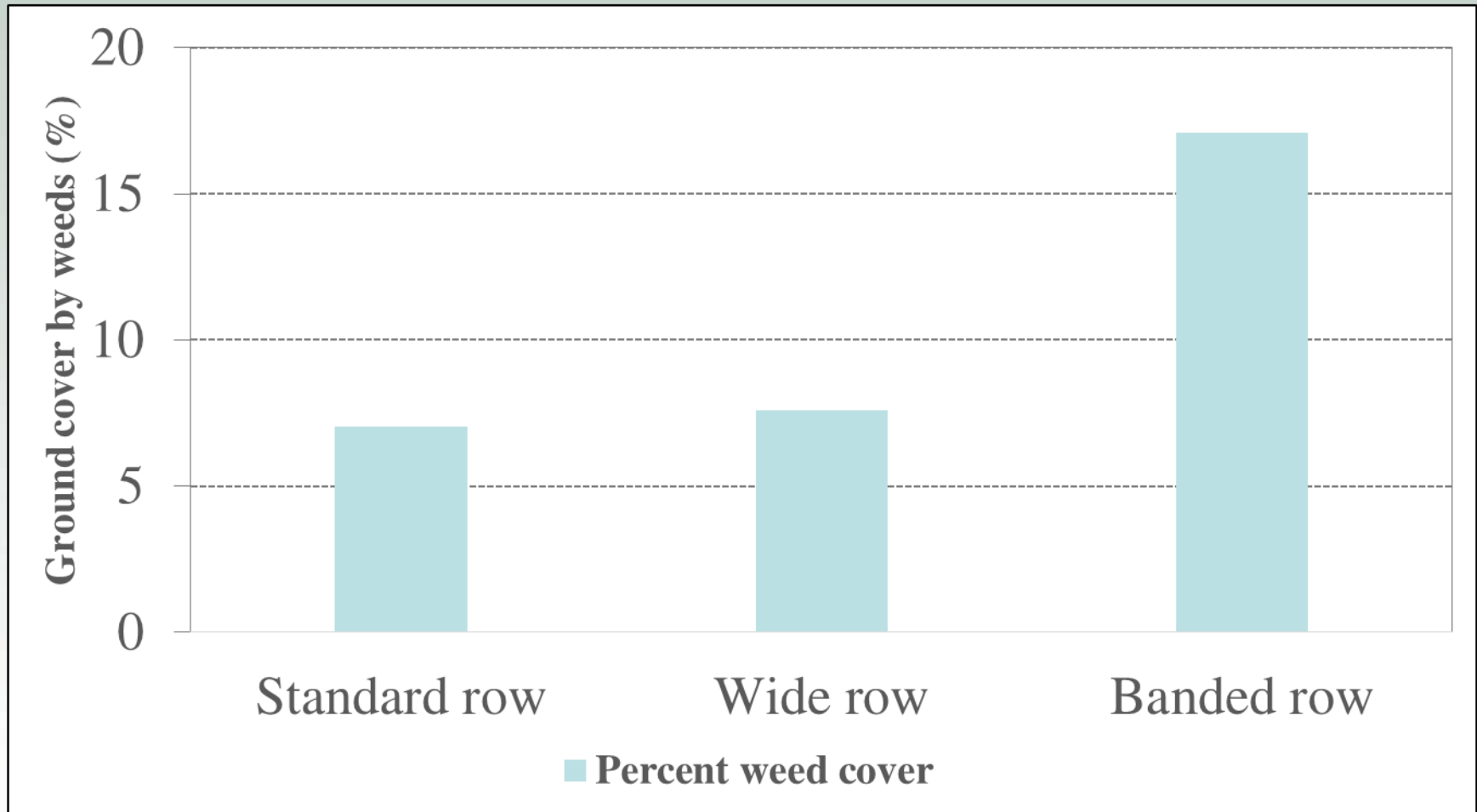


Figure 9. Row spacing effect on percent of ground covered by weeds. No significant difference

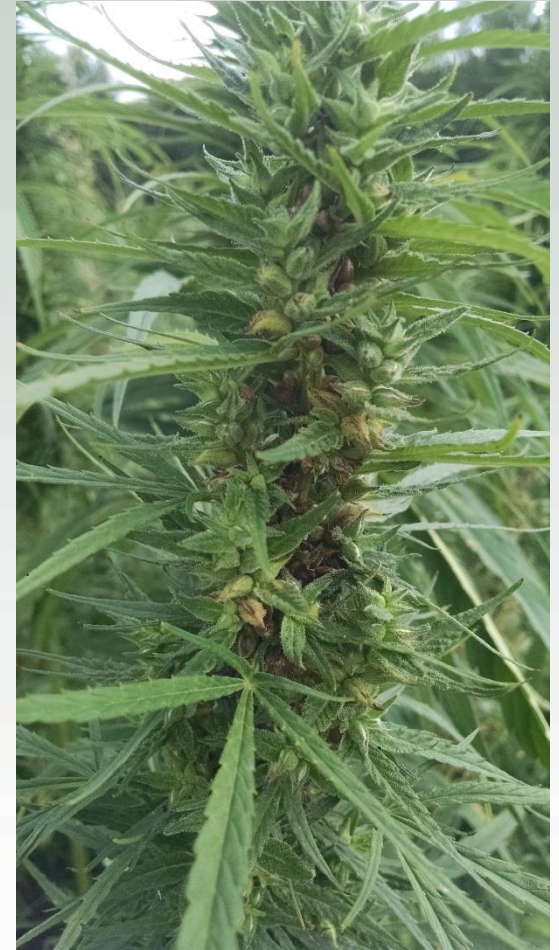
Growth stages



Staminate, male flower



Pistillate, female flower

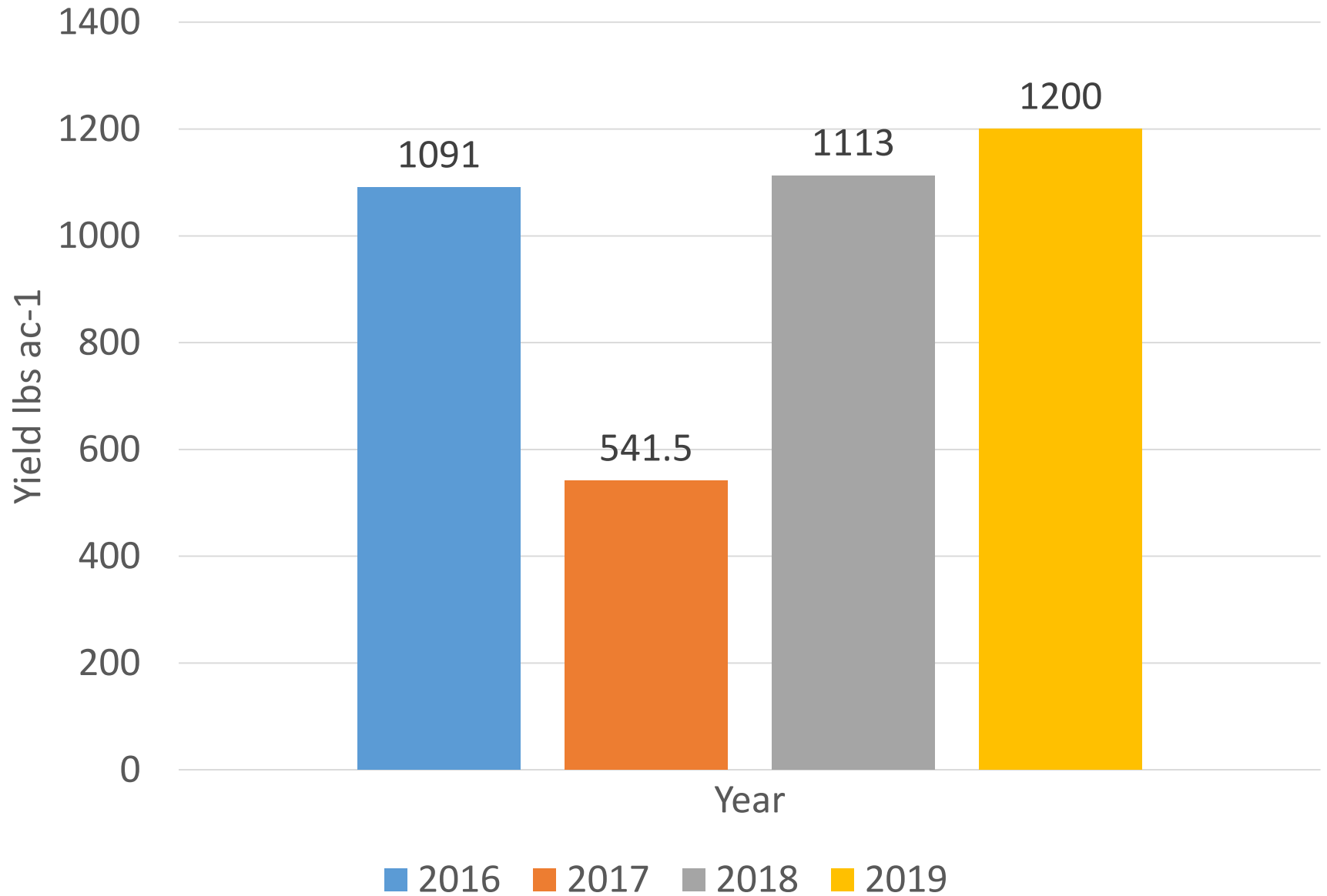


Seed development

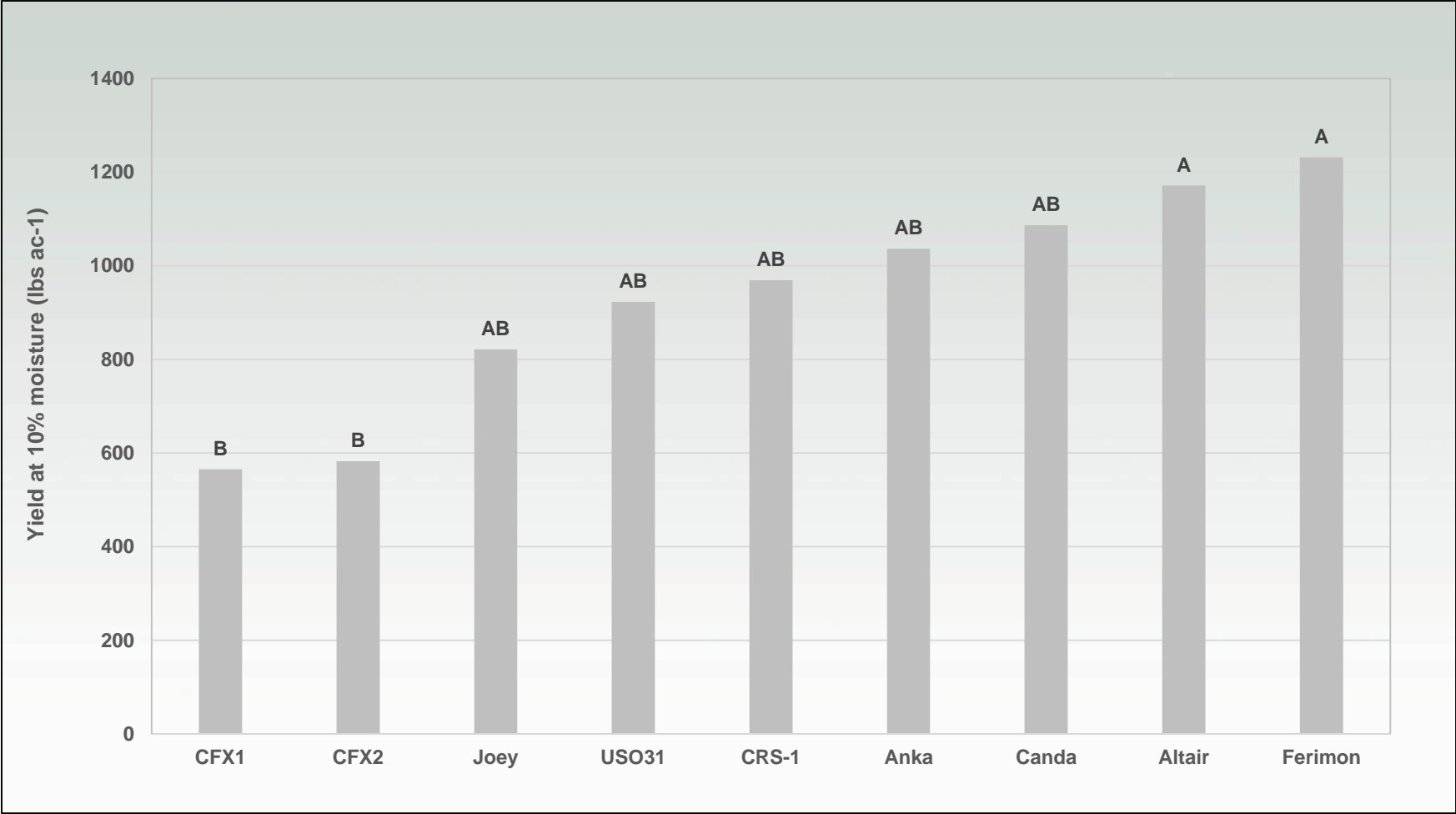




Grain Yields in Vermont



Industrial grain hemp variety trial



Sickle Bar Mower



Fiber Retting – 2 Weeks

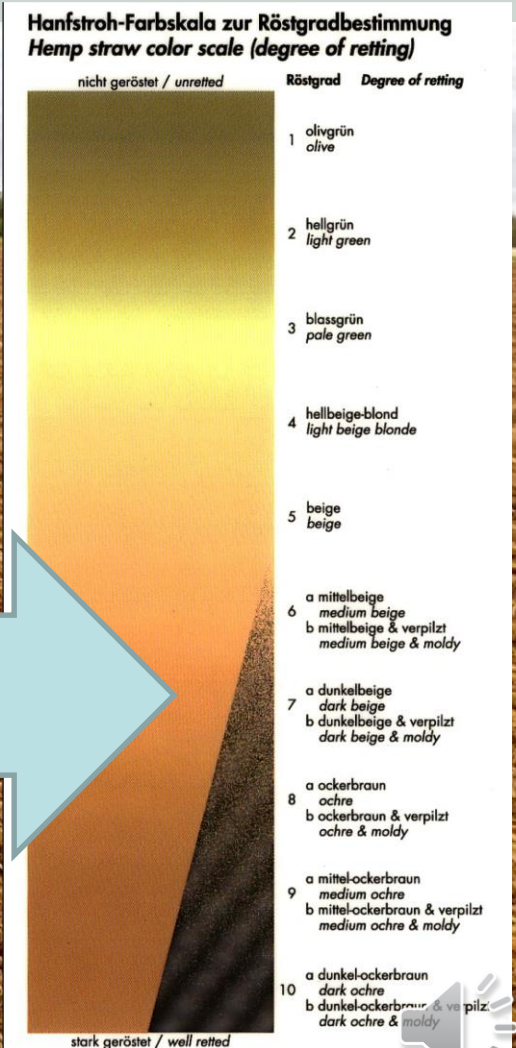


Photo courtesy of <http://www.hemptrade.ca/eguide/>

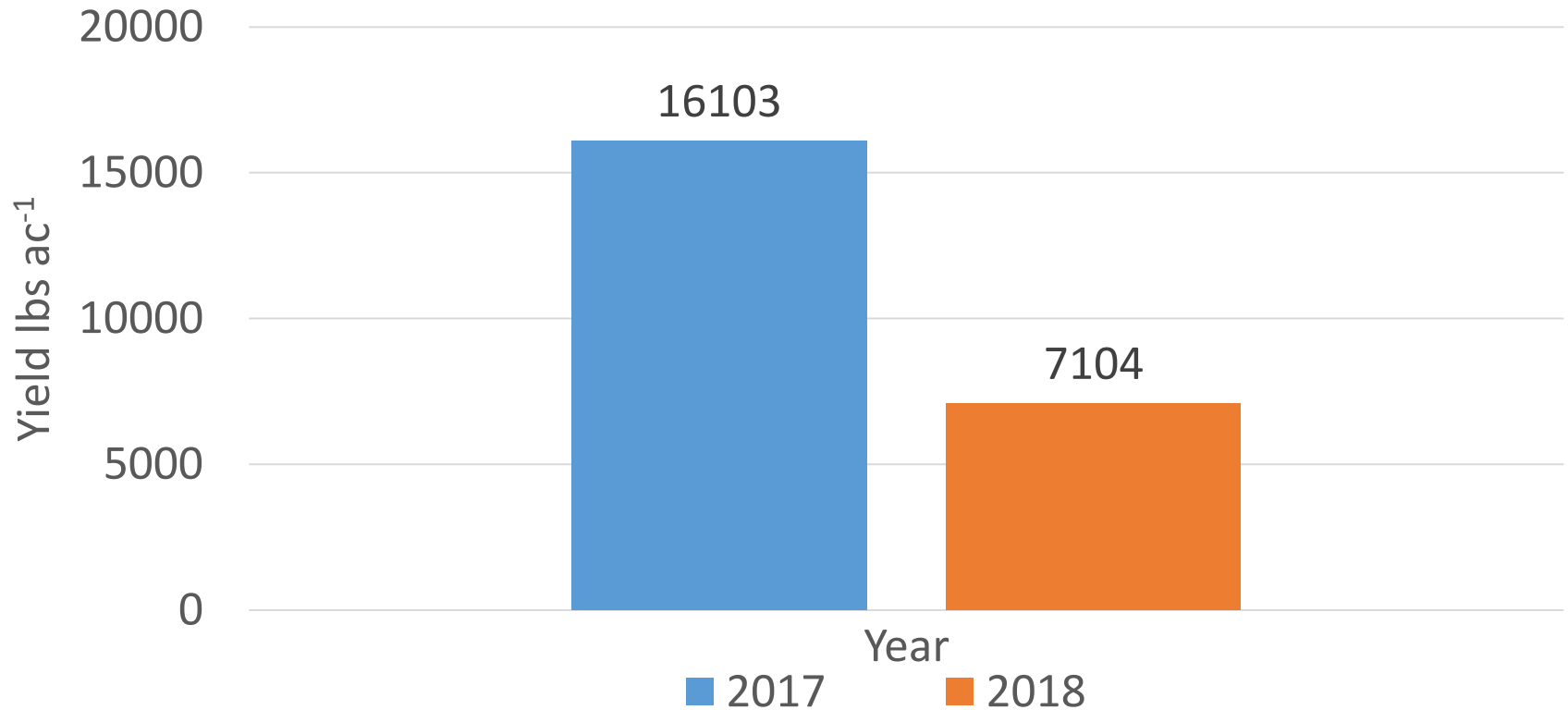
Fiber Windrowed



Photo courtesy of <http://www.hemptrade.ca/eguide/>



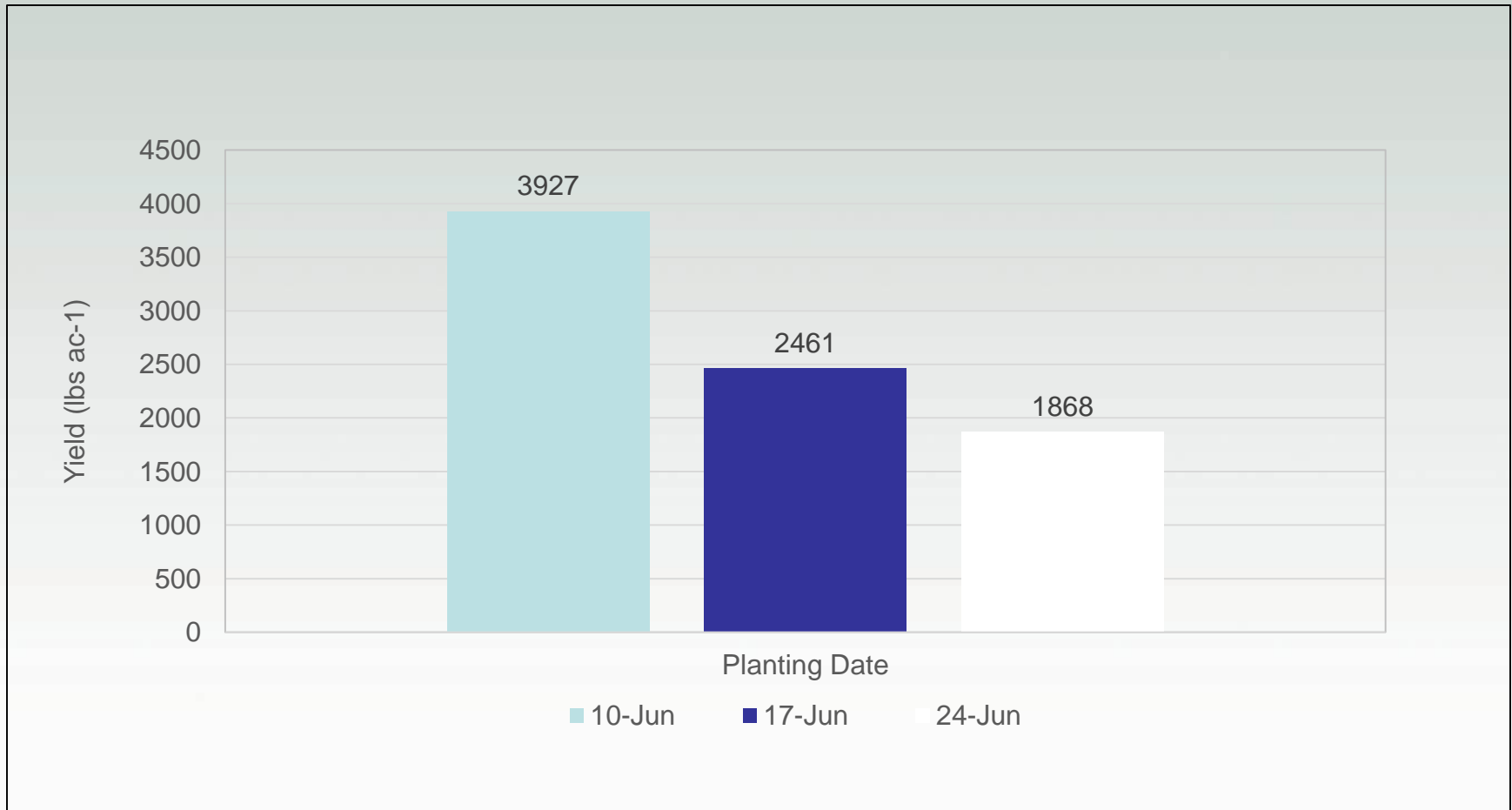
Fiber Yields in Vermont





CBD Plant Spacing x Planting Date Trial

Flower bud dry matter yields by planting date



How Many Seeds/Plants

- $5 \times 5 = 1,742$
- $6 \times 6 = 1,260$
- $4 \times 4 = 2,723$
- $2 \times 2 = 10,890$

Genetics & Planting Stock – Large Expense

\$1 to \$2 per seed = \$1,890/A

\$ 3 to \$8 per plant = \$5,040/A

\$ 4 to \$8 per clone = \$7,560/A





Approximately 1 month in greenhouse
Deep 72 or 50 cell trays
Potting mix many successes – Fort-V Lite



Transplanting Hemp



Transplanting Hemp



Plastic Mulch



Transplanting Hemp




Hemp and Plasticulture







Harvesting for Flower

- Hand Harvest – Labor Intensive
 - Biomass market
 - Flower market – 1 to 3 hours per plant
- Mechanical – Less Labor 
 - Primarily biomass
- Mechanical and Hand Harvest - Combo
 - Biomass
 - Flower



High-CBD Hemp Harvest 2018! Hemp Handler Prototype Test - July 2018

Hemp Harvesters

File Transfer Service : University x SuperCrop LP | Hemp Flower Row x +

hempharvestworks.com/supercrop-lp

-CBD HEMP-

The SuperCrop® LP

- First Row-Crop Header Designed for CBD Hemp Production
- Proprietary cutting and feeding mechanism reduce or eliminate the wrapping issues that many headers encounter
- Snoots lift branches to increase yield while leaving stalk
- Easy to change sickle-section design allows you to swap out to use a more aggressive section for hemp, allowing you to get more life out of your knife components
- Backscreen reduces material loss, increasing bushel/acre yields
- Able to harvest narrow row drilled (7 ½") crops as well as crops planted up to 40" apart



Type here to search

11:10 PM
1/7/2020

HarvestLogic

CUSTOM CBD HARVESTING



HempLogic.com

Harvest Tools







Hemp Dryers



Hemp Dryers



Contact Information

heather.darby@uvm.edu

802-524-6501



Virtual tour link -

<https://goo.gl/photos/sRNsdFwnhgNmFhk87>

Hemp webpage -

<http://www.uvm.edu/extension/cropsoil/hemp>

The screenshot shows the website for the University of Vermont's Northwest Crops & Soils Program. The header includes the UVM logo and navigation links such as 'ABOUT UVM', 'ADMISSIONS', 'ACADEMICS', 'STUDENT LIFE', 'RESEARCH', 'ATHLETICS', 'OFFICES', and 'OUTREACH'. A red 'APPLY TO UVM' button is also present. The main content area features a 'Welcome' message and a large banner for the 'NW CROPS & SOILS PROGRAM' with several images: a hay bale, a close-up of a green leaf, a field of crops, a person working in a field, and sunflowers. Below the banner, there is a mission statement: 'The mission of the UVM Extension Northwest Crops and Soils Team is to provide the best and relevant cropping information, both research-based and experiential, delivered in the most practical and understandable ways to Vermont farmers.' A section titled 'OUT CROPPINGS: Important crop news from the field!' includes two articles: 'Northern Corn Leaf Blight' and 'Cereal Grain Testing'. The 'Northern Corn Leaf Blight' article states: 'Once again, We have seen increased Northern Corn Leaf Blight (NLB) pressure in our area. Northern leaf blight is a fungal disease found in humid climates wherever corn is grown. Click here to download entire article.' The 'Cereal Grain Testing' article states: 'comes to the Green Mountains! UVM Extension Northwest Crops and Soils Team Grain Quality Laboratory is up and running! Our lab is currently accepting samples and will continue to do so until December 1, 2010. Click here to download a Cereal Grain Test Submission Form.' A third article, 'Northeast Hop Alliance Presents Hops 101 and 201 Courses, Saturday-Sunday, October 9 and 10, 2010', is partially visible. The left sidebar contains a menu with items like 'UVM Home', 'UVM Extension', 'Northwest Crops and Soils Program', 'About the Northwest Crops and Soils Team', 'Forages', 'Grains', 'Oilseeds', 'Hops', 'Soil Health and Nutrient Management', 'Organic Farming', 'Events and Calendar', 'Videos', 'Out Croppings', and 'What's Happening'. At the bottom left, there is a logo for 'UNIVERSITY OF VERMONT EXTENSION' with the tagline 'CULTIVATING HEALTHY COMMUNITIES'. At the bottom right, there is a speaker icon.