The 'New' Crop in Town; A Revival of Hemp in the Midwest

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http://purduehemp.org

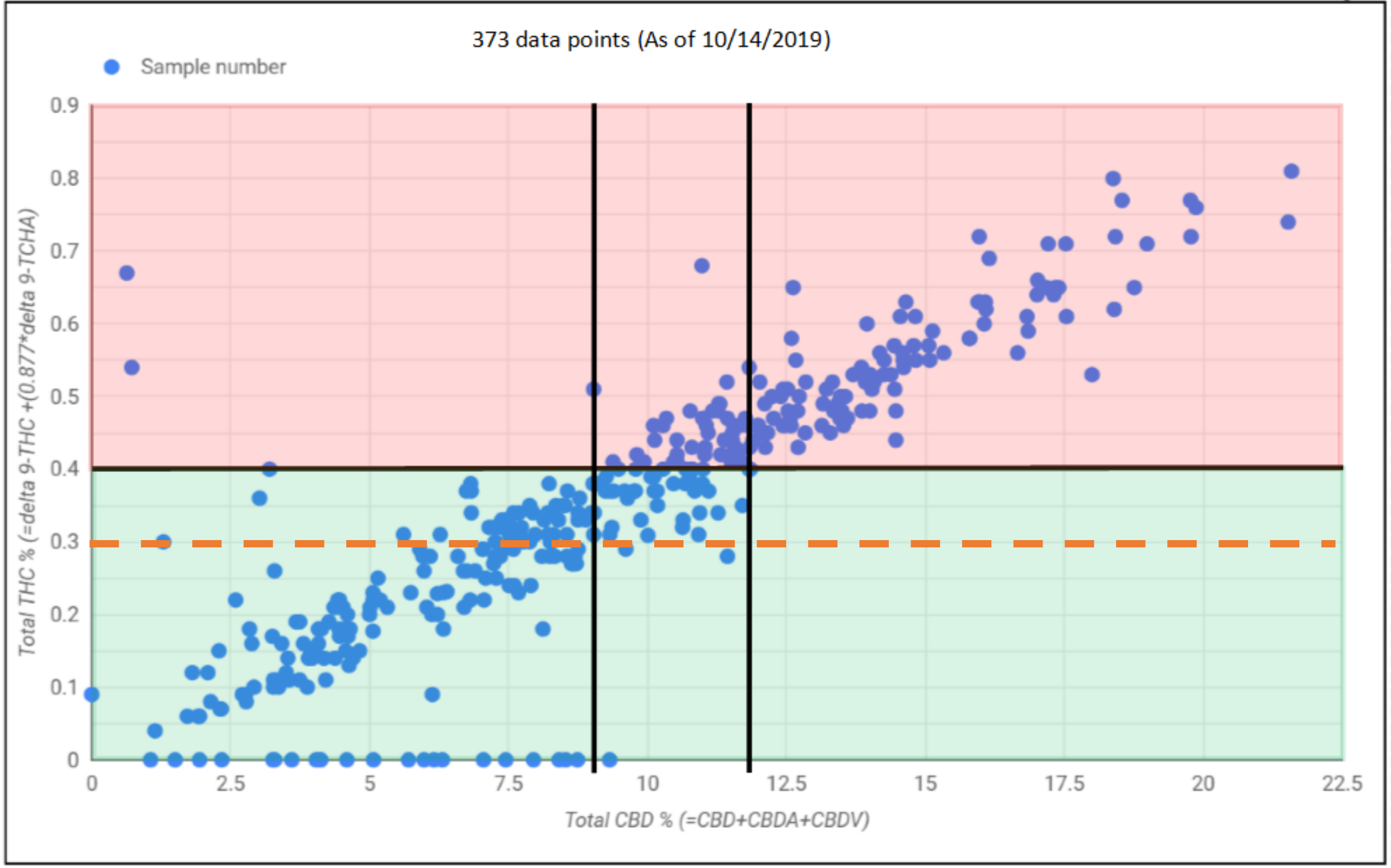
Hemp Biology

Cannabis sativa Biology

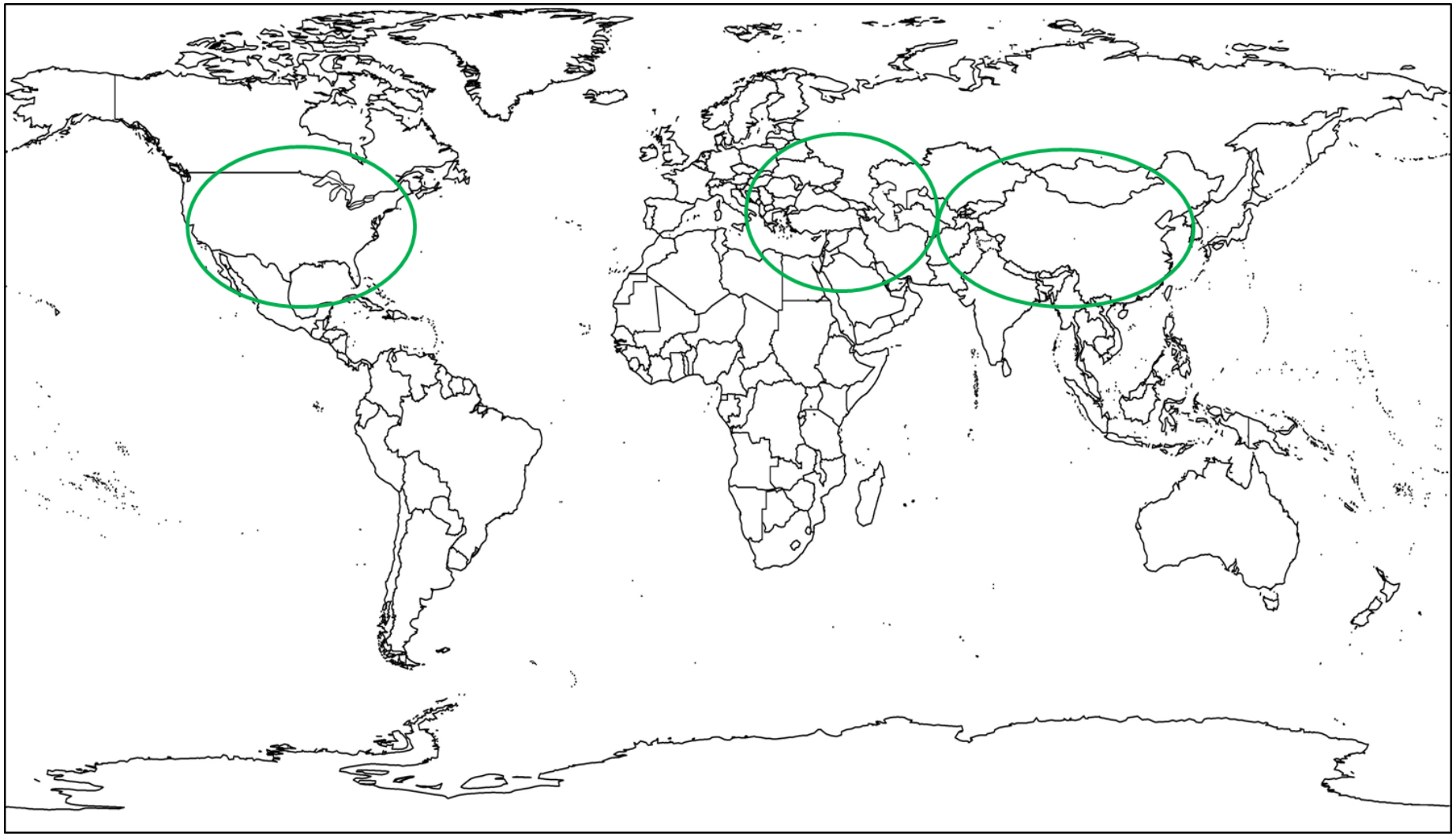
- Hemp is dioecious, meaning plants can be male or female.
  - Think asparagus
- Hemp grown for cannabinoids are typically all female
  - So-called “all-female” can also produce some hermaphrodites
- Photoperiod dependent plant
  - Responds to decrease in daylength

Cannabis sativa Biology

- Cannabis plants produce secondary plant compounds
  - Cannabinoids
  - Terpenoids
- Synthesized in structures on the outside of the plant
  - Glandular trichomes
  - On flowers, leaves, stems

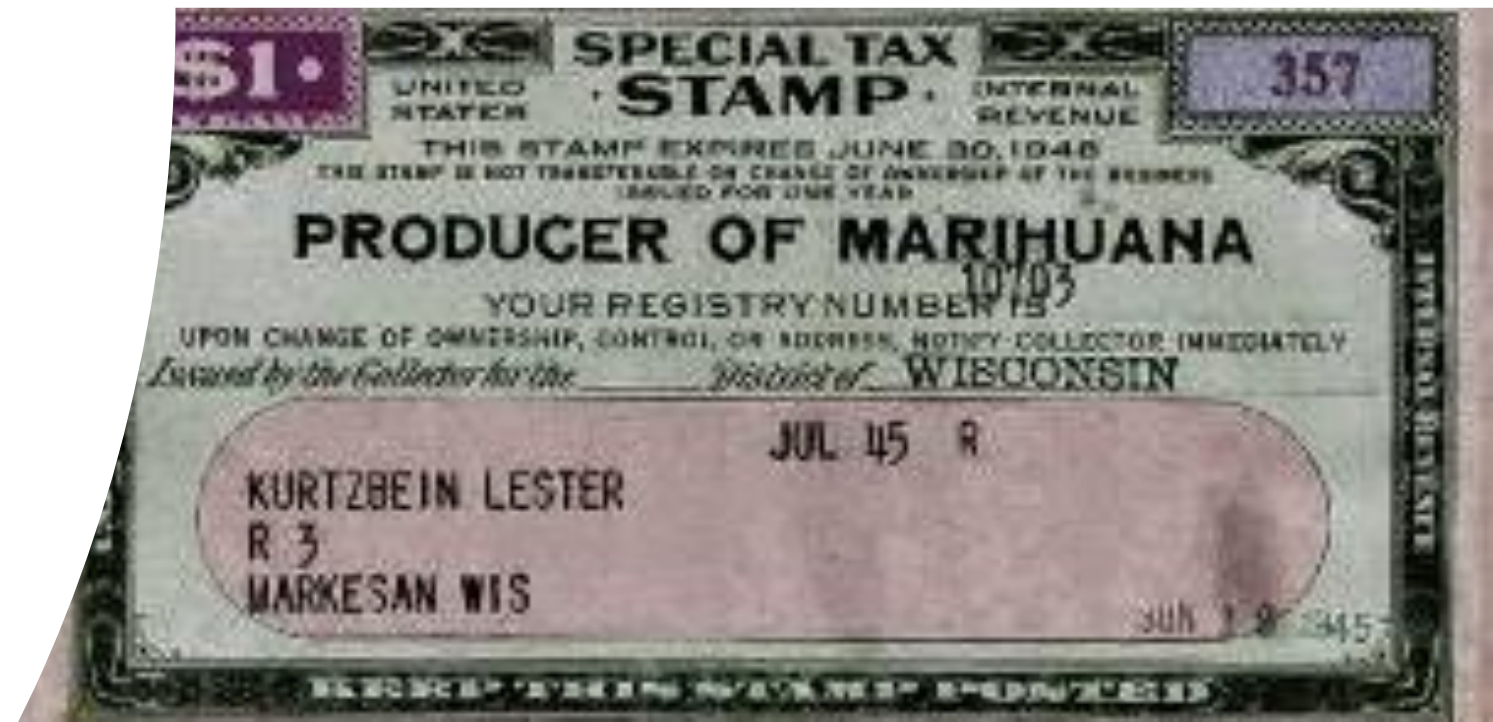

373 data points (As of 10/14/2019)
Sample number
Total THC % (=delta 9-THC +(0.877*delta 9-TCHA)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
Total CBD % (=CBD+CBDA+CBDV)

Cannabis sativa Origins



Hemp History

- Hemp was main textile fiber worldwide until the mid-19th century (replaced by cotton, synthetics)
  - 1857- twenty-seven IN counties grew hemp, ≈ 413 tons
  - Between Civil War and WWI most U.S. hemp grown in Kentucky



Popular Mechanics, 1938

BILLION-DOLLAR CROP

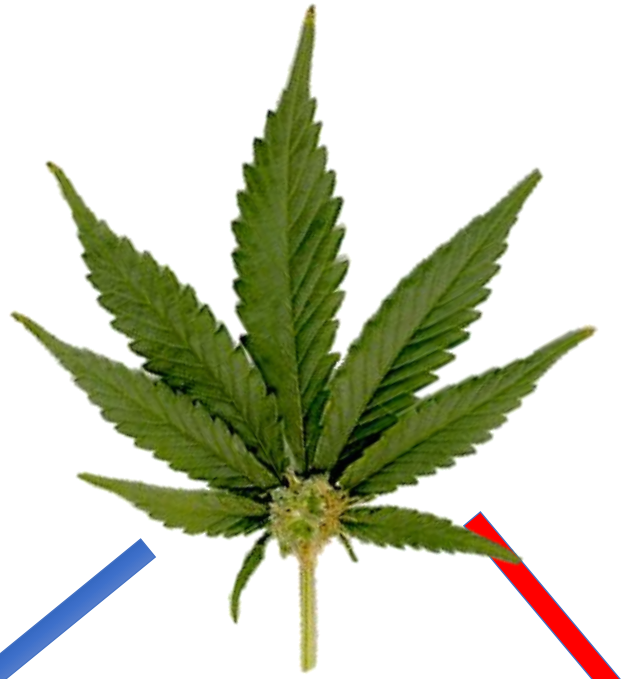
tition with coolie-produced
eign fiber while paying
ners fifteen dollars a ton for
p as it comes from the field.
om the farmers' point of
hemp is an easy crop to
and will yield from three
tons per acre on any land
vill grow corn, wheat, or
It has a short growing
, so that it can be plant-
r other crops are in. It
grown in any state of
ion. The long roots pen-
and break the soil to
in perfect condition for
t year's crop. The dense
f leaves, eight to twelve
ove the ground, chokes
eds. Two successive
are enough to reclaim
at has been abandoned
e of Canadian thistles or
grass.
er old methods, hemp

Continued to page 144A)

Top, modern version of linen duster made from hemp. Bottom, harvesting her with a grain binder. Hemp grows luxuriously in Texas

Uses

Cultivated for over 4,500 years



<0.3% THC

Hemp

Agricultural Production

Fiber

Oil

Food/ Feed

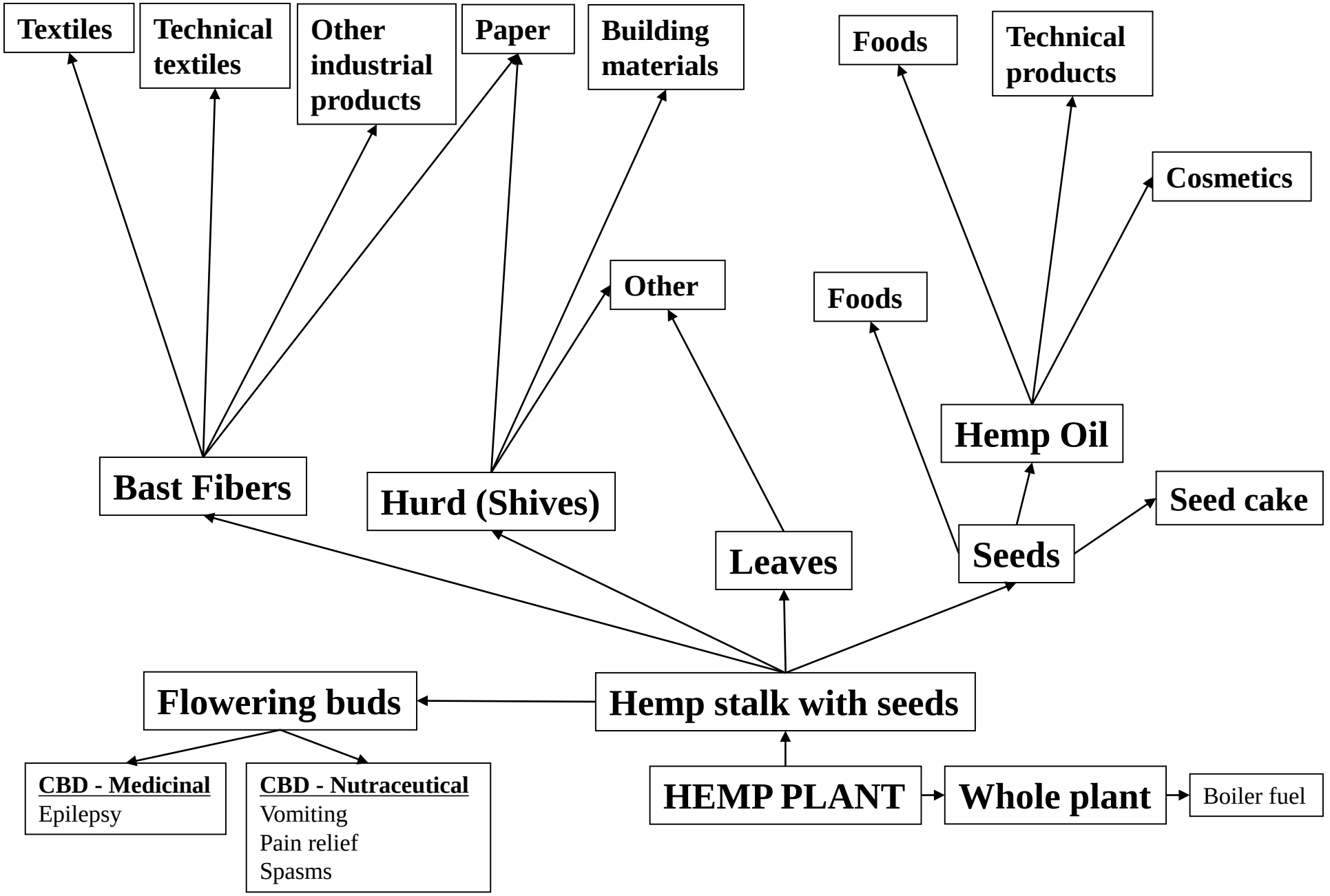
Marijuana

Glasshouse Production

Cannabinoids (CBD, CBG, etc)

THC

Nutraceutical and/or Pharmacological


Textiles
Technical textiles
Other industrial products
Paper
Building materials
Foods
Technical products
Cosmetics
Other
Foods
Bast Fibers
Hurd (Shives)
Hemp Oil
Seed cake
Leaves
Seeds
Flowering buds
Hemp stalk with seeds
CBD - Medicinal
Epilepsy
CBD - Nutraceutical
Vomiting
Pain relief
Spasms
HEMP PLANT
Whole plant
Boiler fuel

Hemp as Food

- Hemp seed is great source of polyunsaturated essential fatty acids.
  - positive effect on cardiovascular function, organ function, immunity levels, inflammation and muscle recovery.
- 30-40% of weight of hemp seed edible oils
- Contains all 20 amino acids including 9 essential
- High in protein and good fatty acids, including the essential fatty acids
  - **alpha-linolenic acid** (an omega-3 fatty acid)
  - **linoleic acid** (an omega-6 fatty acid).

Hemp as Feed

- Hemp material in feed will have to be nutrient driven and supported

TABLE 1: Whole Hemp Seed: Proximate Analysis

Study	Country of cultivation	Variety	DM%	MC%	PRO %	Oil%	Ash %	NDF%	GE (MJ/KG)
1	Finland	Finola		6.5	24.8	35.5			22
2	Canada	10 varieties	93.8		25.6	29.2	5.5	35.7	
3	Canada	Unika B	93.4		24.9	33.2	5.8	37.2	24.9
4	Canada	4 cultivars	94.1		24	30.4	4.8	32.1	24.2
5	Romania	5 varieties*				27.8			
6	China	No data	95.1		21.1	31.5	8.8		
MEAN			94.1 (0.6)	6.5	24.1 (1.6)	31.3 (2.5)	6.2 (1.5)	35.0 (2.1)	23.7(1.2)

DM=Dry Matter, MC= Moisture, PRO=Protein, NDF=Neutral Detergent Fiber, GE=Gross energy
*hemp was grown for phytoremediation

https://agr.wa.gov/getmedia/99f2b088-f956-48f0-a0b8-90b82c5e204c/584-hempseedprodfeedingrlayinghenslegreport.pdf

Organic HempPro Fibre

Organic Hemp Hearts

3. Uses

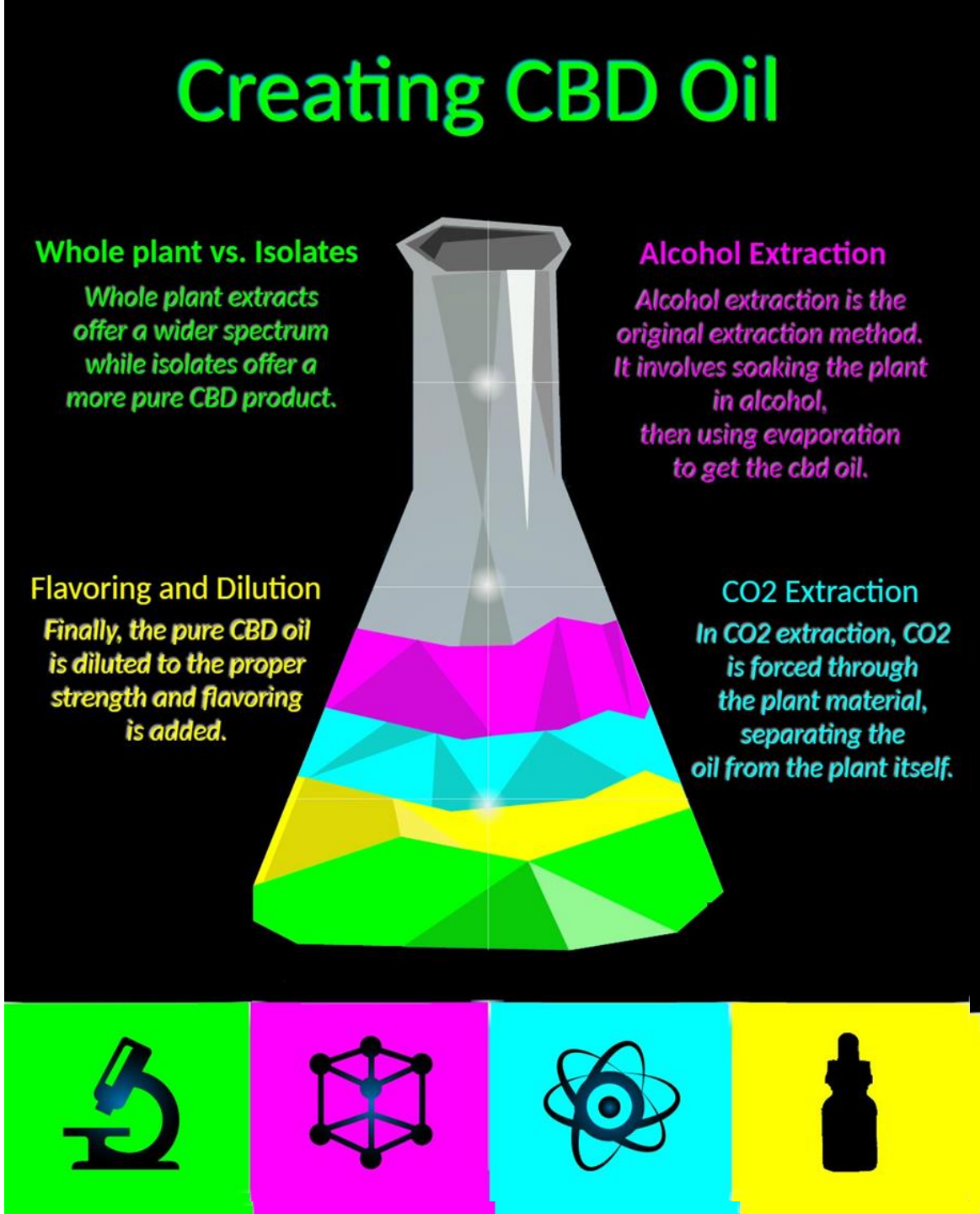
Hemp versus Cotton

- Hemp biomass consists of bast (outer core) about 25 to 30 per cent of the stalk and hurd (pithy inside part.
- Bast fibers are removed from plant material by retting.
- The cell walls of soft, bast or true fibers are cellulose and are not easily broken down by bacteria.
- In retting, the plant material is placed in water or kept wet, while anaerobic bacteria digest away most of the plant tissue except the fibers.
- Compared to other bast fibres (e.g., flax, kenaf, jute or ramie), hemp has excellent length, strength, durability, absorbency, anti-mildew and anti-microbial properties.

- Most important fiber in the world
- Cotton is an epidermal hair of the seed coat. There are both short (linters) and long hairs
- Ginning is used to remove seed fibers from the seeds.


Strong, Lightweight
& Breathable
Hemp
+ Lime
+ Water
Energy
Efficient
Flame, Water
& Pest Resistant
Lasts 100's

- CBD oil is made from Cannabis plants
- Plant buds and leaves are collected, and CBD is extracted
- Different solvents are used to extract dissolved CBD, along with oils and waxes
  - Alcohol (or some other solvent)
  - Oil
  - Supercritical CO_2
- Ethanol is further used to refine the oil and separate CBD from other oils and waxes
- HPLC is used to analyze the CBD oil to determine concentration



Production Basics

Indiana Hemp Production

- 5,308 acres registered in 2019 (2802 acres planted, 1977 acres harvested)
- Average field size ~ 30 acres
- 60% of acres registered for fiber, 35% for CBD, 5% for grain

Office of Indiana State Chemist and Seed Commissioner

2019 Total THC Test Results by Hemp Variety

****OISC does not recommend varieties, this document is the result of testing in 2019.*

Variety	Tested x	Total THC GC	Total THC UPLC	Acres Tested (rounded)	% of tests hot	Ratio
Abacus	2	0.375	0.504	7.5	50%	1 out of 2
Autopilot	3	0.224		15		
Awesome Blossom	1	0.51	0.577	0.05	100%	1 out of 1
Blue Genius	1	0.284		0.02		
Blue Haze	4	0.128		91		
Blue Mammoth	2	0.125		90		
Boax	6	0.2		48		
Bubby Remedy	3	0.578	0.544	12	100%	3 out of 3
CBDRX Cherry	2	0.421	0.489	16	50%	1 out of 2
Chard Cherry	1	0.204		45		
Cherry	4	0.238		50		
Cherry #5	4	0.339	0.501	4	25%	1 out of 4
Cherry Abacus	1	0.31		0.1		
Cherry Blossom	8	0.186		5		
Cherry Bubblegum	2	0.187		67		
Cherry Cherry	1	0.386		1		
Cherry Citrus	1	0.116		0.3		
Cherry DC	1	0.907	0.801	1		1 out of 1
Cherry Diesel	1	0.359		0.3		
Cherry Uno	5	0.265		24		
Cherry Wine	12	0.301	0.65	151	17%	2 out of 12

Quality Issues Facing Hemp

- Seed quality
  - State average ~70% germination in lab
  - Feminized seed as low as ~59% germination
  - Seed shortage for next year?
- Clone quality
  - Clones came infested or dead
  - Some male clones included
  - Some growers will opt for seeds next year

Date Rec'd	Variety	Germination %	Abnormal %	Dead %
3/22/17	CRS-1	64.25	28.75	7.00
3/22/17	CFX-1	52.25	33.25	14.50
3/22/17	Canada	67.00	24.75	8.25
3/22/17	Felina	83.00	4.50	12.50
3/22/17	Delores	69.00	24.75	6.25
3/22/17	Joey	59.50	14.50	26.00
3/22/17	Futura	71.25	14.25	14.50
3/22/17	Carmagnola	28.25	11.00	60.75
3/22/17	CFX-2	70.75	21.75	7.50
3/22/17	X-59	81.75	17.50	0.75

Seed Labels

How to Label Hemp Seed By Scottie Brittsan Office of Indiana State Chemist and Seed Commissioner July 12, 2019

- 1. Product name
- 2. Lot number
- 3. Variety/kind
- 4. Pure seed
- 5. Other crop seed
- 6. Inert matter
- 7. Weed seeds
- 8. Noxious Weed Seeds
- 9. Labeler
- 10. Disclaimer
- 11. Seed treatment
- 12. Germination dates
- 13. Origin
- 14. Germination

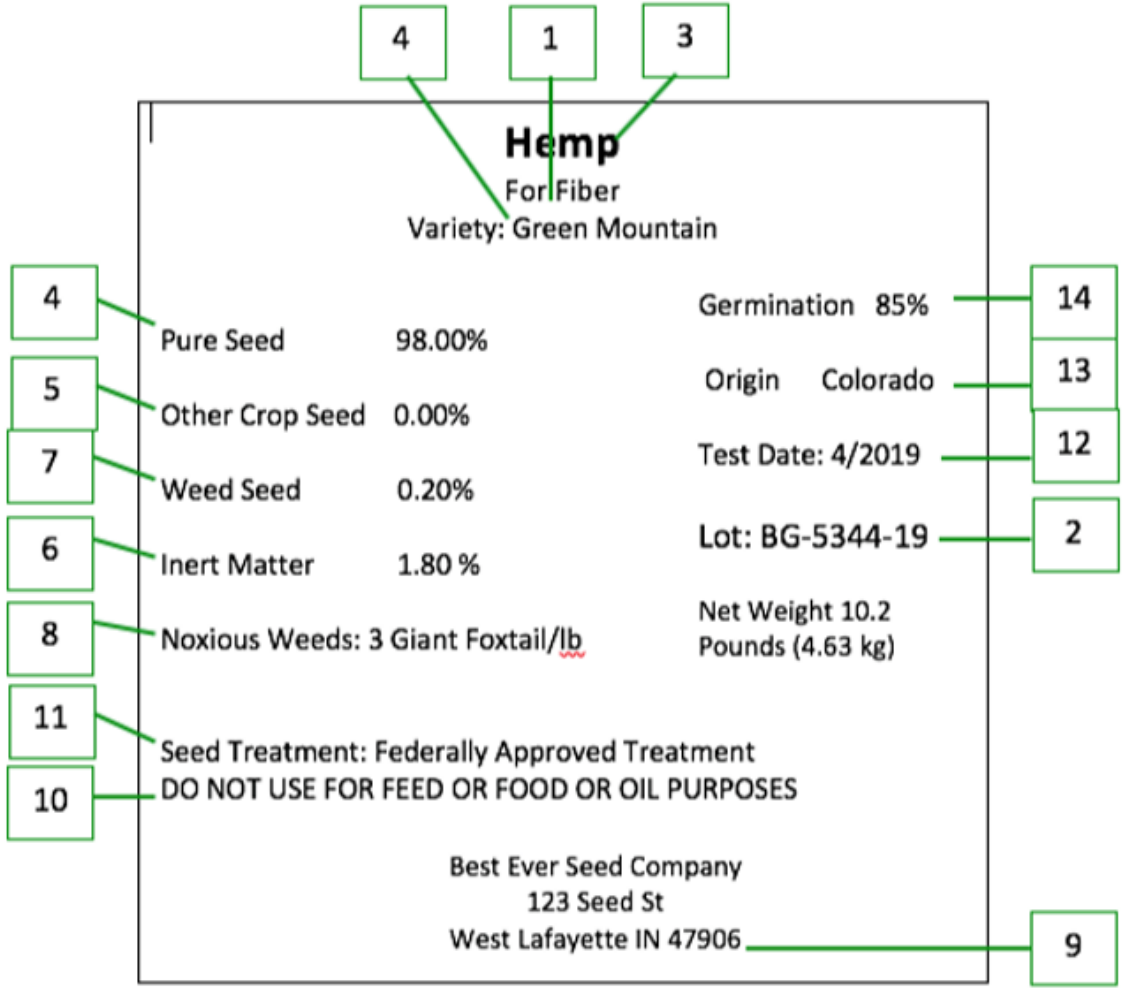
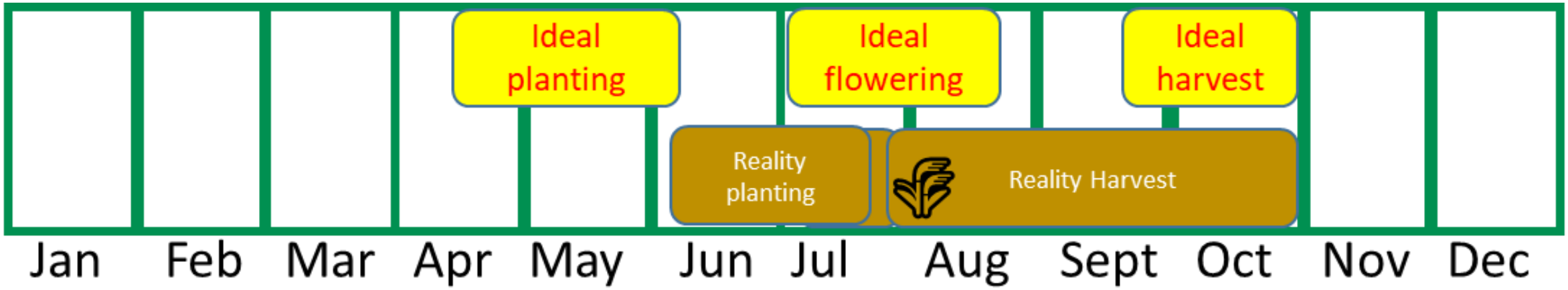


Fig 8. Example of a hemp seed label following the FSA

Planting and Harvest Windows

- No clearly defined planting window yet (may be different for each type of hemp)
- 74% of hemp was planted in June and July
- 72% of hemp was harvested in September and October



Nutrient Management

- Avoid applying nitrogen with seed (salt sensitivity)
- Canadian baseline recommendations 80-120 lb/ac nitrogen, 40 lb/ac phosphorus, 60 lb/ac potassium and 15 lb/ac sulfur
- No established recommendations based on Midwest specific data

Table 1. General agronomic recommendations for the main harvestable components of industrial hemp

	Fiber	Grain/Dual Purpose	Cannabinoids*
Seeding rate (PLS)	40-60#/A	30-40#/A	30-40#/A
Row spacing	8 inches	8-16 inches	8-16 inches
Soil pH	6.2-6.5	6.2-6.5	6.2-6.5
Applied nitrogen	50 lb/A	100 lb/A	50-100 lb/A
Available phosphorus	60 lb/A	60 lb/A	60 lb/A
Available potassium	300 lb/A	300 lb/A	300 lb/A
Harvest timing	</=20% male flowering	~70% grain maturity	~75% trichome maturity

*Optimum agronomic protocols for cannabinoid production in field-scale systems have not been defined by replicated research methods. Much of what is practiced today is extrapolated from *Cannabis* production systems in U.S. states where it is legal and/or from other countries. Many production practices from these systems (e.g., fertility) pertain mostly to indoor and not field-scale production. Very important questions remain regarding field-scale systems to produce cannabinoids. These include understanding the effects of variety, establishment methods (e.g., direct seeding versus transplanting), and general crop management decisions including nitrogen fertility and harvesting/processing/storage issues. Research is under way to address these questions.

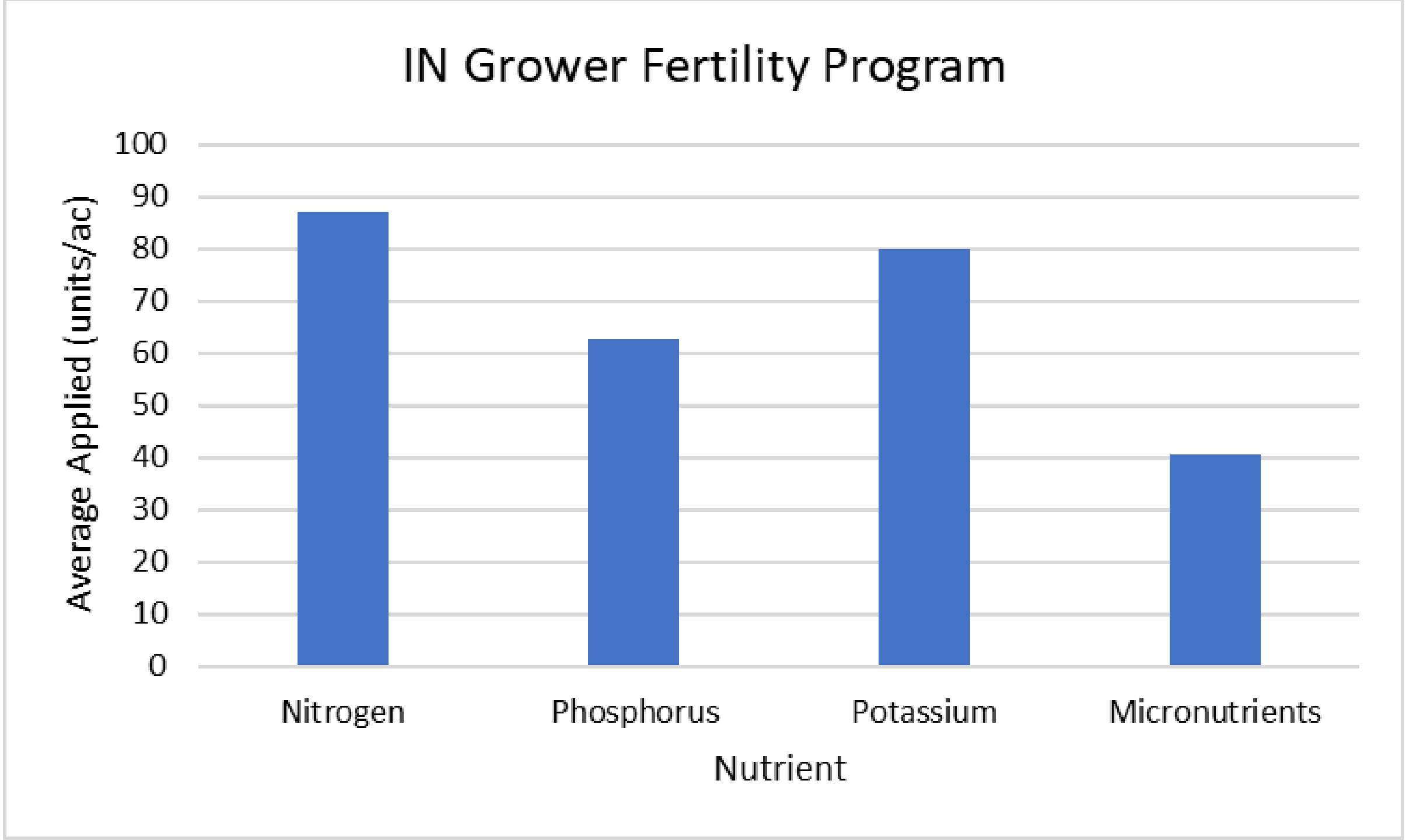
http://www2.ca.uky.edu/agcomm/pubs/ID/ID250/ID250.pdf

Table 1. Phosphorus and K fertilizer application rates based on soil test levels.†

Soil test category	Soil test P		P fertilizer rate	Soil test K		K fertilizer rate
	Loamy soils	Sandy/ Organic soils		Loamy soils	Sandy/ Organic soils	
	ppm P		lb P_2O_5/a	ppm K		lb K_2O/a
Very Low	< 10	< 12	80	< 70	< 45	105
Low	10 to 15	12 to 22	75	70 to 100	45 to 65	90
Optimum	16 to 20	23 to 32	45	101 to 130	66 to 90	60
High	21 to 30	33 to 42	20	131 to 160	91 to 130	30
Very high	-	-	-	161 to 190	-	15
Excessively high	> 30	> 42	0	> 190	> 130	0

†Bray-1 extractant is used for both P and K.

Figure from https://npketc.soils.wisc.edu/2018/05/02/fertility-guidelines-for-hemp-in-wisconsin/

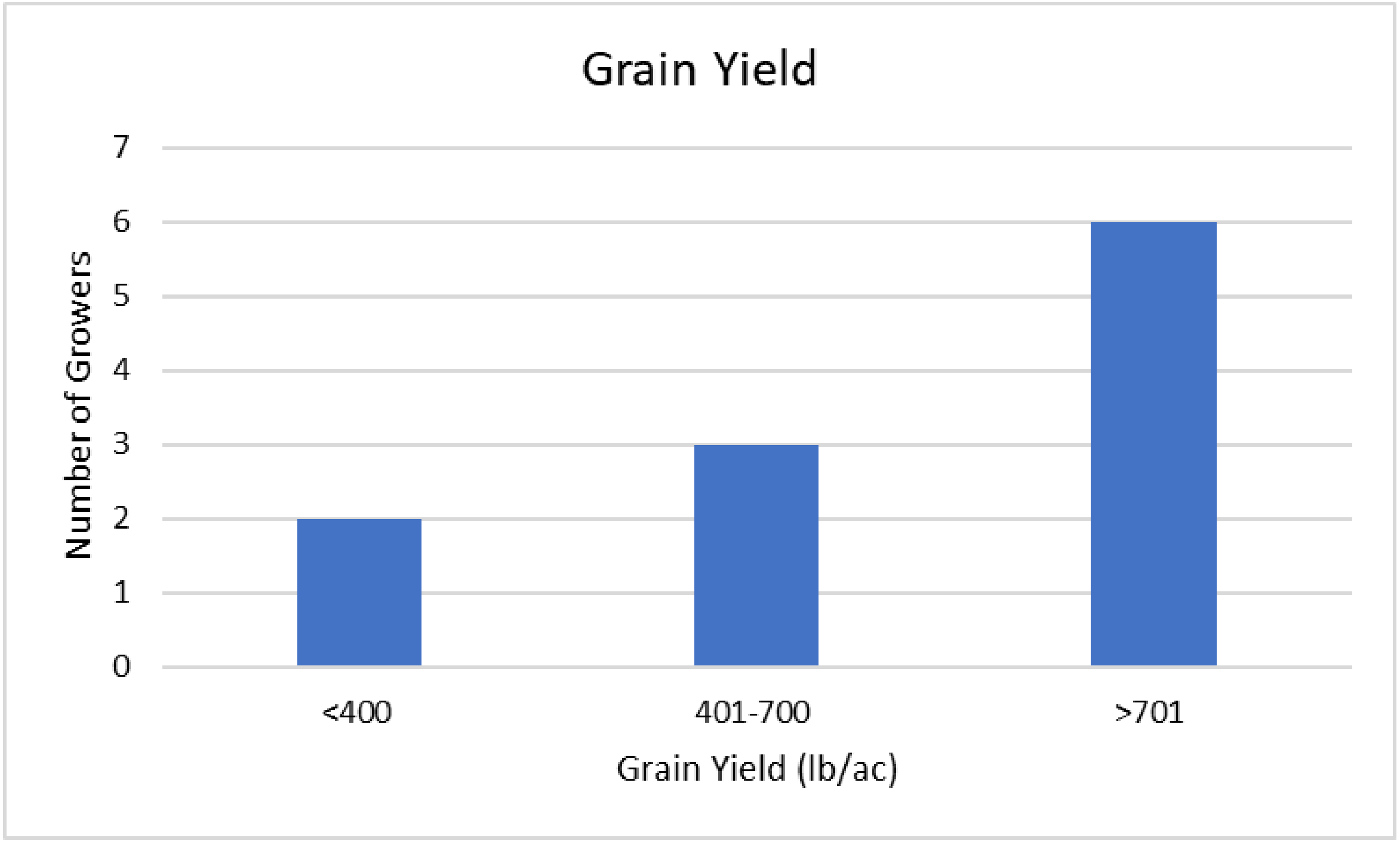

IN Grower Fertility Program
Average Applied (units/ac)
100
90
80
70
60
50
40
30
20
10
0
Nitrogen
Phosphorus
Potassium
Micronutrients
Nutrient

Producing for Grain/Seed

- Seed at 20-40 lb/ac
- Grain drill, Brillion seeder, corn planter were common methods in 2019
- Depth target of ¼ - ¾ inch (deeper plantings may be tolerated in sandy soil)
- Plant after a rain, not before

Producing for Grain/Seed

- $.40-1.23 per pound (2011)
- $.55-1.20 per pound (2019)


Grain Yield
Number of Growers
7
6
5
4
3
2
1
0
<400
401-700
>701
Grain Yield (lb/ac)

Producing for Fiber

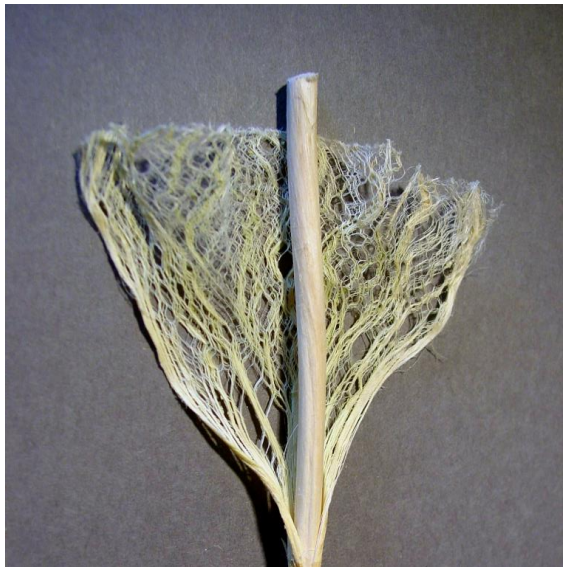
- Seed at 50-70 lb/ac
- Grain drill or broadcast were common methods in 2019
- Depth target of ¼ - ¾ inch (deeper plantings may be tolerated)
- Plant after a rain, not before

Wiki

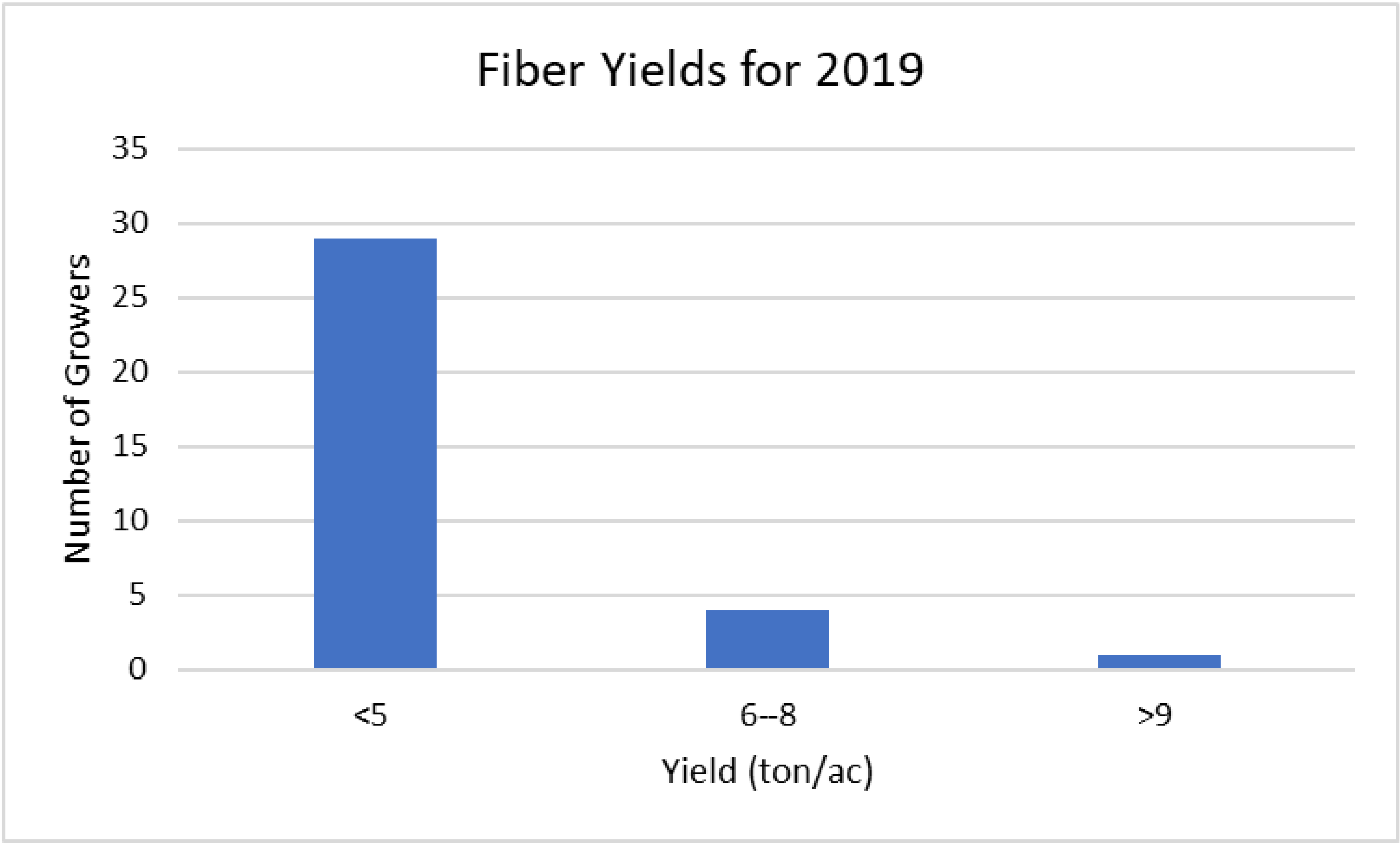
http://www.frankferrisco.com/hemp_casting/hemp_casting_fiber.html

Producing for Fiber

- $0.08 per lb dry stalk or $160 per ton
- 5,300 lbs transforms into approximately 1,300 pounds of fiber.
- Methods for processing the fiber, specifically separating the core/hurds from the fiber is considerably more difficult.



Wiki

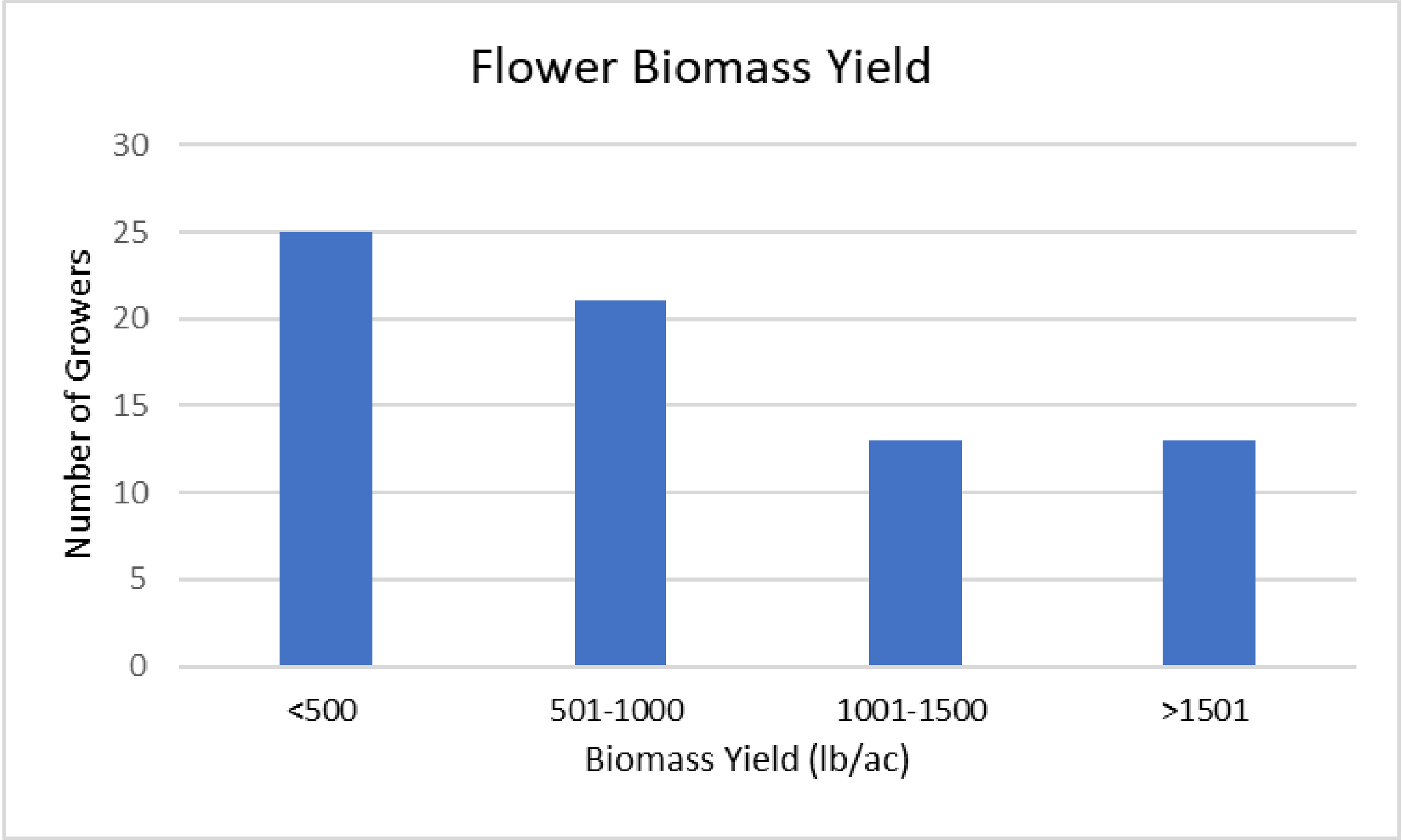

Fiber Yields for 2019
35
30
25
20
15
10
5
0
Number of Growers
<5
6--8
>9
Yield (ton/ac)

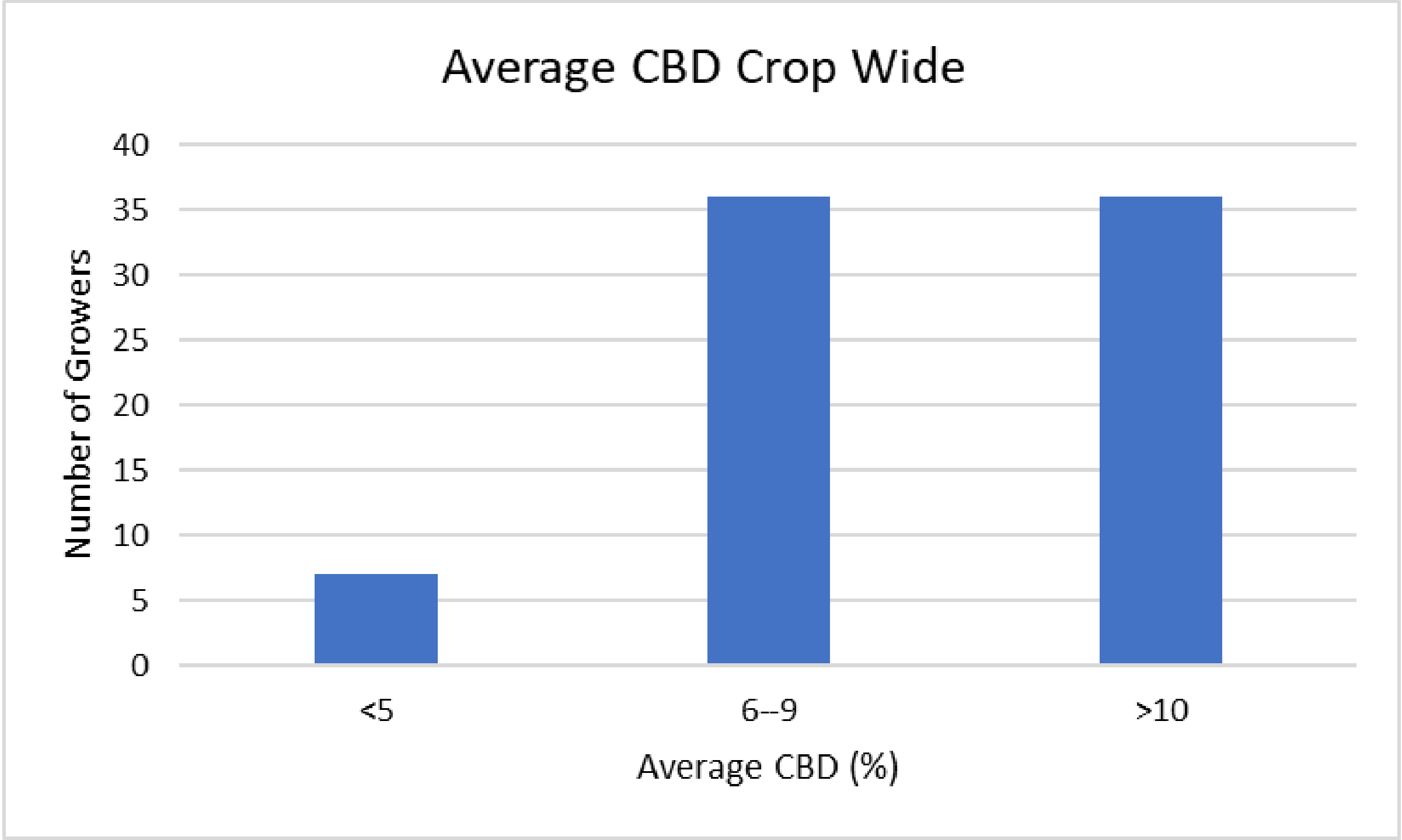
Producing for Cannabinoids

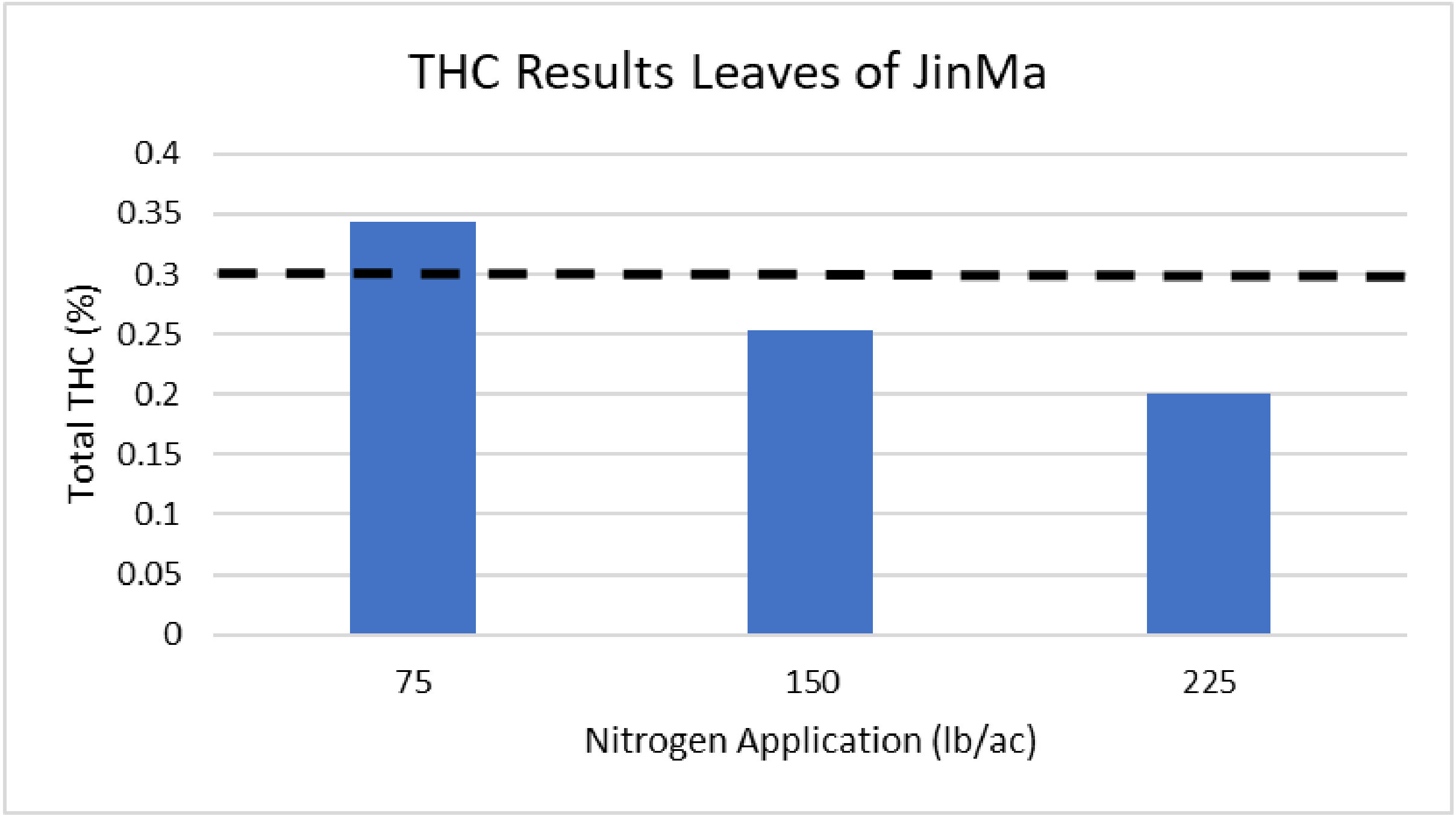
- Planting 800-2400 plants/ac
- Transplanted seedlings or clones using water wheel/tobacco setter or by hand in 2019
- Raised beds, plasticulture, drip irrigation

Producing for Cannabinoids

- Example of price breakdown:
  - Average yield of one pound of floral material @ 10% CBD
  - Price/percentage/lb
- $1.50/percentage/lb @ 10% CBD makes that plant worth $15
  - At 1500 plants/ac you have $22,500
- Price for CBD has decreased since spring


Flower Biomass Yield
30
25
20
15
10
5
0
Number of Growers
<500
501-1000
1001-1500
>1501
Biomass Yield (lb/ac)

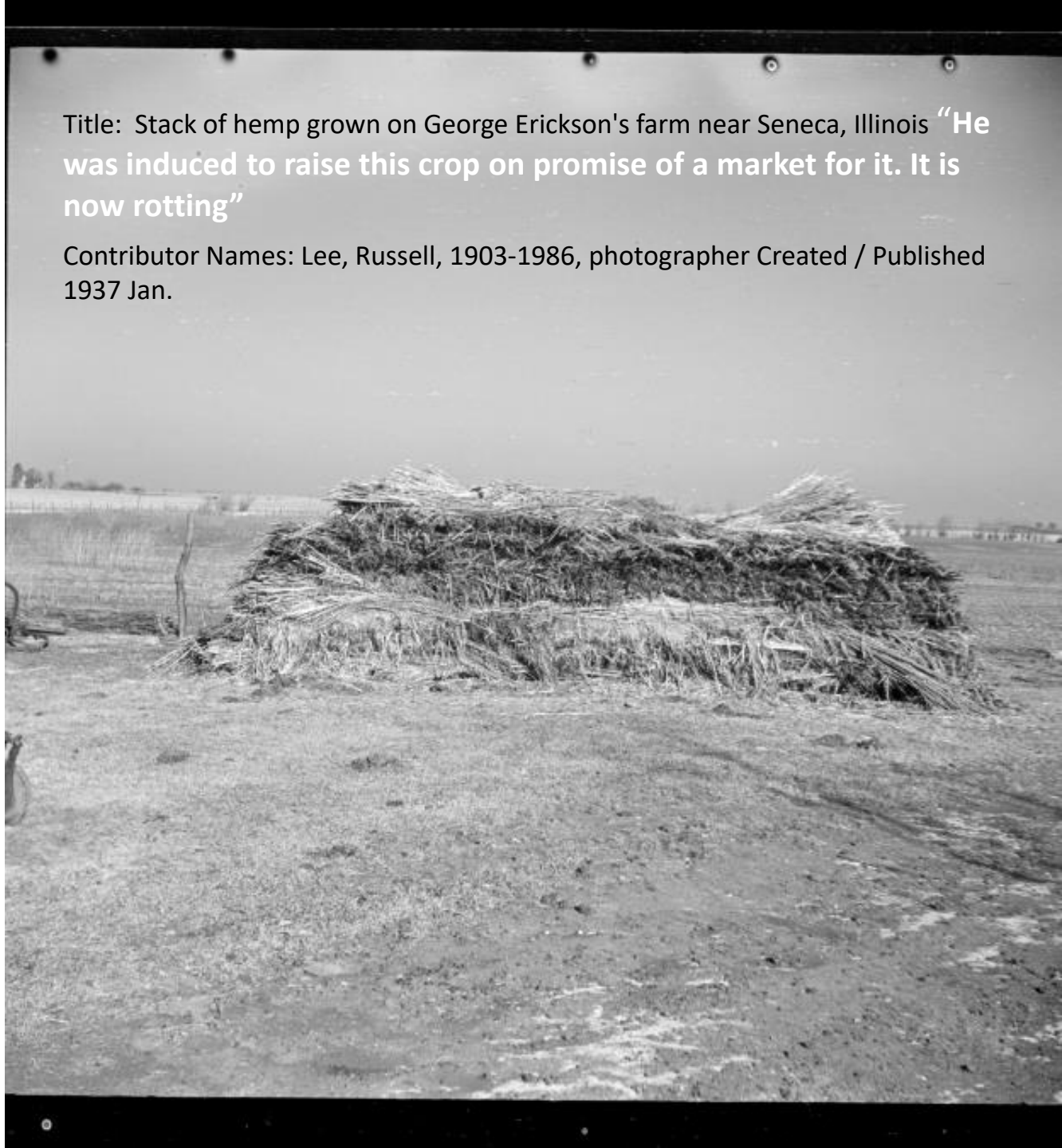

Average CBD Crop Wide
40
35
30
25
20
15
10
5
0
Number of Growers
<5
6--9
>10
Average CBD (%)


THC Results Leaves of JinMa
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Total THC (%)
75
150
225
Nitrogen Application (lb/ac)

Key Issues

Key Issues Facing Hemp Production

- Legal climate is in flux
- Contracts
- Seed/clone quality and availability
- Location of production
- Pest and pest management



Site Selection Issues

- Hemp does not like wet feet
- Avoid clay heavy soils or compacted soils
- Choose fertile field sites
- Poor quality fields will produce poor quality hemp


6/18/2015


7/10/2015

Emergence Issues

- Hemp, soybeans, and other ‘dicots’ are more prone to poor stand establishment than corn or wheat
  - the seedling must pull the cotyledon seed leaves through the ground to emerge.

Crusting

- Can delay or prevent emergence
- Hemp hypocotyls become swollen and/or break
- If the hypocotyl breaks, the seedling usually dies
- Fields with fine-textured soils, low organic matter, and little surface residue can be vulnerable to crusting, especially where excessive tillage has taken place.

Pests and Pesticides

- Pathogens, insects, weeds
  - Some pathogens and insects were observed for the first time
- 25(b) products are allowed
  - OISC has their own list specific to Indiana
- Lack of registered products makes control an issue
  - EPA released a list of 10 products

Indiana list of 25(b), minimum risk, pesticide products acceptable for use on hemp
updated 9/10/19

OISC Product ID	Company Name	Product Name	OISC 25B Number
2014076760	BONIDE PRODUCTS INC	BONIDE BURNOUT FAST ACTING WEED & GRASS KILLER CONCENTRATE	4-25B-20
2014075459	BONIDE PRODUCTS INC	BONIDE MAIZE WEED PREVENTER READY TO	4-25B-19
2016079566	DR EARTH CO	DR EARTH PURE & NATURAL FINAL STOP VEGETABLE GARDEN INSECT KILLER	999999-25B-5
2016079572	DR EARTH CO	DR EARTH PURE & NATURAL FINAL STOP VEGETABLE GARDEN INSECT KILLER	999999-25B-11
2016079564	DR EARTH CO	DR EARTH PURE & NATURAL FINAL STOP WEED & GRASS HERBICIDE	999999-25B-3
2016079568	DR EARTH CO	DR EARTH PURE & NATURAL FINAL STOP YARD & GARDEN INSECT KILLER	999999-25B-7
2016079570	DR EARTH CO	DR EARTH PURE & NATURAL FINAL STOP YARD & GARDEN INSECT KILLER CONCENTRATE	999999-25B-9
2017081117	GARDENS ALIVE!	WOW! WITHOUT WEEDS PRE-EMERGENT WEED CONTROL FOR LAWNS AND GARDENS 9-0-	56872-25B-20
2008066324	JH BIOTECH INC	SAFERGRO ANT OUT NATURAL ANT/INSECT KILLER RTU	68573-25B-1
2014076718	JH BIOTECH INC	SAFERGRO BIOREPEL NATURAL INSECT	68573-25B-9
2008066326	JH BIOTECH INC	SAFERGRO MILDEW CURE NATURAL POWDERY MILDEW FUNGICIDE RTU	68573-25B-2
2008066327	JH BIOTECH INC	SAFERGRO PEST OUT NATURAL INSECTICIDE & MITICIDE RTU	68573-25B-3
2008066325	JH BIOTECH INC	SAFERGRO WEEDZAP NATURAL BIODEGRADABLE NON-SELECTIVE HERBICIDE	68573-25B-4
2016080213	KEMIN INDUSTRIES INC	TETRACURB CONCENTRATE	8596-25B-1
2005060211	KTI DIRECT	MOLEXIT	999999-99999
2014075869	LIQUID FENCE CO	ECOLOGIC GARDEN INSECT KILLER	72041-25B-25
2014075870	LIQUID FENCE CO	ECOLOGIC GARDEN INSECT KILLER	72041-25B-24
2014075875	LIQUID FENCE CO	ECOLOGIC HOUSEPLANT & GARDEN INSECT	72041-25B-26
201207355	MOTOMCO	TOMCAT MOLE & GOPHER REPELLENT LIQUID	3240-25B-2
2019084806	P F HARRIS MANUFACTURING COMPANY LLC	HARRIS DEER & RABBIT REPELLENT SPRAY	3-25b-5
2017082173	PACIFIC SHORE HOLDINGS INC	NATURE-CIDE ALL-PURPOSE COMMERCIAL CONCENTRATE INSECTICIDE	90395-25B-3
2019085259	SAFER INC	SAFER BRAND WEED PREVENTION PLUS	42697-25B-3
2010068464	ST GABRIEL ORGANICS	HOLY MOLEY MOLE REPELLENT	63191-25B-1
2018085257	UNITED COMPOST & ORGANICS INC	BUSHDOCTOR FORCE OF NATURE INSECT REPELLENT (CONCENTRATE)	71996-25B-1
2018085258	UNITED COMPOST & ORGANICS INC	BUSHDOCTOR FORCE OF NATURE MITICIDE (CONCENTRATE)	71996-25B-2
2019084573	VIC WEST IMPORTERS	GRANDPA GUS'S CINNA-MINT SCENTED MOUSE REPELLENT POUCHES	93142-25B-3
2019084573	VIC WEST IMPORTERS	GRANDPA GUS'S MOUSE REPELLENT POUCHES	93142-25B-2

Pythium species

Compaction and lack of drainage predispose plants to disease.

Standing water increases humidity and foliar phase

- Periods of saturated soil = more *Pythium* damage.
- Improved drainage of soil after a few years will lower the risk of *Pythium* root rot.

How many species of *Pythium* are there?

- *P. ultimum**
- *P. aphenidermatum**
- *P. graminicola*
- *P. afertile*
- *P. irreg.-debaryanum*
- *P. catenulatem*
- *P. dissotocum*
- *P. rostratum*
- *P. torulosum**
- *P. heterothallicum**
- *P. vexans*
- *P. middletonium*
- *P. sylvaticum**
- *P. venosum*
- other *Pythium* spp

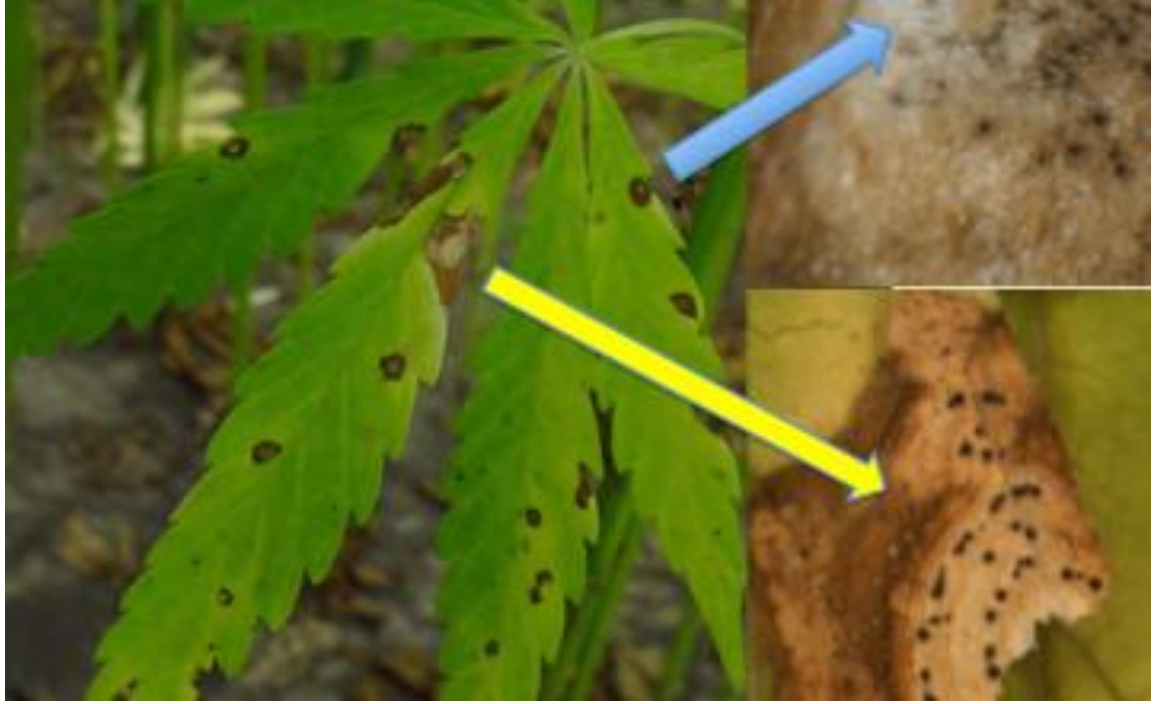
Other Hemp Root Rots

- Phytophthora spp.
- Fusarium spp.
- Rhizoctonia spp.
- A lot of unknowns.

Hemp Foliar Disease

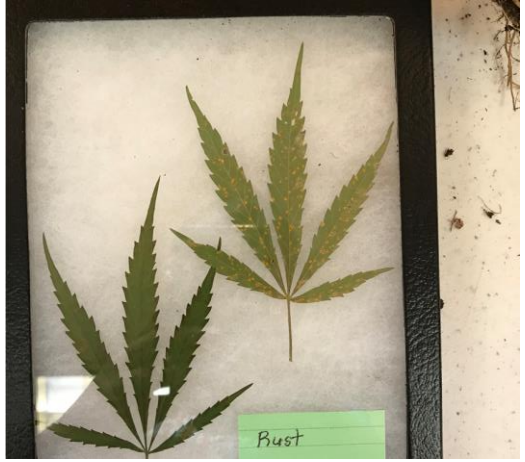
- Hemp is susceptible to several foliar diseases, including:
  - Cercospora leaf spot results in circular, depressed sunken centers.
  - Phoma leaf spot has been reported to reduce yield

- Hemp Leaf Spot
  - Biopolaris spp. Small, round spots on leaves, leaf curling/browning



Hemp Foliar Diseases

- Foliar Diseases
  - Powdery Mildew
  - Rust
  - Virus

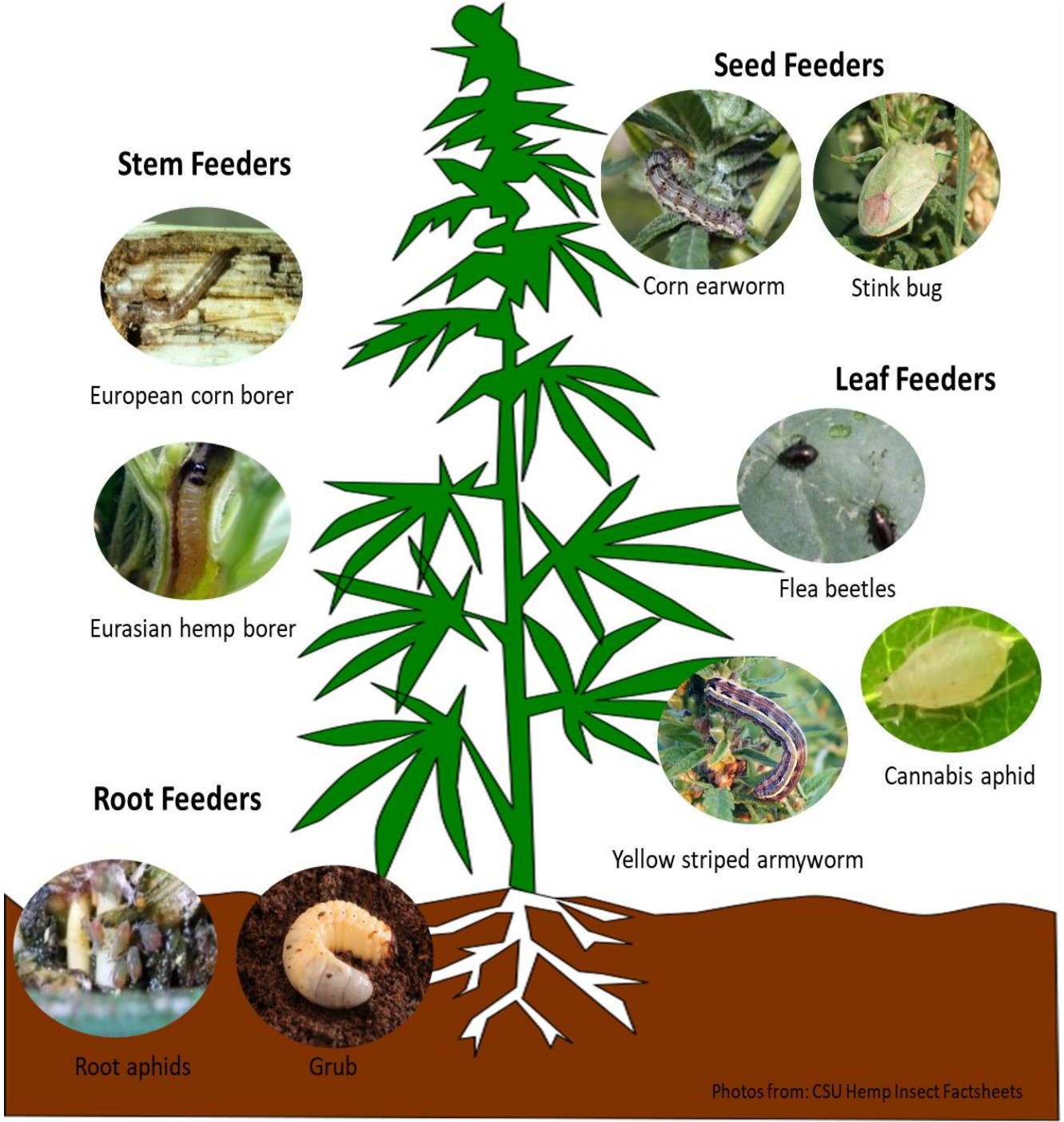


Hemp Stem Diseases

- Select field sites that don’t have a history of disease.
- White mold
- Southern blight

Hemp Insects

- Hemp is fed on by many insects
- Which ones are economically important?
- Some growers observed insects cause minimal damage to the leaves
  - adult beetles, armyworms, variegated cutworms



Corn earworm (*Helicoverpa zea*)

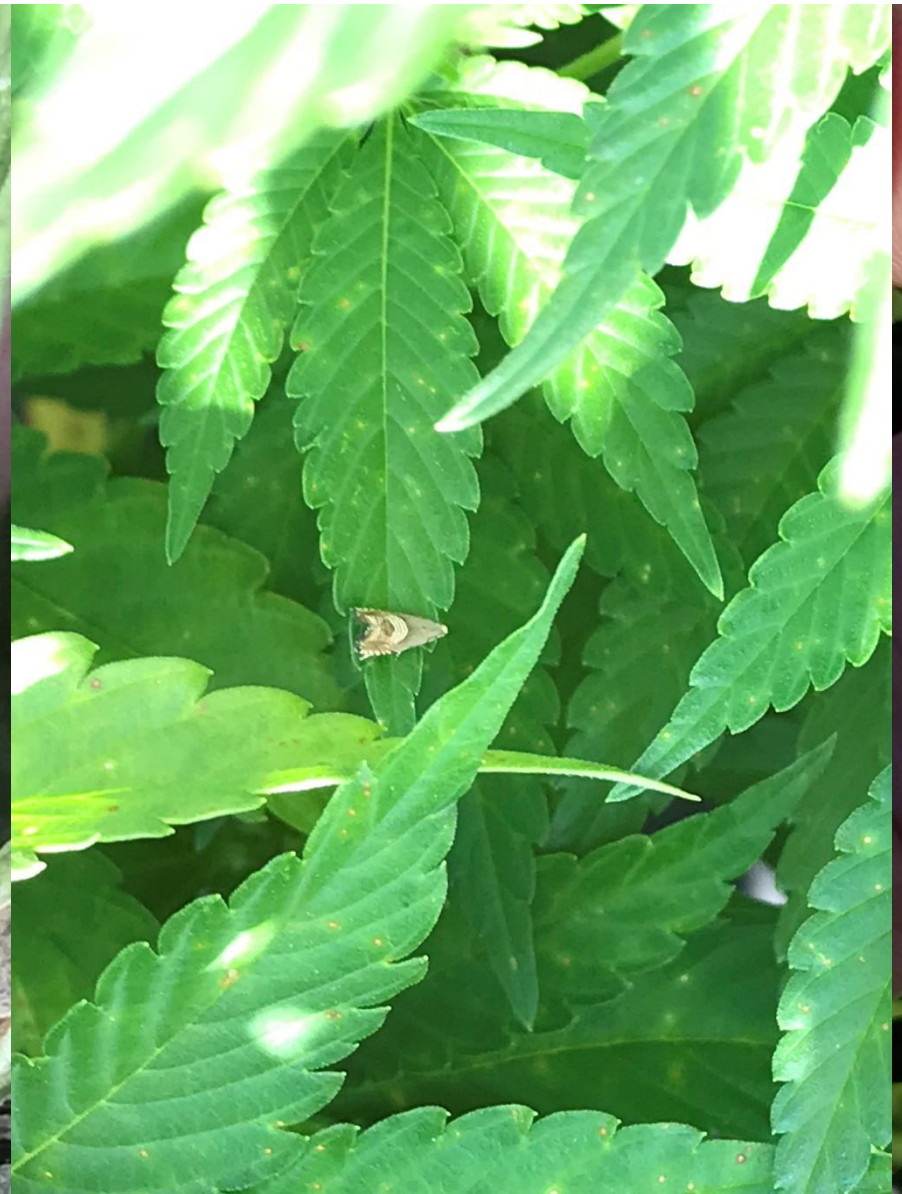
https://extension.entm.purdue.edu/cornearworm/index.html

Potato leafhopper (*Empoasca fabae*)

Indiana Ditchweed

- Ditchweed populations around northern Indiana
- Reservoir for hemp specialists
- Both Eurasian hemp borer and cannabis aphid found in ditchweed

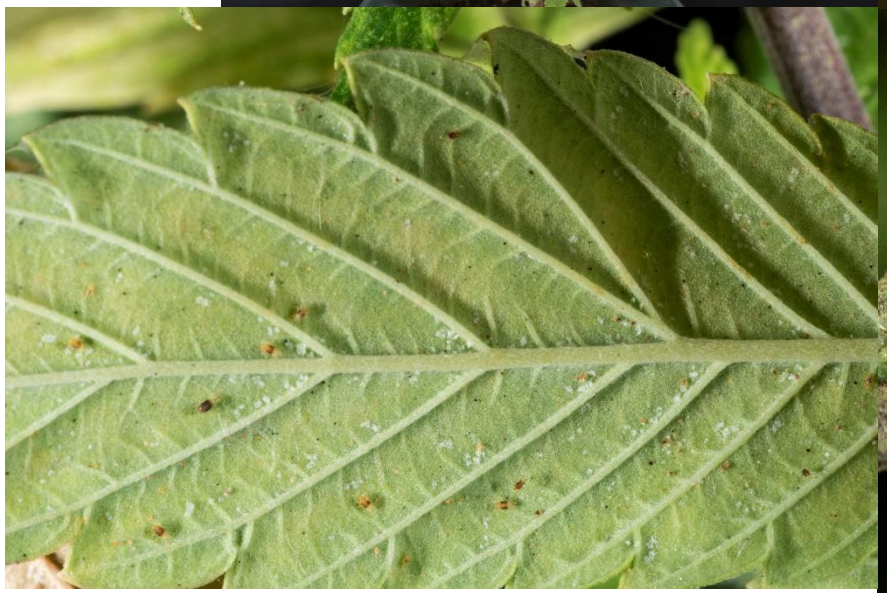
Eurasian hemp borer (*Grapholita delineana*)



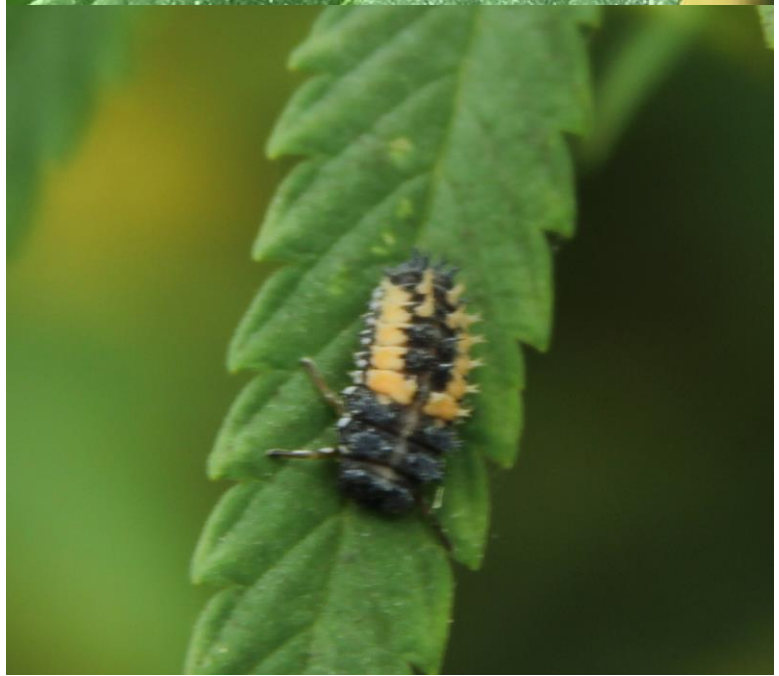
Hemp Insects and Mites

Photos: John Obermeyer

- Greenhouse pests are concerning for indoor production
  - Spider mites
  - Whiteflies
  - Thrips
  - Hemp russet mites
  - Cannabis aphid



Beneficial Insects

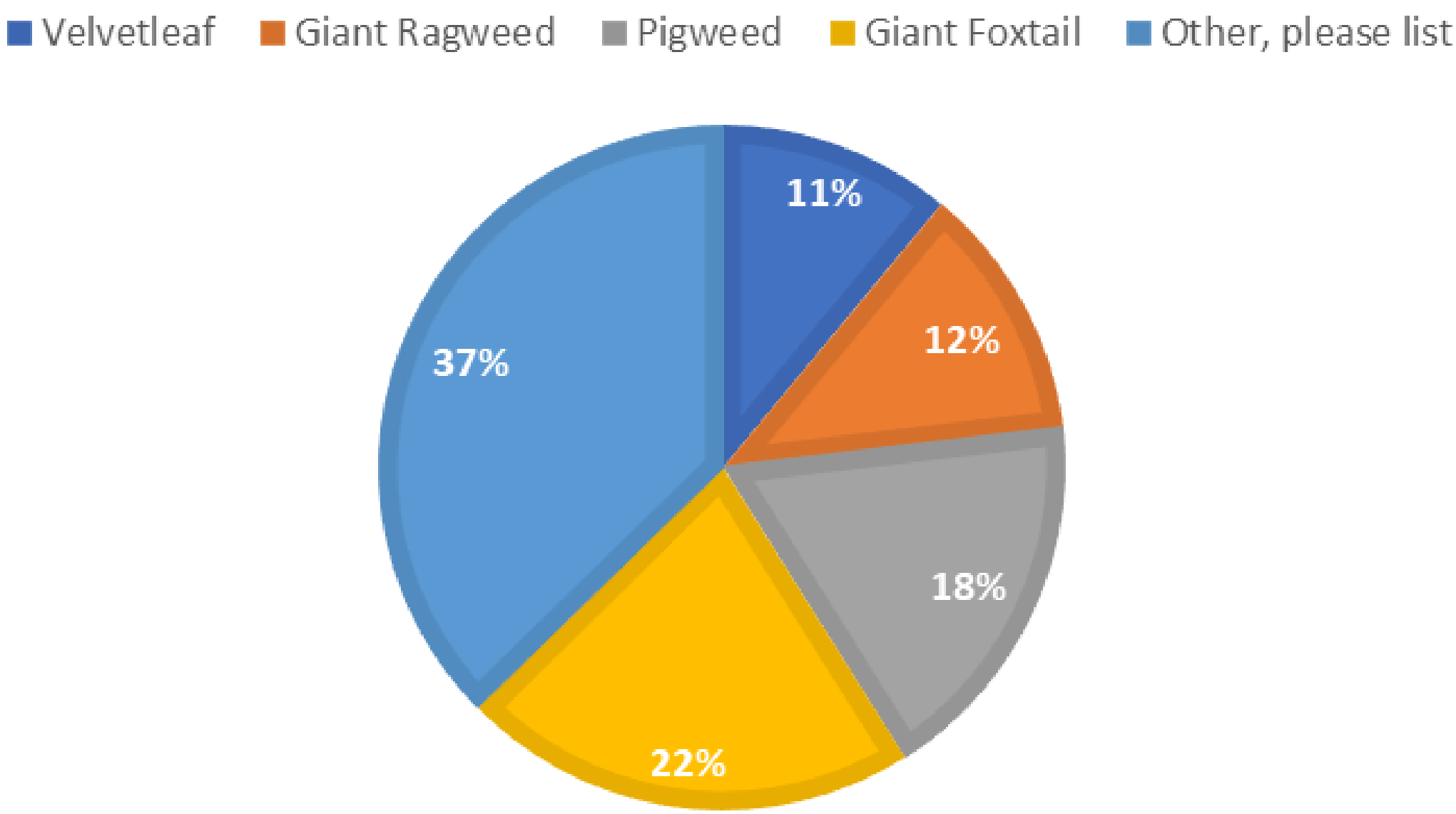


More Beneficial Insects…

Weed Issues

- Slow growth phase of hemp
  - Hemp is not competitive in first 3-4 weeks
- Weed control is challenging
  - No herbicides labeled for use in hemp
- Growers struggled with weed control
  - Used hand labor to remove weeds

WEED ISSUES


Velvetleaf
Giant Ragweed
Pigweed
Giant Foxtail
Other, please list
11%
12%
18%
22%
37%

Herbicide Spray Records

Rotation Restrictions Before Planting Industrial Hemp (in Months After Application):

- **0 months** = Cadet, Cobra, Glyphosate 4 Plus, Glyphosate 5.4, Gramoxone SL 2.0, Roundup PowerMAX
- **1 month** = Fusilade DX, Resource, Select Max
- **1.5 months** = Harmony SG
- **3 months** = 2,4-D (e.g., 2,4-D Amine, Barrage HF, Salvo, Shredder 2,4-D LV4)
- **4 months** = Assure II, dicamba (e.g., Clarity, Engenia, Fexapan, Status, XtendiMax)
- **6 months** = Liberty 280
- **9 months** = Confidence, Harness, Outlook, Sharpen, Verdict, Warrant
- **12 months** = Aim, Authority Elite, Boundary, Cinch, Command 3ME, Dual II Magnum, Parallel
- **18 months** = Anthem, Anthem Maxx, Armezon, Authority MTZ, Balance Flexx, Basis Blend, Beacon, Callisto, Callisto GT, Corvus, Dimetric DF 75%, FirstRate, Halex GT, Impact, Instigate, Lumax EZ, Prefix, Prequel, Raptor, Require Q, Resolve DF, Resolve Q, Resolve SG, Rowel, Solstice, Spirit, Valor SX, Valor EZ, Vise, Zemax, Zidua, Zidua SC
- **24 months** = Prowl H2O
- **26 months** = Hornet, SureStart II, TripleFLEX
- **30 months** = Authority Assist, Authority First, Canopy, Classic, Enlite, Envive, Rowel FX, Sonic, Synchrony, Trivence, Valor XLT
- **36 months** = Authority Maxx, Authority XL, Permit
- **40 months** = Extreme, Optill, Optill PRO, Pursuit, Torment

http://www.wiscweeds.info/post/herbicide-rotation-restrictions-before-planting-industrial-hemp/

We will soon release an in-detail publication with additional information on how herbicide rates and soil characteristics influence rotational Industrial Hemp crop restrictions. Stay tuned!

PU Hemp Specialist

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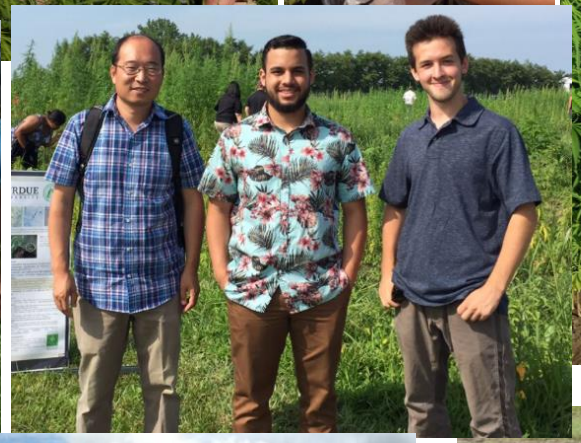




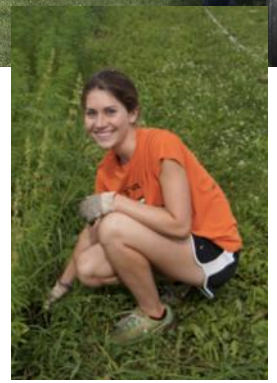


Thank you!