Agronomic practices regarding industrial hemp production for cannabinoids: A pilot study in Florida

Josh Freeman
Rui Yang
Erin Berthold
Sarah Benevenute

What is Industrial Hemp

Cannabis sativa with THC < 0.3% per dry weight

Botanically: indistinguishable from marijuana

Legally: distinguished by THC content

Economically: potentially valuable alternative crop

Ecologically: potential invasive species

Why Industrial Hemp

Multi-use crop

- Fiber (textiles)
- Food (hemp seed oil, greens)
- Feed (forage)
- Building material (hempcrete)
- Bioplastics
- Medicinal (CBD extract)
- Environmental remediation

Hemp Basics

Fiber (Stem)

Grain (Seed)

- Has been grown in Europe, Canada, and China
- Pilot project in Kentucky
- Typical “commodity” crop model with mechanization

Industrial Hemp

CBD (Female flower)

- Typical “specialty” crop model
- Mechanization is coming but currently not ready
- Very little information is published on how to grow CBD-type industrial hemp

What is Industrial Hemp

Hemp Basics

- **Most varieties are day-length sensitive**
  - ✓ Vegetative during long days – Flower during short days
  - ✓ Defined growing season outdoors – late May – early July
- **Can be grown from seedlings or "clones" (rooted cuttings)**
  - ✓ Cost differential between the two - $1.50 - $7
- **Only female plants are desirable for CBD production**
  - ✓ Feminized seed or rooted cuttings from female plants
  - ✓ Desirable extracts are contained in the trichomes found primarily on female flowers (buds)
  - ✓ Pollination is detrimental – male plants must be rogued

Hemp Basics

- **Plants must be dried, and female flowers must be stripped from stems (for most processors)**
  - ✓ Mechanization is coming but not ready at this time
- **No registered pesticides (herbicide, insecticide, fungicide)**
  - ✓ Weed control is a serious problem
  - ✓ Caterpillar pests are a serious problem

UF/IFAS Research Objectives

The Goal Support the future viability and sustainability of an industrial hemp industry

The Plan Industry funded research and outreach at UF/IFAS research facilities with a multidisciplinary team to:

- ✓ Identify hemp varieties suitable for planting in Florida's various environments
- ✓ Develop hemp management practices and cropping systems economically viable for Florida
- ✓ Assess hemp invasion risk in Florida's natural and agricultural environments

Variety trial

- Evaluated varieties (5)
  - Day-length-sensitive varieties (3)
    - ✓ Cherry Blossom (CBL), Cherry ×T1 (CT1), and Cherry Wine (CW)
    - ✓ Two planting dates (PD): July 3, 2019 and July 25, 2019
  - Day-length-neutral varieties (2)
    - ✓ KayaGene 9201 (KG9201) and KayaGene 9202 (KG9202)
    - ✓ Two planting dates (PD): July 3, 2019 and September 11, 2019
- Raised bed plasticulture production
  - 6 ft row spacing and 5 ft in-row spacing → ~1450 plants per acre
  - Irrigation was applied using drip tape
  - Fertilizer
    - ✓ N: 150 lb/acre
    - ✓ P_2O_5: 100 lb/acre
    - ✓ K_2O: 200 lb/acre

Variety trial

- Day-length-sensitive varieties
  - The SAME date of flowering for both planting date: 8/7/2019 (day length: ~13.5 h)
    - ✓ Planting date 1--vegetative stage 35 d + reproductive stage 50 d = total 85 d
    - ✓ Planting date 2--vegetative stage 14 d + reproductive stage 70 d = total 84 d

Variety	Flower yield (lb/acre)	THC	CBD	CBG
		% dry weight		
Planting date – July 3, 2019				
CBL	2730 a	0.521 ab	9.589 a	0.197 ab
CT1	2424 b	0.582 a	10.254 a	0.260 a
CW	2352 b	0.474 b	8.927 a	0.189 b
Planting date – July 25, 2019				
CBL	1326 ab	0.502 ab	9.477 a	0.208 a
CT1	1467 a	0.607 a	10.923 a	0.246 a
CW	703 b	0.473 b	8.895 a	0.201 a

§ Different uppercase letters indicate significant differences between the two planting dates, and lowercase letters indicate significant differences among varieties for each planting date

Variety trial

- Day-length-neutral varieties
  - Planting date 1
    - ✓ Flowered at 21 d after seeding
    - ✓ vegetative stage 21 d + reproductive stage 50 d = total 71 d
  - Planting date 2
    - ✓ Flowered at 38 d after seeding
    - ✓ vegetative stage 18 d + reproductive stage 32 d = total 50 d

Variety	Flower yield (lb/acre)	THC	CBD	CBG
		% dry weight		
Planting date – July 3, 2019				
KG 9201	66 a	0.28 a	4.54 a	0.20 a
KG 9202	149 a	0.31 a	5.56 a	0.21 a
Planting date – September 25, 2019				
KG 9201	77 a	0.33 a	6.28 a	0.22 b
KG 9202	100 a	0.38 a	7.30 a	0.32 a

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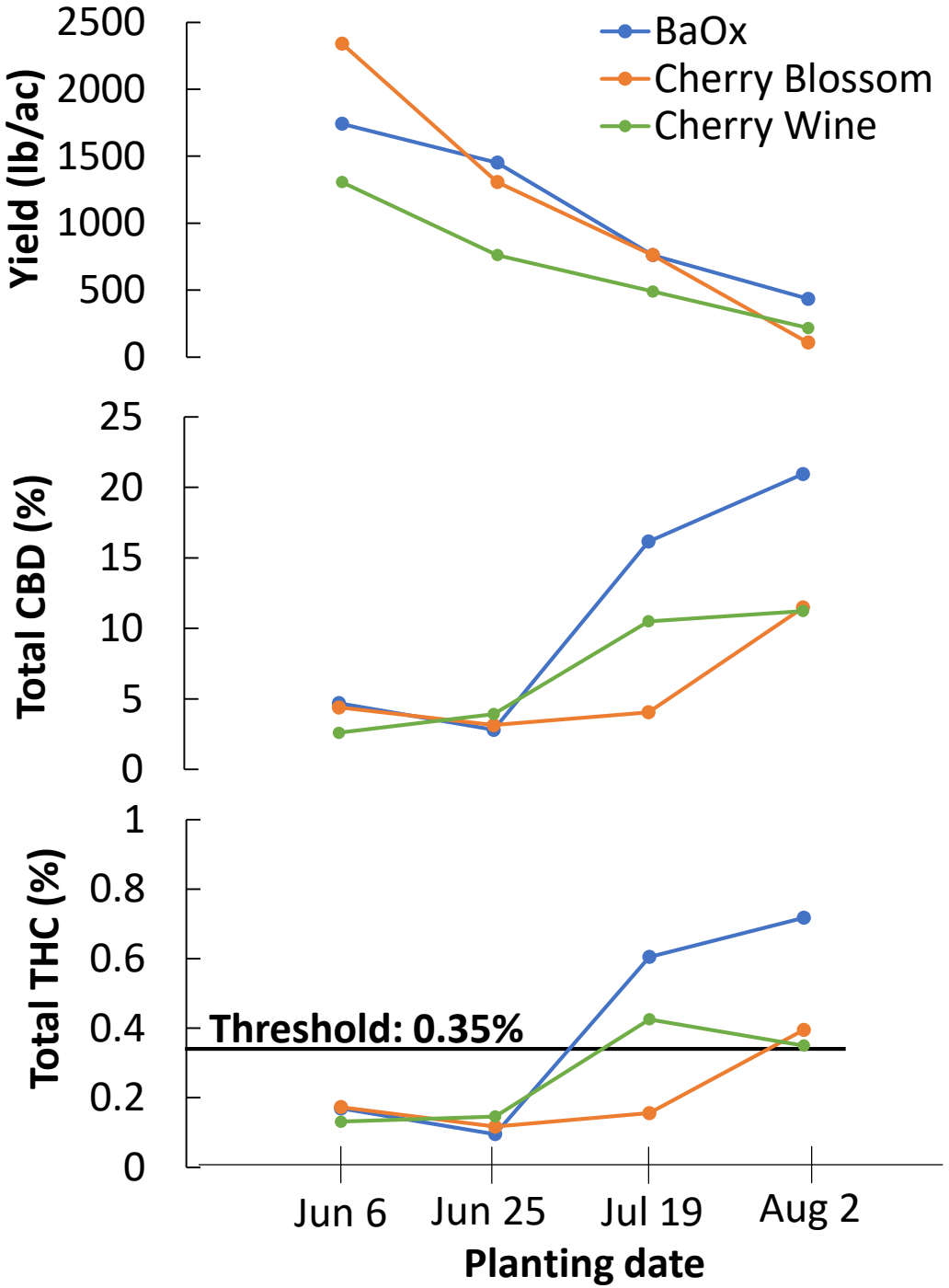
Variety trial

- Different planting date
  - Data courtesy of Dr. Gilbert Miller, Clemson University, SC
  - As the planting date getting late,
    - ✓ Flower yield notably dropped
    - ✓ CBD and THC content notably increased
- Similar planting date, different location

	Cherry Blossom		Cherry Wine	
	SC	FL	SC	FL
Yield (lb/ac)	1307	2739	762	2360
CBD (%)	3.1	11.9	3.9	10.4
THC (%)	0.12	0.61	0.15	0.52



Plant density study

- Typical plant density used in current industrial hemp production for cannabinoids is 1500-2000 plants per acre
- Little information is available regarding how plant density affect flower yield and cannabinoid content
- The same field setup as the variety trial except for the plant density
  - Two of the day-length-sensitive varieties including CT1 and CW
  - Different plant density (4) was achieved though different in-row spacing

In-row spacing	**Plant density**	
ft	plants per acre	plants per hectare
1.5	4840	12100
3.0	2420	6050
4.5	1613	4033
6.0	1210	3025

Plant density study

- No significant variety × plant density interaction was observed ($P > 0.05$), therefore data was combined to demonstrate the impact of plant density

Plant density (plants/acre)	Flower yield (lb/plant)	Flower yield (lb/acre)	THC	CBD	CBG
			% dry weight		
4840	0.85 b	4288 a	0.56 a	11.82 a	0.24 a
2420	1.34 a	3256 b	0.54 a	11.78 a	0.22 a
1613	1.58 a	2452 c	0.58 a	11.99 a	0.23 a
1210	1.69 a	2056 c	0.58 a	11.96 a	0.22 a

§ Different lowercase letters indicate significant differences among plant densities

Plant density study

- Assume
  - ✓ CBD content is 10% and market price is $3.5 per percent CBD per lb = $35 per lb
  - ✓ Clone = $3 per plant and seed = $1 per plant
  - ✓ Labor = $15 per hour
  - ✓ 106 man-hours per acre for the lowest plant density based on our experience

Plant density	Flower yield	Income from CBD	Cost from plant material		Cost from labor	Gross income	
			Clones	Seed		Clones	Seed
per acre	lb/ac	dollar/ac	---dollar/ac---		dollar/ac	---dollar/ac---	
4840	4302	150578	14520	4840	6360	129698	139378
2420	3267	114345	7260	2420	3180	103905	108745
1613	2460	86112	4839	1613	2115	79158	82384
1210	2064	72230	3630	1210	1590	67010	69430

- This is the ideal situation, but in reality…

Market is going down

https://panxchange.com/hemp-benchmarks-and-analysis-nov-2019/

Biomass Spot Pricing - November 2019 *Source: PanXchange*				
Region	**Midpoint**	**▲**	**Low**	**High**
Colorado (per % CBD Content/lb.)	$ 1.14	-47%	$ 0.93	$ 1.35
Kentucky (per % CBD Content/lb.)	$ 1.03	-53%	$ 0.80	$ 1.25
Oregon (per % CBD Content/lb.)	$ 1.13	-45%	$ 0.85	$ 1.40

Plant density	**Flower yield**	**Expected $35 per lb**		**Actual $11.5 per lb**
per acre	lb/ac	dollar/ac		dollar/ac
4840	4302	150578	3-times lower →	49473
2420	3267	114345		37571
1613	2460	86112		28290
1210	2064	72230		23736

Cannabinoid development

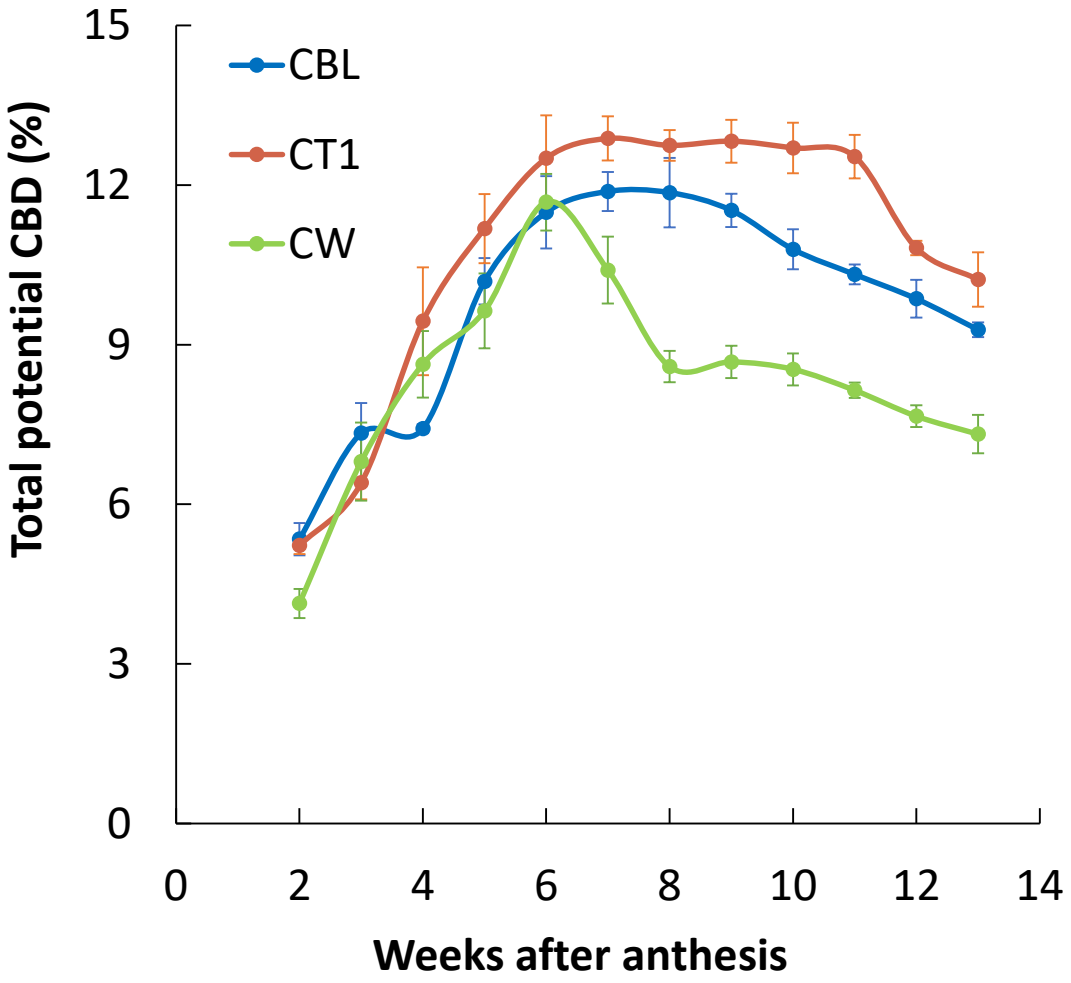
- Greater CBD content means greater revenue
- Industrial hemp must have a delta-9 tetrahydrocannabinol (THC) concentration of ≤ 0.3%, or a total potential THC of ≤ 0.35%, on a dry weight basis by law

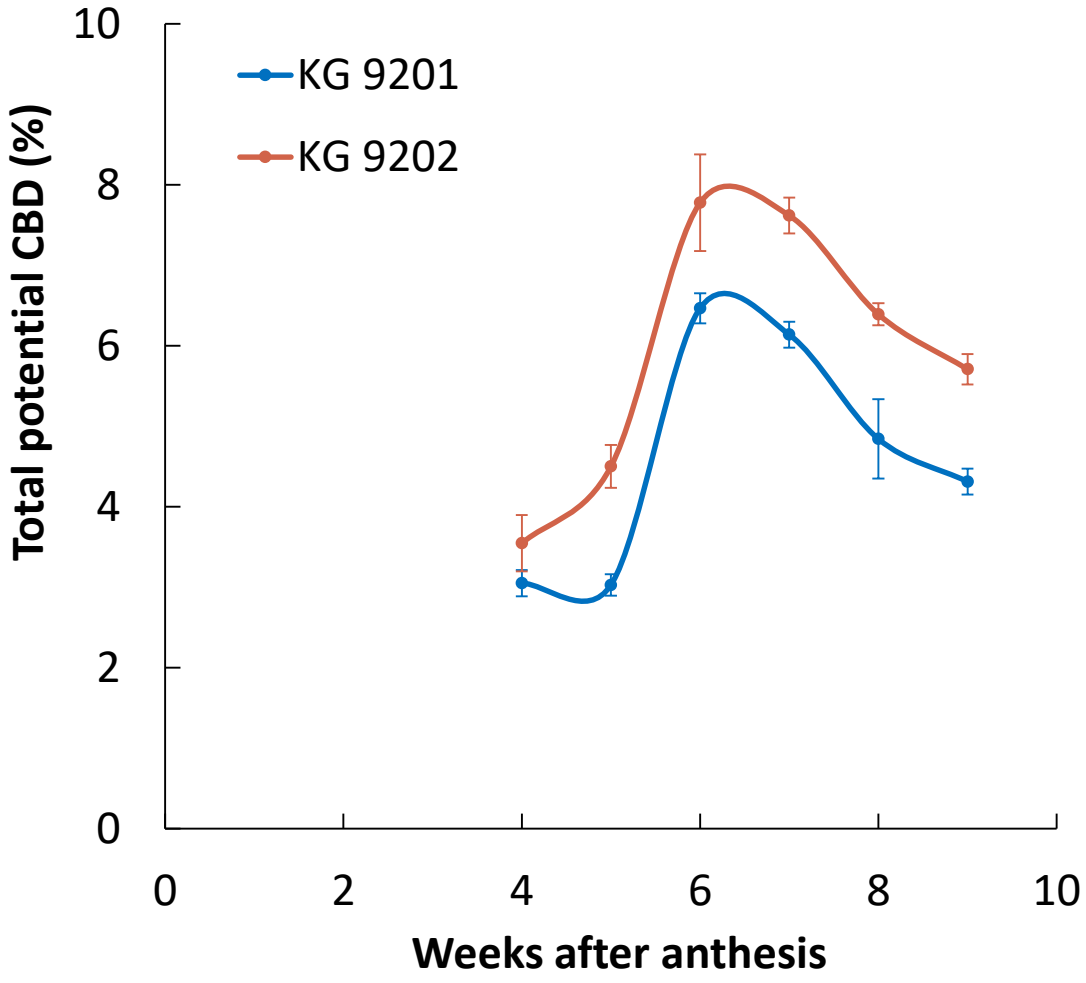
  Total potential THC = Concentration of THC + Concentration of THCA × 0.877

- Knowing how CBD and THC content change over time during the growing season could provide valuable information on date of harvest and date of regulatory sampling
- The same field setup as the variety trial
  - ❑ Included the 3 day-length-sensitive varieties (CBL, CT1, and CW) and the 2 day-length-neutral varieties (KG9201 and KG9202)
  - ❑ Flower samples were taken on a weekly basis from 2-4 weeks after anthesis to full senescence of the plants
  - ❑ Flower samples were taken from 5 uniform plants within each plot and thoroughly mixed for a composite sample

Cannabinoid development

- Total potential CBD
  - A varietal difference existed

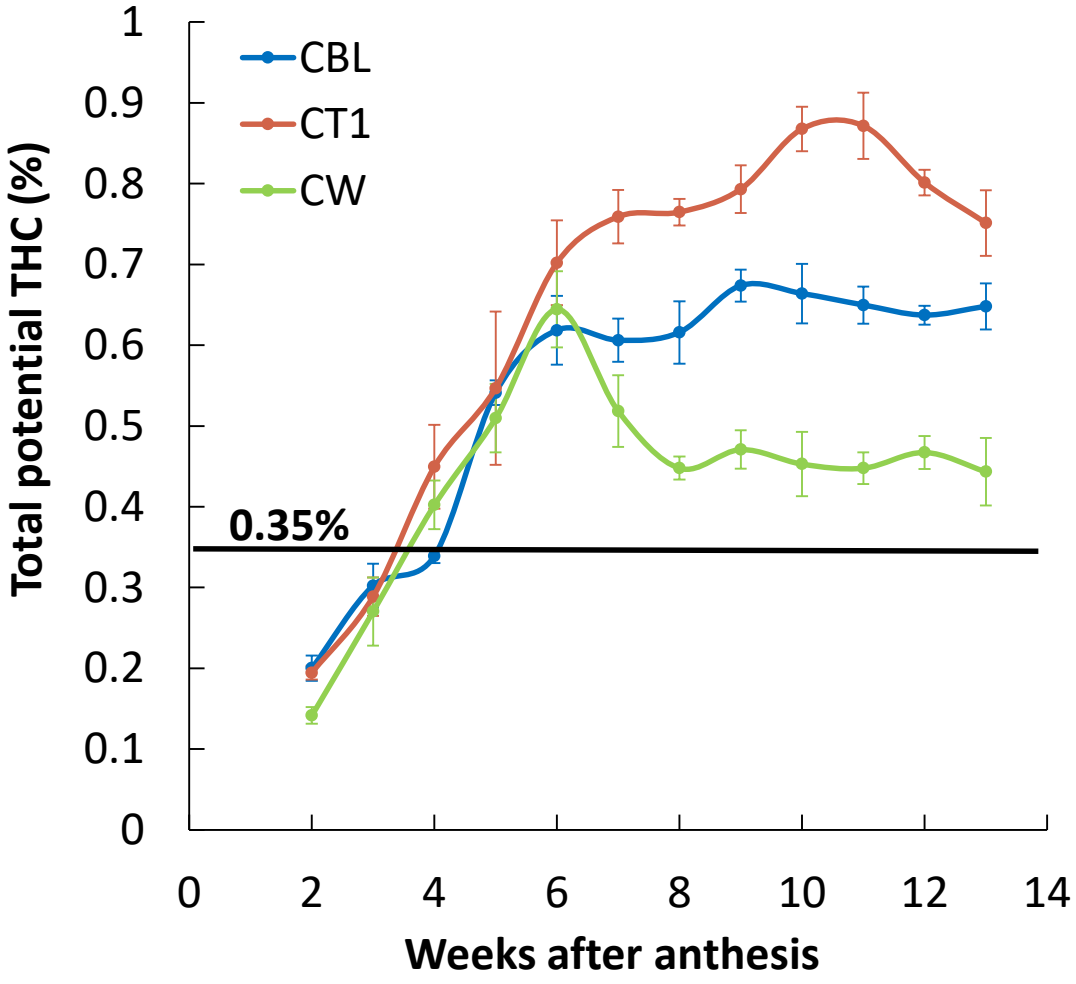


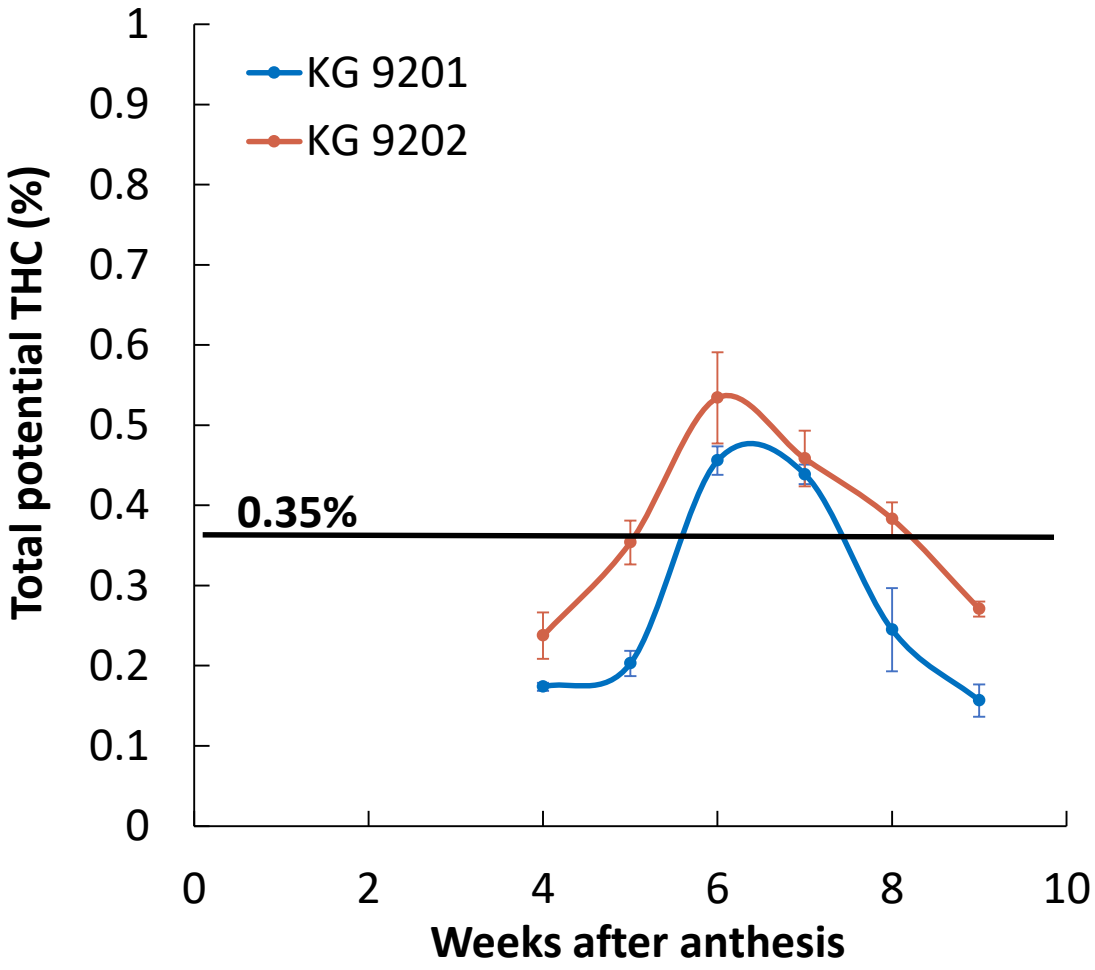


Cannabinoid development

➢ Total potential THC

- ❑ A varietal difference existed





Take-home points

- Day-length-sensitive varieties
  - A later planting date resulted in lower flower yield, but cannabinoid content was not affected
  - Cherry×T1 ≈ Cherry Blossom ≥ Cherry Wine
- Day-length-neutral varieties
  - Lower flower yield and cannabinoid content than day-length-sensitive varieties
  - Comparable flower yield and cannabinoid content between planting dates
  - KG9202 ≥ KG9201
- A greater plant density may result in greater flower yield
- The CBD and THC development in flower synchronized during the growing season

Take-home points

- CBD and THC content
  - THC content increased above the legal threshold early in the season – around 60 days post transplant
  - THC content remained above this threshold for the remainder of the season
  - In our study there was no difference in cannabinoid content between planting dates – July 3 vs July 25
  - It is unclear how and if environmental conditions affect THC development and concentration

- REMINDER: This is one season of data from a limited number of varieties.

Acknowledgements

- Thanks to continued support of Green Roads, Inc. as well as other generous donors
- Thanks to the support of Mr. Sam Maxwell, Mr. Ronnie Pugh, and Dr. Katie Stevens in sample collection and process

- Mr. Jerry Fankhauser, Assistant Director of the Florida Agricultural Experiment Station
- Dr. Zack Brym, Assistant Professor, coordinator of the UF/IFAS Industrial Hemp Pilot Project