UF/IFAS Industrial Hemp Pilot Project
2019/2020 North Florida Research and Education Center

Preliminary Research Report

Josh Freeman
Associate Professor of Horticultural Sciences, University of Florida, North Florida Research and Education Center

Sarah da Silva Benevenute
Graduate Research Assistant, University of Florida, North Florida Research and Education Center

Rui Yang
Institute of Urban Agriculture, Chinese Academy of Agricultural Sciences, Chengdu, Sichuan 610200, China

Introduction

Industrial hemp is legally classified in the USA as *Cannabis spp.* with tetrahydrocannabinol (THC) concentration of ≤ 0.3% per dry weight basis, cannabis plants that exceed the 0.3% THC threshold will no longer be classified as industrial hemp (IH). IH is a potential new crop for the state of Florida, and to support the future viability of this crop appropriate agronomic practices including plant density, varieties, and pruning (pinching) practices need to be determined to achieve successful production. Most varieties of IH are sensitive to day length, meaning they remain vegetative during the long days of summer, and they flower when days begin to shorten. In north Florida, for the varieties tested so far, growing season is defined to be around late May to around the first or second week of August. During this time days are long enough to maintain plants in a vegetative stage, before and after that, plants will flower.

Open field IH production exclusively for essential oils is a new venture in the United States for growers and researchers, and much of what is practiced by growers is deduced from indoor marijuana production systems. It is known that greatest cannabinoid content is usually found in unpollinated female flowers and is often found at much lower concentration in other tissues of female or male plants. Pollination is detrimental to essential oil production thus; male plants should be avoided in the field in order to reduce chances of pollination.

There is a significant economic risk in hemp production due to the high cost of production and the potential for the crop to exceed the 0.3% THC threshold, and therefore be unmarketable.

Experiments were conducted during the 2019 and 2020 growing season at the North Florida Research and Education Center (NFREC) in Quincy, Florida on industrial hemp varieties for essential oil production.

It should be noted that the research presented in this document was obtained from only two seasons, and from a limited number of IH varieties. There will certainly be variation between seasons, locations, and IH varieties. The mention of variety names in this document is not meant to serve as an endorsement nor are these data to be considered a recommendation.

Objective

Evaluate industrial hemp varieties, the impact of pinching, and plant density on flower yield and cannabinoid content of industrial hemp cultivated under open field conditions in northern Florida.

Materials and Methods

For all field experiments, feminized seeds were germinated and grown in a greenhouse with supplemental lighting using peat based potting media. Seedlings were produced in 128 cell trays with only half of the tray planted to increase space for each seedling. Uniform seedlings were transplanted to the field at around 21 days after seeding on July 3, 2019 and July 14, 2020. All experiments were produced utilizing raised beds and the plasticulture production system that is typical for many vegetable crops. Raised beds were 8 in tall and 30 in wide and were covered with white colored plastic to reduce the soil temperature. Fertilizer (N-P_2O_5-K_2O: 10-10-10) was applied under the plastic prior to planting and soluble fertilizer was delivered through the irrigation system during the growing season. Total fertilizer application for the season was 150, 100, and 200 lb/acre for N, P_2O_5, and K_2O, respectively for each growing season. Irrigation was provided to the crop, up to 1.25 acre inches per week, through a single drip tubing located under the plastic.

Variety Study

As with any crop variety selection is critical to achieve successful production. However, there is no history of IH in this area, so growers don't have the necessary information to make decisions on variety selection, planting date, plant density, or other crop management practices. In 2020, eight day-length sensitive IH varieties (Cherry Blossom, Cherry Wine, Berry Blossom, Hot Blonde, Cinderella Story, Cloud Berry, Queen Dream, Cherry Blonde) were evaluated. Seedlings were transplanted to the field on July 14th and plants were harvested on October 1st, 2020. For this study plants were spaced 3 ft within the row and rows were spaced 6 ft apart (~2420 plants per acre). Flowering began around August 13th, and all varieties initiated flowering within one week of each other. Plants were harvested based on pre-harvest THC sampling, dried in a forced-air drier at 130°F for 72 h, flowers were removed by hand and flower yield was recorded. Flowers and leaves were then ground into fine powder for cannabinoid analysis.

USDA allows a measurement of "uncertainty" (analytical error) in addition to the result. The analytical method used in our study has an uncertainty of 0.05%, therefore, the THC threshold of 0.35% was used in the following comparison.

All tested varieties in this trial tested above THC threshold upon harvest. No differences in THC, CBD and other cannabinoids were observed among the tested varieties. Weekly testing was performed to evaluate the THC concentration and THC threshold was exceed around 3-5 weeks post flowering initiation, which was similar to the 2019 season. For most of the varieties tested, when THC concentration goes above the threshold it doesn't go back below this limit. Growers should carefully monitor THC concentrations to avoid having crops exceed THC threshold.

Flower yield and cannabinoid concentration of industrial hemp grown in Quincy, FL during 2020.

Variety	Flower yield lb/ acre	Total THC	Total CBD	Total CBC	Total CBG
		----------% dry weight----------			
Cherry Blonde	1932 a	0.56	12.6	0.56	0.30
Cinderella Story	1761 ab	0.55	12.2	0.60	0.19
Cloud Berry	1712 ab	0.50	11.3	0.57	0.23
Cherry Blossom	1693 ab	0.43^{ns}	10.1^{ns}	0.54^{ns}	0.22^{ns}
Queen Dream	1560 ab	0.40	9.4	0.50	0.25
Hot Blonde	1483 bc	0.44	10.1	0.49	0.20
Cherry Wine	1371 bc	0.45	10.3	0.55	0.21
Berry Blossom	1158 c	0.41	9.3	0.43	0.19

ns = no statistically significant differences detected, means are to be compared within columns.

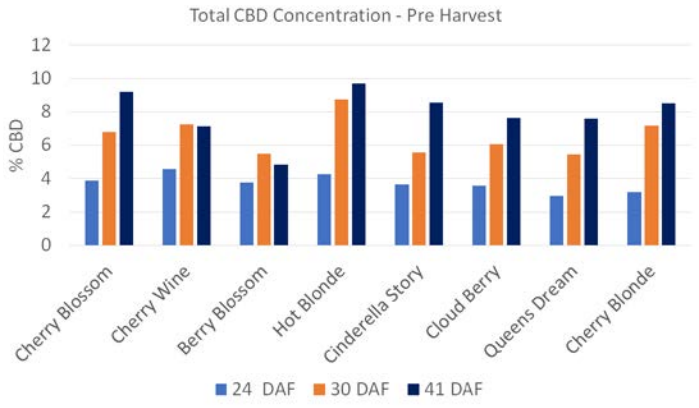
For more information visit: https://programs.ifas.ufl.edu/hemp

THC and CBD Development

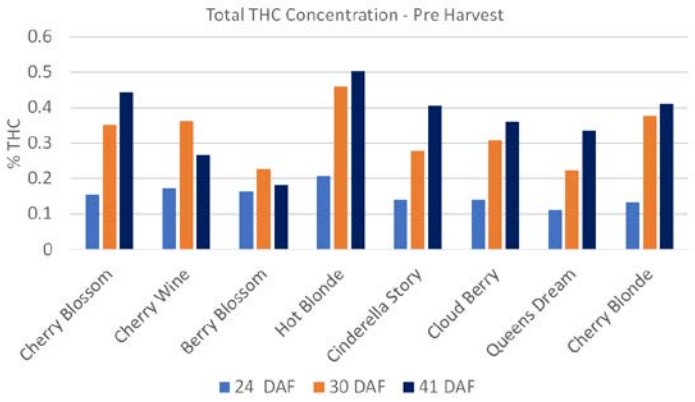
Prior to harvest, flower samples were taken from the top 8" of plants from each variety on a weekly basis and tested for cannabinoid concentration. Our goal with these samples was to time our harvest where THC concentration was below the established threshold. Results showed that both total CBD and total THC content increased with time, as flowers mature.

We noticed a significant increase in total THC between 24 and 30 days after flowering initiation, in which total THC content in Cherry Blossom, Cherry Wine, Hot Blonde, and Cherry Blonde went above the legal threshold. The total THC content in other tested varieties went above the threshold in the following week, between 30 and 40 days after flowering. Once THC content in industrial hemp plants goes above threshold it rarely goes back below threshold in the following weeks. Only in two varieties (Cherry Wine and Berry Blossom) did the THC content decrease from one week to next.

This data illustrates the need to sample industrial hemp frequently prior to harvest to maintain a legal, marketable crop.



DAF = days after flowering.



DAF = days after flowering.

Pinching Study

A common practice among cannabis producers is to remove (known as pinching or topping) the apical meristem in the main shoot of the plant in early stages of plant development to improve flower formation on lateral branches and increase flower yield per plant. However, in high CBD type industrial hemp varieties grown in open field conditions, its unknown if this practice would have any effect on yield or cannabinoid content.

Two day-length sensitive varieties, Cherry Blossom (CBL) and Cherry Wine (CW) were evaluated due to their popularity among growers, and availability of feminized seeds. Pinching was performed 21-27 days after transplanting (DAT), with the apical meristem plus 2-3 subsequent internodes removed with pruning shears. Plants were spaced 5 ft apart within row and rows 6 ft apart, resulting in 1450 plants per acre.

Plants were harvested 8 weeks after anthesis, dried in a forced-air drier at 130°F for 72 h, flowers were removed by hand and flower yield was recorded. Flowers and leaves were then ground into fine powder for cannabinoid analysis.

In 2019, plant height and flower yield were significantly greater than those in 2020, which could be due to a later planting date in 2020. Previous research has demonstrated that early planting dates may result in greater flower yield compared to late planting dates in northern Florida. In 2019, CBL had greater plant height, and flower yield compared to CW, but no difference was observed in THC and CBD content among the two varieties. However, in 2020 while plant height, and flower yield did not significantly differ between the two varieties, total THC and CBD was significantly greater in CBL compared to CW.

For more information visit: https://programs.ifas.ufl.edu/hemp

The effect of industrial hemp variety on plant height, flower yield, and cannabinoid concentration from experiments conducted in Quincy, FL during 2019 and 2020.

Year and variety	Plant height inches	Flower yield (lb/ plant)	Total THC	Total CBD	Total CBC	Total CBG
			----------% dry weight----------			
2019						
CBL	53.5 a	1.96 a	0.561 a	11.454 a	0.712^{ns}	0.242^{ns}
CW	47.2 b	1.52 b	0.510 a	10.950 a	0.774	0.230
2020						
CBL	35.8 c	0.85 c	0.541 a	12.614 a	0.780	0.274
CW	36.6 c	0.88 c	0.316 b	7.953 b	0.658	0.189

ns = no statistically significant differences detected.

There was no interaction between IH variety, pinching, and year, so the data were combined to illustrate the main impact of pinching. Pinching showed no significant effect on yield traits or total cannabinoid concentration except that pinched plants were shorter relative to non-pinched plants. Since pinching can increase labor expenses, a lack of yield improvement could lower the overall economic return.

The effect of pinching on yield and cannabinoid concentration of industrial hemp grown in Quincy, FL during 2019 and 2020.

Treatment	Plant height inches	Flower yield (lb/ plant)	Total THC	Total CBD	Total CBC	Total CBG
			----------% dry weight----------			
Non-pinched	46.0 a	1.32^{ns}	0.527^{ns}	11.225^{ns}	0.789^{ns}	0.257^{ns}
Pinched	41.3 b	1.33	0.488	10.703	0.696	0.217

ns = no statistically significant differences detected.

Plant Density Study

Appropriate plant density is a critical factor that can affect crop yield, and consequently, profitability. Currently, in the southeast USA, industrial hemp fields for essential oil production are established between 1,000 and 2,000 plants per acre but it is still unknow if that is the most appropriate plant density. For the plant density study, only Cherry Wine (CW) was evaluated. Four plant densities, including 1210, 1613, 2420, and 4840 plants per acre were achieved by using different in-row spacing (1.5, 3.0, 4.5, and 6.0 ft). Rows were spaced 6ft apart. Seedlings were transplanted to the field at around 21 days after seeding on July 3, 2019 and July 14, 2020.

The effect of plant density on yield and cannabinoid concentration of industrial hemp grown in Quincy, FL during 2019 and 2020.

Plant density plants/acre	Plant height inches	Flower yield lb/plant	Flower yield lb/acre	Total THC	Total CBD	Total CBC	Total CBG
				----------% dry weight----------			
1210	39.7^{ns}	0.9 a	1267 c	0.489^{ns}	10.798^{ns}	0.729^{ns}	0.193^{ns}
1613	40.1	0.9 a	1497 c	0.464	10.175	0.710	0.199
2420	41.3	0.89 a	2108 b	0.442	10.188	0.631	0.194
4840	42.9	0.6 b	3482 a	0.472	10.236	0.687	0.220

ns = no statistically significant differences detected.

For more information visit: https://programs.ifas.ufl.edu/hemp

Flower yield per acre gradually increased with increasing plant density (more plants per acre led to greater total flower yield). The greatest plant density (4840 plants per acre) resulted in the greatest flower yield per acre, and the two lower plant densities (1210 and 1613 plants per acre) did not significantly differ from each other in total flower yield. This trend, however, reversed on a per-plant basis. The greatest plant density tested in this study (4840 plants per acre) produced the lowest flower yield per-plant (less plants per acre led to more flower per plant). Flower yield per plant were not significantly different among the three lower plant densities tested (1210, 1613, and 2420 plants per acre). Plant density did not have a significant impact on total cannabinoid concentration. Plant height also tended to increase with increasing plant density, but this trend did not reach statistical significance.

It is likely that planting date will interact with plant spacing because hemp is day-length sensitive. If the same trial was conducted with a late May planting date, a lower plant density may be more appropriate. Future research is needed to determine appropriate IH plant density for different planting dates.

For more information visit: https://programs.ifas.ufl.edu/hemp