MURRAY STATE UNIVERSITY

Science of Hemp Annual Meeting

Volume 4 Article 1

Science of Hemp: Production and Pest Management Meeting Proceedings (2023)

AUBURN UNIVERSITY

Science of Hemp: Production and Pest Management

While the exponential growth of hemp interest and production has slowed down considerably in recent years, interest remains strong. The National Agricultural Statistics Service (NASS) released the National Hemp Report in April 2023 and reported a 71% reduction in hemp production from 2021 to 2022. The total value of hemp production total $212 million in 2022, with over 18,000 acres harvested in open production areas. Floral hemp continues to make up the majority of hemp produced, however grain and fiber and not too far behind anymore.

Recent years have seen a significant increase in knowledge and research around this once poorly understood crop. Due to the work of dedicated growers, universities, and students, we have made progress towards understanding the agronomy and pest management of hemp. The Science of Hemp: Production and Pest Management has proven to be a great avenue for collaborators to share up to date information and insights learned over the last four years. We held our fourth annual meeting on November 13-15, 2023 in Auburn, Alabama with presentations from 13 different universities across the United States. Topics included agronomy, entomology, plant pathology, weed science, and controlled environment production.

Attendees enjoyed a private tour of the original Bonnie's Plants in Union Springs, AL, as well as the inventive vertical gardens and unique rooftop teaching gardens at the new Five Diamond Laurel Hotel in Auburn. The evening concluded with a banquet held at the Auburn University Hotel and Conference Center where hemp-themed trivia was enjoyed followed by awarding the student competition winners.

Organizers thank Auburn University Hotel and Conference Center, Bonnie's Plants, the Five Diamond Laurel Hotel, and Auburn University Department of Horticulture. We also thank the countless volunteers from Auburn University, the University of Kentucky, and all attendees for their tireless work and contributions that made this meeting a success.

Thank you, from the planning committee:

Katelyn Kesheimer, Jera Dills, Alana De La Riva, Chelsea Lawrence (Auburn University)

Nicole Gauthier and Kim Leonberger (University of Kentucky)

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Meeting Overview

Monday, Nov. 13, 2023

6:00pm - 9:00pm	Welcome Social - Heavy hors d'oeuvres and cash bar - Networking Bingo (with prizes!)

Tuesday, Nov. 14, 2023

7:00am - 8:00am	Breakfast
	Registration, Poster Set-up
8:00am - 8:15am	Welcome (Katelyn Kesheimer and Nicole Gauthier)
8:15am - 8:45am	Nicole Gauthier (University of Kentucky), Karla Gage (Southern Illinois University), and Katelyn Kesheimer (Auburn University) *S-1084 Multistate cultivar trial: Disease, weed, and insect ratings*
8:45am - 11:30am	**Student Oral Presentations**
8:45-9:00am	**Ibrahim Iddrisu** (Alabama State University) *Understanding the mechanisms of Salmonella Typhimurium resistance to CBD*
9:00-9:15am	**Max Schmidtbauer** (Colorado State University) *Occurrence of beet curly top virus in hemp in Colorado*
9:15-9:30am	**Ivy Thweatt** (Alabama State University) *Evaluating cultural and biological control techniques for hemp pest management*
9:30am - 9:50am	Break
9:50-10:05am	**Chelsea Lawrence** (Auburn University) *Insights into trophic interactions: Spider mites, lacewings and coexisting pests in hemp*

10:05-10:20am	**Henry Smith** (University of Kentucky) *Survey and characterization of the Fusarium sambucinum species complex associated with Fusarium head blight in Cannabis sativa in Kentucky*
10:20-10:35am	**Julian Cosner** (University of Tennessee) *Exploring the influence of hemp variety on ovipositional preference of corn earworm and tobacco budworm*
10:35am - 10:55am	Break
10:55-11:10am	**Gorman Saunders** (Southern Illinois University) *Is mechanostimulation improving cannabis development and cannabinoid concentration?*
11:10-11:25am	**Alejandra Velez** (Louisiana State University) *An overview of integrated pest management practices for corn earworm, Helicoverpa zea, in Southeastern hemp*
11:30am - 12:00pm	**Student Poster Presentations**
11:30-11:35am	**Kaitlin Creager** (Southern Illinois University) *The influence of row spacing, density, and herbicide program on weed communities in hemp (Cannabis sativa L.)*
11:35-11:40am	**Kyle Owsley** (Auburn University) *Evaluating the use of the plant growth regulator, uniconazole, on Cannabis sativa L. hemp transplants*
11:40-11:45am	**William Hagan** (Southern Illinois University) *Effect of S-metolachlor on agronomic output of hemp* (*Cannabis sativa L.)*
11:45-11:50am	**Alana De La Riva** (Auburn University) *Harnessing microbial allies: Fungal and bacterial strategies for improving plant and pest resistance in hemp*
11:50-11:55am	**Ibrahim Iddrisu** (Alabama State University) *CBD perturbation of aminoglycoside adenyltransferase of Salmonella enterica subsp. enterica serova Typhimurium activity*
12:00pm - 4:00pm	Lunch & Field Trip Tour of **Bonnie's Plants**, Union Springs, AL Tour of **The Laurel Hotel vertical gardens and rooftop gardens**, Auburn, AL

6:00pm - 9:00pm	Banquet - Student competition awards - Cannabis trivia (with prizes!) - Dinner and cash bar

Wednesday, Nov. 15, 2023

7:00am - 8:00am	Breakfast
	Poster Viewing
8:00am - 8:30am	**Alvaro Sanz-Saez** (Auburn University) *Hemp phenotypic variation to drought and implications for water use efficiency*
8:30am - 2:00pm	**General Session**
8:30-8:42am	**James DeDecker** (Michigan State University) *Grain and fiber hemp cultivar performance in the Midwest US: Findings of the Midwestern hemp research collaborative project*
8:42-8:54am	**Phillip Alberti** (University of Wisconsin - Madison) *The Cultivar Check Program: Participatory on farm research to determine compliant hemp cultivars*
8:54-9:06am	**Esther S Durairaj** (Michael Fields Agricultural Institute) *Rates and dates: An agronomic inquiry into fiber hemp for the Midwest US*
9:06-9:18am	**Jose Leme** (Southern Illinois University) *Cannabis production: Increasing excitement and advancing CEA technology*
9:18-9:30am	**Wayne Morgan** (North Carolina State University) *Investigating the effects of drought intensity and timing on arthropod communities in Western North Carolina hemp (Cannabis sativa L.)*
9:30am - 9:50am	Break
9:50-10:02am	**Raul Villanueva** (University of Kentucky) *Control of hemp russet mite using conventional and organic products*

10:02-10:14am	**Jera Dills** (Auburn University) *Corn earworm (Helicoverpa zea) feeding preference and fitness consequences with sweet corn and hemp diets*
10:14-10:26am	**Junhuan Xu** (Alabama State University) *Exploring the impact of CBD content in hemp cultivars on aphid populations and detoxification gene regulation*
10:26-10:38am	**Armando Falcon** (University of Kentucky) *Factors affecting parasitism levels of Helicoverpa zea (Lepidoptera: Noctuidae) in hemp systems*
10:38-10:50am	**Jacob MacWilliams** (Colorado State University) *Adaptive role of cannabinoids in hemp-aphid interactions*
10:50-11:02am	**Olufemi Ajayi** (Alabama State University) *Helicoverpa zea survival and feeding preference on CBD hemp*
11:02-11:14am	**Magdalena Ricciardi** (University of Kentucky) *Generating tools for growers: Control of corn earworm*
11:15am - 12:30pm	Lunch
12:30-12:42pm	**Kim Leonberger** (University of Kentucky) *Connecting the pieces: Translating hemp research to growers through Extension activities*
12:42-12:54pm	**Marguerite Bolt** (Purdue University) *What issues do current and prospective hemp growers face? Survey says: pests, agronomics, and marketing barriers*
12:54-1:06pm	**Kimberly Gwinn** (University of Tennessee) *What do we do with leftovers? Biopesticidal hemp by-products*
1:06-1:18pm	**Misbakhul Munir** (University of Kentucky) *Leaf spot disease development and its relationship with yield of essential oil-producing hemp cultivars in Kentucky*
1:18-1:30pm	**Joseph Ayariga** (Alabama State University) *Prolonged CBD pressure mediates higher expression of flgA in Salmonella Typhimurium*
1:30pm - 2:00pm	Wrap-Up: Survey, Next Meeting

	General Poster Session
Posters will be on display through the duration of the meeting	**Marguerite Bolt** (Purdue University) *Hemp diagnoses from four Midwest states in 2023*
	Jera Dills (Auburn University) *The influence of nitrogen application rate on outdoor floral hemp in the southeastern United States*
	Armando Falcon (University of Kentucky) *Evaluating the damage of three commonly overlooked insects in hemp*
	Wayne Morgan (North Carolina State University) *CBD:THC ratio of hemp (Cannabis sativa L.) is affected by drought stress and floral progression*
	Ivy Thweatt (Alabama State University) *Biological control of spider mites using Neoseiulus californicus in greenhouse hemp*
	Raul Villanueva (University of Kentucky) *Assessing the damage and yields in grain hemp as result of corn earworm feeding*
	Anna Williams (Auburn University) *Using green lacewings (Chrysoperla sp.) for biological control of two-spotted spider mites (Tetranychus urticae) in cannabis: Potential inference with intraguild predation*

Student Competition Winners

Congratulations to our student winners!

Oral Competition

1st Place: **Julian Cosner**, University of Tennessee

2nd Place: **Ivy Thweatt**, Alabama State University

3rd Place: **Gorman Saunders**, Southern Illinois University

Poster Competition

1st Place: **Alana De La Riva**, Auburn University

2nd Place: **Kyle Owsley**, Auburn University

3rd Place: **Ibrahim Iddrisu**, Alabama State University

Meeting Proceedings

The following are 2023 meeting abstracts, arranged in alphabetical order by presenting author. Oral and poster presentation abstracts are included herein.

Helicoverpa zea Survival and Feeding Preference on CBD Hemp

Olufemi Ajayi, Tyson Knight, Donchel Boone, Junhuan Xu, Joseph Ayariga
and Michelle Samuel-Foo
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The corn earworm *Helicoverpa zea* Boddie (Lepidoptera: Noctuidae) is a polyphagous insect pest. It attacks several crops of economic importance including industrial hemp *Cannabis sativa* L. (Rosales: Cannabaceae). *H. zea* is often the insect that is most damaging to hemp, tunneling into maturing flower buds of hemp cultivated for cannabidiol (CBD) and developing seeds of hemp cultivated for fiber. Plants are known to respond to attacks by herbivores with defense systems that deter herbivore feeding. The feeding preference and performance of *H. zea* on cannabis hemp varieties is poorly understood. We hypothesized that different hemp varieties affect the feeding preference and survival of *H. zea*. We assessed the feeding preference and survival of *H. zea* on leaves and flowers of eight CBD hemp varieties in no-choice assays. Survival and observed feeding behaviors were used to indicate preference. Results demonstrated that *H. zea* showed feeding preference among the hemp varieties. Furthermore, *H. zea* survival was affected by hemp varieties. If *H. zea* exhibits similar behavior under field conditions, information on preference can be used to inform management practices in hemp and may aid in the development of conventionally bred and transgenic varieties.

The Cultivar Check Program: Participatory On Farm Research to Determine Compliant Hemp Cultivars

Phillip Alberti
The University of Wisconsin-Madison, Madison, Wisconsin, USA

Hemp is still a “new” crop to the region, with research regarding cultivar performance still in the early stages. Without the presence of certified hemp seed there is a tremendous amount of variability within and across cultivars, often leaving growers without reliable sources of information as they navigate this new industry. Utilizing findings from university trials and the Midwestern Hemp Database, criteria were established to identify a list of cultivars to be further evaluated. Considerations among cultivar selections include uniformity among expected flowering dates and cannabinoid production for both THC (compliance) and CBD/CBG (profit potential).

Established via a Sustainable Agriculture Research and Education (SARE) Partnership Grant, the Cultivar Check Program operates as a series of participatory on-farm trials using an extensive grower-cooperator network across the Midwest. Since its inception in 2021, 48 grower cooperators across the Midwest have participated in this project, evaluating 38 varieties and submitting over 1100 samples for cannabinoid profiling. Data is uploaded to an interactive, publicly available interface giving growers the ability to review agronomic performance and cannabinoid development of select hemp cultivars and genetics providers when making selections.

Preliminary data shows that many CBD dominant cultivars exhibit a linear (or curvilinear) relationship between Total CBD (%) and Total THC (%). Given this relationship, Total CBD (%) is often not able to exceed ~8% without exceeding the regulatory threshold of 0.3% Total THC. Similarly, data shows that most high cannabinoid cultivars will need to be harvested between 5 and 7 weeks after flower initiation has begun to remain compliant. Cultivars with a stable CBD:THC (~25:1) throughout flowering will help to maximize profitability while maintaining compliance.

The information synthesized from these trials marks a significant increase in regional hemp knowledge and is an important step toward successful adaptation of hemp as a viable option for Midwestern farmers.

Prolonged CBD Pressure Mediates Higher Expression of flgA in *Salmonella Typhimurium*

Iddrisu Ibrahim[1], Alexa Mathis[1], Daron Johnson[1], Emmanuel Ndezure[2], Joseph Atia Ayariga[1*], Junhuan Xu[1], Robertson K. Boakai[1], Olufemi S. Ajayi[1*]
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[2]Department of Theoretical and Applied Biology, College of Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana

Salmonella Typhimurium is a typical Gram-Negative bacterium associated with food-borne illness threatening public health. This pathogen is reported to have caused millions of infections and thousands of hospitalizations yearly in the United States alone. *Salmonella* Typhimurium has a sophisticated array of virulent factors, including its flagella, that contribute significantly to its pathogenicity. Cannabidiol (CBD), the non-psychoactive component of the cannabis plant, has attracted the interest of many researchers recently because of its antimicrobial properties. With the growing interest in exploring CBD's antimicrobial properties, we, in this study, have delved into unravelling how prolonged exposure of *Salmonella* Typhimurium to CBD influences the expression of the flgA gene. We hypothesized that the exposure of S*almonella* Typhimurium to CBD may result in flgA upregulation, causing the bacteria to withstand various stresses and potentially enhance its survival rates and pathogenicity. We have employed several assays, such as mRNA expression, motility assays, pH induction assays, nutrient starvation interventions, and biofilm analysis, to explore the influence of CBD on the pathophysiology of *Salmonella* Typhimurium. Our findings reveal that CBD-resistant strains exhibit enhanced resilience to extreme pH levels and motility and survive poorly under nutrient starvation, with more robust biofilm formation compared to the susceptible strains. The results contribute to the broader comprehension of CBD resistance mechanisms in bacteria. This work provides insight into the potential therapeutic interventions for controlling CBD-resistant bacterial infections. This study also underscores the essence of exploring novel alternative antimicrobial agents to tackle the ever-persistence of bacterial antibiotic resistance.
Keywords: *Salmonella* Typhimurium, Cannabidiol (CBD), Antibiotic resistance, Bacterial motility, Environmental stresses, Bacterial survival

What Issues Do Current and Prospective Hemp Growers Face? Survey Says: Pests, Agronomics, and Marketing Barriers

Jean Zavala[1], Scheska Villier[1], Sanchez Philocles[1], Ariana Torres[1], Stephen Meyers[1], Marguerite Bolt*[2], Elizabeth Long[3]
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[2]Department of Agronomy, Purdue University, West Lafayette, Indiana, USA
[3]Department of Entomology, Purdue University, West Lafayette, Indiana, USA

The hemp industry has rapidly changed since the Agriculture Improvement Act of 2018. Navigating this nascent industry has garnered excitement but has also presented challenges. Both current and prospective face economic and agronomic barriers that affect production. To better understand these barriers in marketing and production, a multi-state survey was conducted in 2021. The questions covered economics, marketing, agronomics, and pest management. The findings highlighted several marketing barriers that are significant to hemp production. Government regulations, finding buyers, and price premiums were considered major barriers. Pest management and labor costs pose a great challenge for current and prospective growers. However, when growers were asked about which pest management techniques they use, many respondents indicated multiple techniques for managing insects, diseases, and weeds. An integrated pest management approach can greatly improve efficacy, especially in a system where few conventional pesticides are available. There are management strategies that were less commonly used, including site selection and crop rotation. There is an opportunity to improve educational materials to focus on all the possible strategies to mitigate crop loss due to pests. We also found growers perceive the usefulness of hemp production information differently depending on the source. Respondents indicated that advice from other growers, pest bulletins, webinars, and site visits from Extension specialists as extremely or very useful. Developing resources focused on grower-to-grower transfer of knowledge, in person visits, and web-based information should be a key strategy moving forward.

Hemp Diagnoses from Four Midwest States in 2023

Esneider Mahecha[1] , Diane Plewa[2] , Alison Colgrove[1] , Houria Ouzidane[1] , Megan Ray[1] , Marguerite Bolt[3].

[1]Department of Crop Sciences, [2] Illinois Extension, College of Agricultural, Consumer and Environmental Sciences, University of Illinois Urbana-Champaign, [3] Hemp Extension Specialist Department of Agronomy, Purdue University Extension.

Hemp (*Cannabis sativa* L.) is a significant crop in the Midwest, cultivated for both seed and fiber production. A total of 131 field hemp samples ranging in maturity from seedlings to mature plants were received for diagnosis at the Plant Clinic at the University of Illinois Urbana-Champaign. In addition, field soil samples were assayed for the presence of vermiform nematodes, and *Helicoverpa zea* (corn earworm) moth counts were conducted in hemp fields. These samples and moth counts were collected from research stations, growers, and commercial companies across Indiana, Michigan, Wisconsin, and Illinois.

The fungal pathogens Botrytis and Fusarium emerged as the most prevalent diseases toward the end of the season among the hemp samples. High numbers of *Helicoverpa zea* moths were collected in Illinois, particularly in locations near cornfields. Lesion and spiral nematodes were the most frequently identified nematodes in the soil samples, both of which are common pathogens in Midwestern cornfields. Current reports indicate that lesion nematode is one of the most significant nematode pathogens affecting hemp.

The objective of this work is to establish an initial database documenting the pathogens and pests of hemp within these states, track their progression over the coming years, and propose management strategies based on the primary concerns in the surrounding states.

Exploring the Influence of Hemp Variety on Ovipositional Preference of Corn Earworm and Tobacco Budworm

Julian Cosner, Jerome Grant, Mitchell Richmond, Kimberly Gwinn, Feng Chen
University of Tennessee Knoxville, Knoxville, Tennessee, USA

Industrial hemp, *Cannabis sativa* L., production has tremendously increased in the United States since its legalization through the Agricultural Improvement Act of 2018 (a.k.a. 2018 Farm Bill). This emerging industry has been negatively impacted by larvae of corn earworm, *Helicoverpa zea* (Boddie), and the tobacco budworm, *Chloridea virescens* (F.), which feed on the developing inflorescences. Theories about the evolution of insect host plant choice suggest a strong selection for a close link between oviposition preferences and the nutritional requirements of offspring. However, with polyphagous species, such as *C. virescens* and *H. zea*, a strong correlation between adult preference and progeny performance does not exist. In previous years, larval abundance in field plots has varied among hemp varieties including those sharing the same floral maturity window, indicating that varietal preference may occur during oviposition. The aromatic profiles of *Cannabis* are generally dominated by monoterpene blends which generate distinct fragrances. Terpene concentrations in *Cannabis* are known to evolve at different rates among chemotypes throughout the flowering phase but the influence of these chemicals on *C. virescens* and *H. zea* behavior is not clearly understood. To investigate the role of plant volatiles from hemp inflorescence on the ovipositional behavior of *C. virescens* and *H. zea*, a multi-choice oviposition bioassay and a two-choice oviposition bioassay were performed using several hemp varieties. Results will be presented and discussed. This study was aimed at understanding host and varietal preference of similar species to potentially select varieties that are productive for growers and less attractive to insect pests.

The Influence of Row Spacing, Density, and Herbicide Program on Weed Communities in Hemp (*cannabis sativa* l.)

Kaitlin E. Creager*[1], Eric J. Miller[1], Kevin W. Bamber[2], Matthew P. Spoth[2], Michael L. Flessner[2], Karla L. Gage[1,3]

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Hemp is defined as *Cannabis sativa* L. that has less than 0.3% tetrahydrocannabinol (THC). "Dual-purpose" hemp may be grown for both seed and fiber. Currently in the United States, there are only two labeled herbicides, ethalfluralin and quizalofop, for growers to use in hemp production. Research is still needed to expand knowledge of best weed management practices. The purpose of this study was to evaluate the effectiveness of both cultural and chemical weed management practices in a dual-purpose hemp cultivar. The study design was a 3 x 2 x 3 factorial with four replications, conducted in Illinois and Virginia. Research plots were planted at seeding rates of 100, 200, or 300 plants m-1 on either 19 or 38 cm rows. Herbicide applications were nontreated, ethalfluralin (1050 g ai ha-1) followed by (fb) quizalofop (77 g ai ha-1); and S-metolachlor (1423 g ai ha-1) fb clethodim (76 g ai ha-1). The weed community data collected at end of season consisted of weed species counts and above-ground biomass by species. Data were analyzed using Analysis of Variance (ANOVA). There was no difference in Shannon's Diversity Index (H') for any of the factors: site, herbicide, row spacing, or seeding rate. Species richness was higher in Illinois compared to Virginia; and there was an interaction of herbicide, row spacing, and seeding rate in Illinois, which suggests that the nontreated 19 cm row spacings at 100 plants m-1 had the highest richness of all treatments. Only herbicide significantly affected richness in Virginia, and the S-metolachlor fb clethodim had the lowest richness of all the treatments. Evenness (J') was lower in Illinois than in Virginia, following the same trends as richness. Waterhemp (Amaranthus tuberculatus) biomass in Illinois was affected by the herbicide program and seeding rate, with the lowest biomass occurring in the S-metolachlor fb clethodim and the 300 plants m-1 seeding rate. Ivyleaf morningglory (Ipomoea hederacea) biomass in Illinois was higher than in the nontreated plots but not significantly different than the ethalfluralin fb quizalofop treatments. Broadleaf signalgrass (Urochloa platyphylla) biomass in Illinois was lowest in the S-metolachlor fb clethodim treatment, followed by ethalfluralin fb quizalofop, followed by the nontreated. Total monocot abundance was higher in Illinois than in Virginia, and both herbicide programs resulted in significantly lower biomass than in the nontreated. There were no differences in monocot biomass by treatment in Virginia. Sites were not significantly different for total dicot biomass; sites were pooled and both herbicide programs resulted in significantly lower biomass than in the nontreated. Weed communities were tested for differences using Permutational Analysis of Variance (PERMANOVA) which suggested no interactions between factors but different community composition by site and herbicide treatment independently. In conclusion, there were no differences in weed biomass by cultural factors, but biomass was significantly reduced by one or both herbicide programs, depending upon site and species. Therefore, the herbicide programs affected some weed diversity measures.

Grain and Fiber Hemp Cultivar Performance in the Midwest US: Findings of the Midwestern Hemp Research Collaborative Project

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In 2023, the Midwestern Hemp Research Collaborative received funding from USDA-NIFA under the Supplemental and Alternative Crops Program (award # 2022-38624-38368) to conduct multi-location hemp grain and fiber variety trials in Michigan, Indiana, Illinois and Wisconsin. Six locations grew a total of twenty-six grain and twenty-seven grain cultivars solicited from private seed companies in the US, Canada and Europe. Trial design was an RCBD with four replications, and cultivars were generally assigned to either Michigan and Wisconsin (early maturing) or Illinois and Indiana locations (late maturing). Small plots 4-5 ft. wide by 15-20 ft. long with row spacing of 7-7.5 inches were planted May 26-June 16, 2023. Seeding rates were 19.5 pure live seed (PLS)/ft^2 for grain cultivars and 32.5 PLS/ft^2 for fiber cultivars, based on average seed size and germination. 100 lbs/ac of actual nitrogen was applied as urea. Fiber plots were harvested 10-14 days after female flowering using hand methods. Grain plots were harvested at seed maturity using either a plot combine or hand cutting and stationary threshing equipment depending on the location. Fiber yields were adjusted to 0% moisture, while grain was cleaned and dried before weighing and adjustment to a standard 9% moisture content. Two-way ANOVA and Tukey's HSD test were used to analyze differences among cultivars. Fiber cultivars differed significantly in flower timing and yield ($P < 0.0001$). They flowered between July 7 and September 5 (Avg. July 26). Unretted fiber yields ranged between 260 and 13,148 DM lbs/ac (Avg. 5,570 lbs/ac) and were maximized at populations of 15-17 plants/ft^2. Grain cultivars also differed significantly in flower timing and yield ($P < 0.0001$). They flowered between July 6 and Aug 28 (Avg. July 21). Grain yields ranged between 83 and 2,893 lbs/ac (Avg. 891 lbs/ac). In general, hybrid grain varieties provided better establishment (vigor) and higher grain yield than open pollinated cultivars.

Harnessing Microbial Allies: Fungal and Bacterial Strategies for Improving Plant and Pest Resistance in Hemp

Chelsea A. Lawrence, Alana L. De La Riva, Jera R. Dills, and Katelyn A. Kesheimer
Department of Entomology and Plant Pathology, Auburn University, Auburn, Alabama, USA

Soil microbes interact with plants and can affect plant health, but how these interactions affect pests is less understood. These relationships may reduce pest populations, leading to effective integrated pest management (IPM) strategies. This is particularly important in hemp, *Cannabis sativa*, a crop that has seen a major resurgence. Two-spotted spider mites (*Tetranychus urticae*) and whiteflies (*Bemisia tabaci*) cause significant damage in hemp, due to high reproduction rates and lack of chemical control options. Prior research found that soil microbes may alter plant microbiomes beneficially to combat pest pressures. Therefore, we sought to examine the effect of soil-applied fungicidal or bacterial microbes on aboveground pests.

Three commercially available products and one untreated control were used in a randomized complete block design replicated six times. Treatments included Mikro-Root Biofertilizer and Phosphate Solubilizer, Mycosupreme, and Garden Friendly Fungicide. Vegetative hemp plants were treated with weekly soil drenches and kept in greenhouse bug dorms. After three weeks, 10 leaves were randomly selected from each plant and pests counted. Results varied between treatments, pest species, and life stage. Treatments had no effect on two-spotted spider mite or whitefly eggs compared to the untreated control. Plants treated with Mikro-Root Biofertilizer had significantly less two-spotted spider mite adults compared to other treatments. Plants treated with Mycosupreme had significantly less whitefly nymphs compared to other treatments.

Two of the three products used in this experiment showed significant reduction in pest numbers. Future studies should examine application methods, such as granular or foliar sprays, and the result on soil composition and plant root length. Different hemp varieties and additional products should also be explored. These findings will help contribute to strategies that limit yield reduction by pests and provide growers with alternative IPM strategies.

Corn Earworm (*Helicoverpa zea)* Feeding Preference and Fitness Consequences with Sweet Corn and Hemp Diets

Jera Dills and Katelyn Kesheimer
Department of Entomology and Plant Pathology, Auburn University, Auburn, Alabama, USA

Hemp (*Cannabis sativa* L.) is a recently legalized crop in the United States that is facing many challenges in outdoor growing systems. A major obstacle grower s face is the control of corn earworms (*Helicoverpa zea*), as the larvae feed on the inflorescence, seeds, and leaves of the plant which can lead to pathogen introduction and significant yield loss. Corn earworm infestations are especially concerning for hemp growers due to the lack of control options that have been approved. This leads to the need to discover novel pest management solutions for hemp, such as trap cropping. Trap cropping has shown to be an effective solution for managing pests in various other growing systems and is especially promising when using sweet corn as it is a preferred host for female corn earworm moth oviposition.

The objective of this study was to further explore the relationship between corn earworm adult and larval preference in replicated lab studies. We sought to test sweet corn as a trap crop for outdoor hemp and evaluate corn earworm feeding preference for the trap crop or cash crop. A choice test was conducted by rearing three groups of 50 larvae from egg on sweet corn, hemp, or an artificial diet (control), and then were given the choice of sweet corn or hemp. Larval position on fruit was recorded as well as proportion of food consumed and larval weight gain. A second no-choice test was conducted to evaluate the fitness consequences of their diet choices. Using larvae hatched from egg, four groups of 75 first instar caterpillars were individually placed in Petri dishes and reared on hemp flowers, hemp leaves, sweet corn kernels, or an artificial diet. Caterpillars were provided food *ad libidum*, mortality was monitored daily, and larval weight was measured every seven days to compare growth and survival rates.

The results showed a larval preference for sweet corn and paired with adult moth oviposition preference from previous studies, we concluded that a sweet corn trap crop is promising as part of an IPM strategy for outdoor hemp. This study can influence further exploration of trap cropping and gives growers a glimpse into the behavior of corn earworms which is crucial in the decision-making process of managing outdoor crops.

The Influence of Nitrogen Application Rate on Outdoor Floral Hemp in the Southeastern United States

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Hemp (*Cannabis sativa* L.) is seeing a resurgence following the designation as a legal agricultural commodity in the United States with the 2018 Farm Bill. Despite growing interest in hemp production, there is a lack of comprehensive information regarding agronomic practices in today's environment causing an urgent demand to identify standardized management practices. Nutrient management, specifically nitrogen applications, has the potential to affect crop physiology, cannabinoid production, and the surrounding insect population. Many studies have examined this relationship recently, but results are varied, and no uniform fertility recommendations exist.

We sought to address this knowledge gap by examining the impact of five different nitrogen application rates on hemp growth, cannabinoid content, and insect diversity in outdoor floral hemp. An in-field study was conducted at the E.V. Smith Research Unit in Shorter, AL in 2021 and 2022. BaOx variety hemp seedlings were grown in a greenhouse and hand transplanted in the field six weeks after sowing. Treatments consisted of four (2021) and five (2022) nitrogen rates applied in a randomized complete block design with four replications. Plots were treated with Ultasol Multipurpose Plus 20-20-20 nitrogen fertilizer at rates of 0 (only 2022), 57, 85, 112, or 183 kg/hectare. Plant height and stem width were measured weekly and leaf tissue samples were collected at pre-flowering, flowering, and late-flowering for nutrient evaluations. Floral samples were collected from each plot prior to harvest for an 11-panel cannabinoid analysis, and arthropod samples were collected weekly using a black vinyl drop cloth. In 2022, three plants from each plot were harvested. Harvest did not occur in 2021 due to severe damage and weather events. Fresh weight and dry weight were recorded.

Nitrogen rate did not have a significant effect on plant height or width, or nutrient levels in the plant tissue. The middle two rates of nitrogen (85, 112 kg/hectare) resulted in higher cannabidiol and tetrahydrocannabinol concentrations in 2021, but these differences were not significant. All cannabinoid concentrations were lower in 2022 compared to 2021, and no differences between treatments were found. These numeric differences, while not statistically significant, will greatly impact grower profitability and should therefore continue to be researched. The results of the arthropod survey revealed over 80 families including pests, predators, parasitoids, and incidentals. In both years across all rates, the largest group of insects surveyed were incidentals, and not pest insects. This highlights the need for grower education in insect identification as part of an integrated pest management strategy. Overall, this study reveals how important it is to continue researching nitrogen's effect on hemp to supply growers with research-based information.

Rates and Dates: An Agronomic Inquiry into Fiber Hemp for the Midwest US

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With the increase in the production of industrial hemp (*Cannabis sativa*) in the United States since its legalization, there is great potential for the grain and fiber crop. Standardizing the production practices for the highest possible yields is important so the farmer can get maximum benefits. The Midwest Hemp Collaborative worked on this initiative in the Midwest US through a collaboration between researchers in the Land Grant Universities, a non-profit, and growers. Field trials were laid out with fiber hemp in different states – Wisconsin, Michigan, Illinois, and Indiana - with an objective to refine best management practices for hemp agronomy investigation, soil preparation, planting, nitrogen fertility and crop rotation. Presented here is the research on planting dates and nitrogen fertility. Planting date trials were laid out at East Troy, Wisconsin, at the Michael Fields Agricultural Institute and at Chatham, UPREC, Michigan State University, while the N rate studies were laid out at Michigan State University, Purdue, and University of Illinois- Urbana Champaign. Four planting dates (late May to early July) with two varieties (CRS 1 and IH Williams) were the treatments laid out, while the N rates study had the following treatments: 0, 50, 100 and 150 lbs/acre. N was applied as urea at all locations. Seeds were sourced from commercial suppliers and small plot experiments were laid out in a split plot design, with four replications. The fiber hemp was hand harvested at flowering before male senescence.

The effect of planting dates on fiber yield was inconsistent across locations. The year recorded different intensities of drought which played a key role in establishment, growth, and yield. In Michigan, while results favored the usual trajectory of summer planting, recording higher yields with earlier planting dates, the yield was higher with later planting dates in Wisconsin (June 20 and 30). The second planting date of June 9th recorded highest yields in Michigan (on par with later plantings). However, in Wisconsin, rains received before the third and fourth planting dates of June 20 and 30 ensured higher yields with later plantings. This opens the possibility of having fiber hemp as a prevent-plant or second crop. IH Williams yielded higher than CRS 1, and took longer to flower (65 to 110 days against 35-60 days with CRS 1).

The response curve of fiber hemp to applied N also varied across states. Michigan recorded the highest yields with 50 lbs/ac of N applied as urea, which was on par with the yields at 100 lbs/ac. At Indiana, a higher response to N application was recorded at 100 lbs/ha. There was no response to applied N at Illinois, at all levels ie. 0, 50, 100 and 150 lbs/ac. This goes to prove that while fiber hemp responds to applied N, the response is location specific and depends on the soils of the region. N rates of 50-100 lbs/ac were sufficient to maximize hemp yields. The Midwest Hemp Collaborative will run trials again next year at all these locations for fiber hemp in the Midwest US.

Acknowledgement: The Midwest Collaborative team acknowledges the funding received from USDA-NIFA to carry out this research.

Factors Affecting Parasitism Levels of *Helicoverpa zea* (Lepidoptera: Noctuidae) in Hemp Systems

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Among the specialty crops grown in the United States, hemp stands out given the scarce research regarding insect pest management. The corn earworm (CEW) *Helicoverpa zea* is probably one of the major pests in grown hemp throughout the country. Here we quantify the interactions of tachinid parasitoids attacking *H. zea* larvae in hemp systems of western Kentucky. We hypothesized that the food supplied to the CEW larvae (hemp VS laboratory diet) affects the performance of tachinid flies in terms of survival and number of individuals per host larva. Moreover, other factors such as the number of fly eggs and the caterpillar size are considered. Our findings reveal new insights to assess future plant-insect-parasitoid interactions in hemp systems.

Effect of S-metolachlor on Agronomic Output of Hemp (*Cannabis sativa* L.)

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Industrial hemp (*Cannabis sativa* L.) is known for its use in the production of fiber, oilseed, and pharmaceutical compounds. The 2018 Farm Bill expanded the potential of hemp to be grown as an agronomic row crop. While hemp is a competitive crop, weeds may reduce establishment and yield of hemp. However, only two herbicides have been labeled for use in hemp for fiber and oilseed: the preemergent herbicide ethalfluralin and the postemergent grass-specific herbicide quizalofop. Although ethalfluralin can help provide conditions for good hemp establishment, some other preemergence herbicides, such as S-metolachlor, have better activity on waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) and other species. This study seeks to quantify the effects of S-metolachlor on stand count, average stem diameter, average height, and fresh biomass of various hemp cultivars. This cultivar trial was conducted at the Belleville Research Center in Belleville, IL in 2022, and at the Agronomy Research Center in Carbondale, IL in 2023. Each hemp cultivar was planted in 1.5 m x 6 m plots. Preemergence applications of S-metolachlor at 1423.5 g ai ha^{-1} followed by postemergence applications of clethodim at 85 g ai ha^{-1} were made at 15 GPA using a handheld boom and backpack sprayer, and hemp growth and yield in the treated plots were compared to nontreated plots. Stand counts were taken in both years at both sites for all cultivars and herbicide treatments. There were seven cultivars in the cultivar trial across both years. These data were analyzed using a 3-way ANOVA, testing for differences in stand count by herbicide application (yes/no), cultivar, and year. Average stem diameter, average height, and fresh biomass measures were taken in 2023 for all fourteen cultivars in all plots using 1 m^2 subplots, and these data were analyzed using a 2-way ANOVA testing for differences by herbicide application and cultivar. There were interactions of year x cultivar and year x herbicide application for stand count. Stand count was significantly lower overall in 2022, compared to 2023, for many cultivars. In 2022, the application of herbicide reduced the stand count of cultivars overall, while in 2023 there was no difference in stand count by herbicide application. Average stem diameter and average height were only different by cultivar. Total fresh weight was different by non-interacting factors cultivar and herbicide. Fresh weight was significantly higher in treatments with an herbicide application in 2023, with an average 1320 g m^{-2} without herbicide and 1522 g m^{-2} with herbicide, likely due to improved weed control. In conclusion, the effects of S-metolachlor on establishment and yield parameters was variable by year and cultivar. Although stand was reduced in 2022, application of S-metolachlor was associated with higher fresh weight in 2023. While US hemp fiber and oilseed are still underdeveloped commodity markets, more research is needed to improve weed control in this potential new crop.

Cannabidiol Perturbation of Aminoglycoside Adenyltransferase of *Salmonella enterica* subsp. *enterica* serovar Typhimurium Activity

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Some broad-spectrum antibiotics such as aminoglycosides possess bactericidal activity via their discriminatory affinity to bacterial ribosome, thus hindering ribosomal activity during translation. Due to their high activity and selectivity, aminoglycosides are commonly used as antibiotics for the treatment of extracellular bacterial infections especially in animals. Recent studies in our lab demonstrate the potential of cannabidiol (CBD) as an antibiotic agent against *Salmonella* spp. We hypothesized that CBD sensitization affects the physiological states of *Salmonella* resulting in higher antibiotic resistance development especially against aminoglycosides. The goal of this study was to analyze the effects of CBD on the aminoglycosidase adenyltransferase of *Salmonella* Typhimurium. Thus, in this study, we planned to demonstrate that *Salmonella* under continued CBD pressure responds differently to both streptomycin and gentamicin than the non-CBD-sensitized strains. In an *in vitro* study, we attempted to demonstrate the possibility that CBD-pretreatment differentially activates aminoglycosidase adenyltransferase expression, enforces higher motility, and mediate intracellular *Salmonella* resistance to streptomycin and gentamicin mono-treatments. However, we thought that a combinatorial treatment of *Salmonella* infection with CBD and these two aminoglycosides will completely eradicate both extracellular and intracellular bacterial infections. We proposed to evaluate the bacterial stress, bacterial membrane integrity, expression of aadA gene, and finally *Salmonella* motility via a variety of biological assays. We also planned to investigate the effect of duration of CBD pressure on aminoglycosides killing abilities, invasion of animal cells and cytopathic effects under slightly different pH conditions. The results of the study are discussed by revealing the mechanisms of which CBD sensitization could trigger antibiotic resistance to well-known antibiotics such as streptomycin and gentamycin.

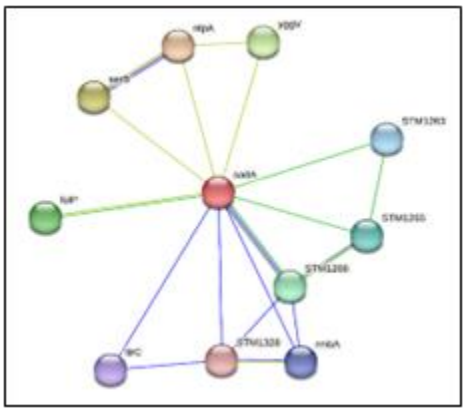

Figure showing string network display of aadA interacting with partner proteins in regulating aminoglycosides resistance

Understanding the Mechanisms of *Salmonella* Typhimurium Resistance to CDB

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The recalcitrance of pathogenic bacteria indicates that millions of people who are at risk of infections arising from chronic diseases, surgery, organ transplant, diabetes, and several other debilitating diseases are faced with a wide range of potentially untreatable illnesses due to resistance development. Antimicrobial resistance has successfully become a global health menace, and resistances are often acquired by bacteria through health-care-related incidence (HRI) orchestrated by multi-drug resistant (MDR) and extended drug-resistant pathogens (EDRP). To understand the mechanisms that *Salmonella* Typhimurium uses to resist CDB, we studied the abundance of LPS modification, Ergosterols, Mysristic palmitic resistance, and Oleic acid resistance of susceptible and resistant *S.* Typhimurium. Using qPCR, we analyzed the expressions of selected genes known to enable resistance in *S.* Typhimurium. We found high abundance of LPS, Ergosterols, Mysristic palmitic resistance, Oleic acid resistance of, and high expression of resistant genes in *S.* Typhimurium compared to the susceptible strain. LPS modification, Ergosterols, Mysristic palmitic resistance, Oleic acid, and genes such as Fims, integrons, blaTEM are important indicators of resistance development of *S.* typhimurium.

Cannabis Production: Increasing Excitement and Advancing CEA Technology

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Supported by cutting-edge technologies and innovations that boost efficiency and sustainability, controlled environment agriculture (CEA) is continuing to advance rapidly, especially in its application for cannabis cultivation. Indeed, for the production of economically important phytochemical compounds, such as cannabinoids and terpenes, cannabis crops are cultivated indoors for optimal productivity and biosecurity -- thus, attracting significant investments that drive further advances in CEA innovations from sensors to lighting to irrigation to control systems, etc. Cannabis CEA is, in fact, helping create further heightened awareness for CEA strategies even after vertical or urban farming has already helped bring the significant advantages of CEA into greater focus. The pace and adoption of the foregoing technological advances in cannabis CEA may vary across regions, influenced by factors such as infrastructure, regulatory frameworks, economic viability, and societal acceptance. It is clear, however, that the cannabis CEA sector is significantly facilitating the development and adoption of advanced CEA techniques and strategies and increasing their accessibility for application to food crops. Hence, vegetables, fruits, and horticultural crops, in general, are indeed benefiting, if unexpectedly, from the CEA advances that changes in cannabis regulations have been making possible.

Connecting the Pieces: Translating Hemp Research to Growers through Extension Activities

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Prior to the reintroduction of industrial hemp under the Agricultural Act of 2014 (Farm Bill), the last time hemp was commercially produced in the United States was in the 1940s. During this nearly 75-year period, production practices modernized, cultivars changed, and pests/pathogens shifted. In addition, science advanced significantly. The reintroduction of hemp created a need for university-based research to support the quickly expanding hemp industry. While numerous experiments and valuable data have been generated through university research efforts, this information can remain inaccessible to growers. Scientific jargon may limit the ability to understand the importance or significance of hemp research studies. Thus, efforts that translate scientific findings to a format more accessible to growers allows for easier consumption, adoption of new production practices, and ultimately increased yield or decreased production costs. The University of Kentucky, Department of Plant Pathology Hemp Extension & Research Program utilizes research reports, videos, newsletter articles, websites, factsheets, social media, and grower educational events to improve research and understanding of research results. Since 2014, written and digital resources were developed to translate research results and educational materials. All materials and events consider grower interests and needs. Surveys are used to measure changes in knowledge and practices. Through these efforts, growers in Kentucky have come to rely on research-based information generated at the University instead of potentially unreliable sources.

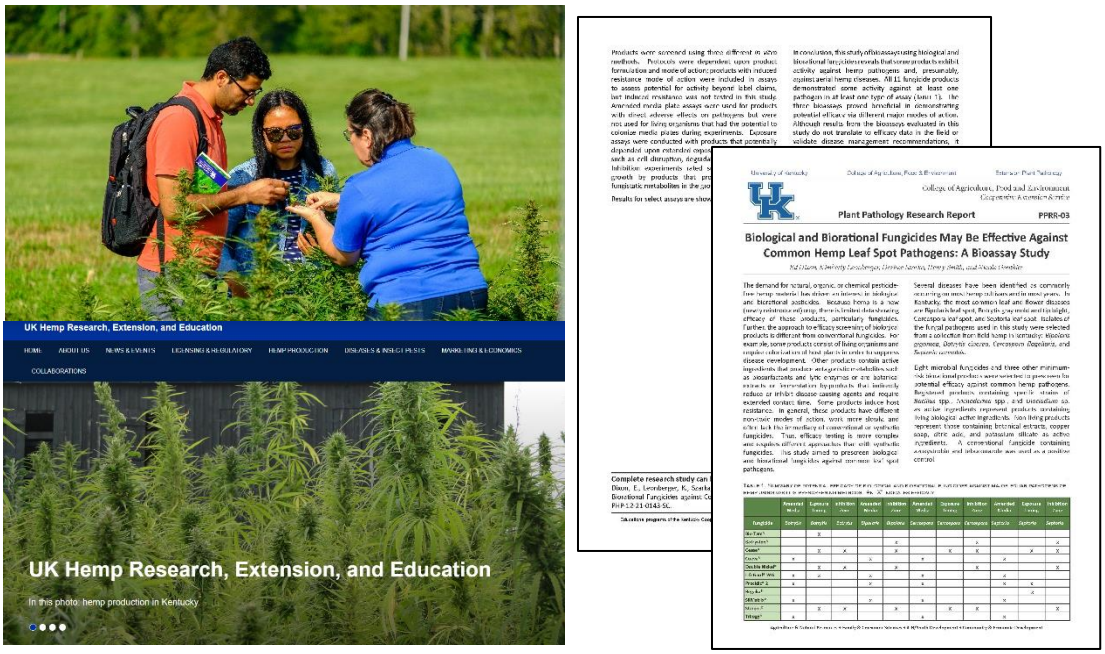

Figure 1: Examples of University of Kentucky, Department of Plant Pathology Hemp Research Program resources for growers.

Adaptive Role of Cannabinoids in Hemp-Aphid Interactions

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Cannabis sativa is known for having unique specialized or secondary metabolites, cannabinoids that are derived from an extension of the terpene pathway in the *Cannabis* lineage and includes more than 100 other similar metabolites. Despite the assumption that cannabinoids evolved as novel herbivory defense adaptations, there is limited research addressing the role of cannabinoids in *C. sativa* responses to insect herbivores. Here we investigated the role of cannabidiol (CBD), the predominant cannabinoid in hemp, in plant defense against cannabis aphid (*Phorodon cannabis*), one of the most damaging pests of hemp. We hypothesize that insect feeding may induce changes in cannabinoids as an adaptive strategy for defense. We found that mean fecundity, net reproductive rate (R_0) and adult longevity of cannabis aphids was reduced on the high cannabinoid cultivar compared to the low- cannabinoid cultivar in whole plant assays. In contrast, supplementation of CBD in artificial feeding assays increased aphid fecundity from day 1 to day 3. Additionally, aphid feeding did not impact cannabinoid levels in leaf tissues with the exception of Δ^9-tetrahydrocannabinol (THC). This suggests that other cannabinoids and/or metabolites such as terpenes are causing the observed decrease in aphid performance in the whole plant assays. In addition to cannabinoids, *C. sativa* also possesses a range of defense mechanisms via phytohormone signaling pathways that are well described in other plant species. Indeed, cannabis aphid feeding significantly increased levels of the major phytohormones, salicylic acid, jasmonic acid, and abscisic acid, which are known to be involved in plant defense responses against aphid species. These results highlight the interplay between cannabinoid synthesis and phytohormone pathways and necessitate further investigation into this complex interaction.

Investigating the Effects of Drought Intensity and Timing on Arthropod Communities in Western North Carolina Hemp (*Cannabis sativa* L.)

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Drought is a common abiotic stress that can influence the effects of biotic stresses such as damaging arthropods. These pests can damage crops and lead to losses for producers. Hemp (*Cannabis sativa* L.) is an ancient crop with renewed interest because of its many uses in modern society. There are limited studies on drought stress effects on arthropod populations in hemp. Therefore, the objective of this study was to determine how arthropod populations were affected under drought-stressed hemp in western North Carolina. This study was conducted in a greenhouse in Zirconia, North Carolina during the summer and fall of 2021 and 2022. Three drought treatments (extreme, moderate, and intermittent) with two drought timings (early and late) and a well-watered control were studied to determine the effects on arthropod communities. Arthropods were identified and quantified using a 10x-40x lens to identify each to the order. This study found that drought stress did not significantly affect populations of two-spotted spider mites or cannabis aphids however cultivars were affected significantly differently. It was found that throughout the flowering period, two-spotted spider mite populations significantly increased, and cannabis aphid populations decreased. This study shows that while irrigation control may not be necessary in terms of pest deterrence, cultivar selection is important as some cultivars are much more susceptible to others. Cultivar selection for pest resistance is a viable facet in an integrated pest management (IPM) program.

CBD:THC Ratio of Hemp (*Cannabis sativa* L.) is Affected By Drought Stress and Floral Progression

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Drought is an abiotic stressor that has the potential to affect the secondary metabolites synthesized by a number of crops. Hemp is grown for a multitude of uses however cannabinoids are specific secondary metabolites produced that are of economic importance. However, for hemp to remain compliant it has to have a total THC of less than 0.3%. The objective of this study was to subject two cultivars of hemp across an array of drought intensities and timings to determine if the two predominant cannabinoids are affected differently by drought stress. The cultivars 'BaOx' and 'Cherry Mom' were grown under three drought conditions (extreme, moderate, and intermittent) and two drought timings (early and late). Additionally, there was a well-watered control. This study found that the CBD:THC ratio is affected by the intensity of the drought as well as when the drought is initiated. More intense drought stresses result in the lowest CBD:THC ratios, whereas well-watered plants produce a greater CBD:THC ratio. Later drought stress also resulted in greater CBD:THC ratios than the early counterpart. These findings are important as this shows that large-scale production of cannabinoids can be affected by the irrigation practices incorporated as the well-watered plants had a greater ratio of CBD:THC than the severely drought-stressed plants. According to this study, producers can extract and isolate more CBD from material that was well-watered, potentially leading to greater profits.

Leaf Spot Disease Development and Its Relationship with Yield of Essential Oil-Producing Hemp Cultivars in Kentucky

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Three leaf spot diseases, including Bipolaris, Cercospora, and Septoria leaf spots, are the most common foliar diseases of hemp in Kentucky. While growers have been concerned about the capability of these diseases to cause defoliation and blighting, information regarding the disease development on commonly planted hemp cultivars and its effect on yield was unavailable. Field experiments were conducted in 2020 and 2021 at two different locations to investigate development of the three leaf spot diseases and their relationship with yield on four cultivars (BaOx, Cherry, Otto II group, and Trump group). To encourage different levels of leaf spot severity, three treatments (non-inoculated + no fungicide; inoculated + no fungicide, and non-inoculated + fungicide) were applied via a split-plot design. Disease severities were rated at weekly intervals beginning at 7 weeks after planting until harvest, with harvest date determined according to federal compliance levels (THC <0.3%). Yield (floral biomass and cannabinoid levels) was measured.
Septoria leaf spot was the first leaf spot disease to be observed in the field, followed by Bipolaris leaf spot. Cercospora leaf spot developed in the late reproductive stages as harvest approached. A wide range of susceptibility was observed among cultivars, suggesting genetic variability across cultivars. Trump group cultivars were the most susceptible, while Otto II group cultivars were the least susceptible to the three foliar diseases. Most importantly, leaf spot diseases had weak and inconsistent relationships with floral biomass and no significant relationships with CBD yield, suggesting that, regardless of disease severity, leaf spot diseases may seldom warrant management. While the importance of foliar disease and corresponding yield loss can shift over time, variation in disease progress among leafspot diseases and susceptibility of hemp cultivars documented in this study suggest potential disease management through cultural practices such as cultivar and planting date selections.

Evaluating the Use of the Plant Growth Regulator, *Uniconazole,* on *Cannabis sativa* L. Hemp Transplants

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Plant growth regulators are widely used in other crops to reduce growth and make plants more uniform and compact. The purpose of this project was to evaluate the effects of the plant growth regulator, uniconazole and its associated root ball soak method in greenhouse hemp production. Currently, uniconazole is the only plant growth regulator (PGR) labeled for vegetable transplants, and there is no PGR at this time labeled for *Cannabis sp*.

On 6 December 2021, *Cannabis sativa* L. 'Berry Blossom' transplants (50-cell tray) were treated with the PGR product Concise® as a pre-transplant liner soak. The trial evaluated four treatment rates (0, 1, 3, and 5 mg/L uniconazole) and four different soak times (0, 30, 75, and 120 seconds). Plants were arranged in a randomized complete block design with three replications per treatment. After treatment, plants were immediately potted into 1-gallon nursery pots. Plant growth was measured throughout the trial with yield data collected 99 days after treatment. Results indicated that there was no interaction between the rate of uniconazole and soak time of the 'Berry Blossom' liners in the uniconazole, but the greatest influence on the growth of 'Berry Blossom' was the rate of uniconazole and its interaction with days after treatment. Differences in size between uniconazole treatments and the untreated control began between 7 and 14 days after treatment (DAT). Uniconazole treatments differentiated between each other at 29 DAT. In Trial 1, the calculated yield per area was 2 to 2.5 times the yield when the lowest treatments (0 and 1 ppm) were compared to the two highest-yielding treatments (3 and 5 ppm). The trial was repeated on 14 June 2022, using similar methods to the first trial; however, soak time was removed as a main effect as it did not impact growth within the first trial. In Trial 2, plants receiving 3 ppm uniconazole were 1.3 times greater in calculated yield per area when compared to the untreated control. Plants receiving 5 ppm were unable to be harvested due to increased disease pressure. Calculated yield per area simulates an increased plant density based on the average surface area occupied by each treatment. While yield per plant decreased with increasing rates of uniconazole, the calculated yield per area increased. Results suggest a potential benefit of increased yield per area using smaller uniconazole-treated plants and greater planting densities. Currently, uniconazole is not labeled for use on *Cannabis,* but this study demonstrates the potential opportunities for the use of PGR's in *Cannabis* production.

Generating Tools For Growers: Control of Corn Earworm

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Corn earworm (*Helicoverpa Zea*, CEW) is considered a primary insect pest affecting hemp (*Cannabis sativa* L.) production according to survey information collected during 2021-2023 at University of Kentucky research trials (Fayette and Breathitt Counties). This project aimed to improve the understanding of the CEW infestation cycle in hemp, assess crop damage, and evaluate potential management strategies. In 2023 a field trial was conducted using transplanted plants of a CBG dominant cultivar ("White CBG", Oregon CBD). Nine treatments were arranged in a randomized complete block design with four replications. Treatments included three biopesticides applied weekly or every 15 days, an alternate treatment (weekly alternation between two biopesticides); a positive control (water-only), and a negative control (conventional insecticide), both every 15 days. Treatment applications started when the CEW population was considered significant (7 larvae/plot, average). Five plants per plot were evaluated for the total number of CEW (weekly), the CEW damage (once, pre-harvest), and the yield (dry flower material, lbs./acre). Initial results indicate no statistical differences in the CEW number or damage between treatments. The yield of the conventional insecticide treatment was significantly higher than the water-only control. Yields of biopesticide treatments were intermediate and not different from both controls. Additional trials with higher CEW pressures are needed to better assess the potential efficacy of CEW management treatments.

Is Mechanostimulation Improving Cannabis Development and Cannabinoid Concentration?

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As legalization continues to change the cannabis industry, we see an influx of creative innovation, funding, and research as more entities enter the field. The two innovative growing management investigated in this study were Vibration Training (VT) and High Stress Training (HST). Many industry leaders claim that the advantages of using HST include higher canopy, increased biomass, and cannabinoid concentrations, and more effective IPM strategies. However, studies validating these claims are still being determined. VT is a newer technique still in development, as Thigmopriming has been shown to change plant morphology, chemistry and even increase the speed and magnitude of future stress responses. This study aims to compare each growing management under the overall category of mechanostimulation against control (no artificial stimulation) and tease out any synergism between the treatments. Four grow tents with automated environmental controls were housed in a research lab at SIU Carbondale. The treatments consisted of 1-VT+HST; 2-VT; 3-HST; 4-Control. Each tent contained (4) five-gallon fabric pots with a single Suver Haze plant. An amended coco coir substrate was used with a water-soluble nutrient solution, and optimal growing condition was maintained equally in all tents. Weekly plant parameters included stem diameter, plant height, NDVI, chlorophyll concentration, and photosynthetic efficiency. After-harvest parameters included above/below ground biomass, yield mass, bucked biomass, cannabinoid profile, and trichome density. Morphological and numerical differences between treatments indicated the potential for a shorter, more efficient growth cycle. Further testing is currently underway.

Occurrence of Beet Curly Top Virus in Hemp in Colorado

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Beet curly top virus (BCTV) is vectored solely by the beet leafhopper (Circulifer tenellus) and is the most serious diseases affecting sugar beet production in the United States. Hemp is characterized as Cannabis sativa L. which expresses THC at or under a federally set limit of 0.3% and has become a crop of interest in many states. While BCTV has been studied in sugar beet for over one hundred years, in 2019, BCTV was first reported to infect hemp in western Colorado. Starting in 2021, Laine Hackenberg conducted a hemp virome survey in different counties in Colorado. Using next generation sequencing, she hopes to provide understanding around the occurrence and distribution of BCTV and other viruses of interest in hemp in Colorado. Based on this work, we are also hoping to provide understanding on the epidemiology of BCTV and the beet leafhopper in Colorado. By filling in these key knowledge gaps, we hope to provide our growers with information on how to best plan for and manage this destructive agricultural pest.

Survey and Characterization of the Fusarium Sambucinum Species Complex Associated with Fusarium Head Blight in *Cannabis sativa* in Kentucky

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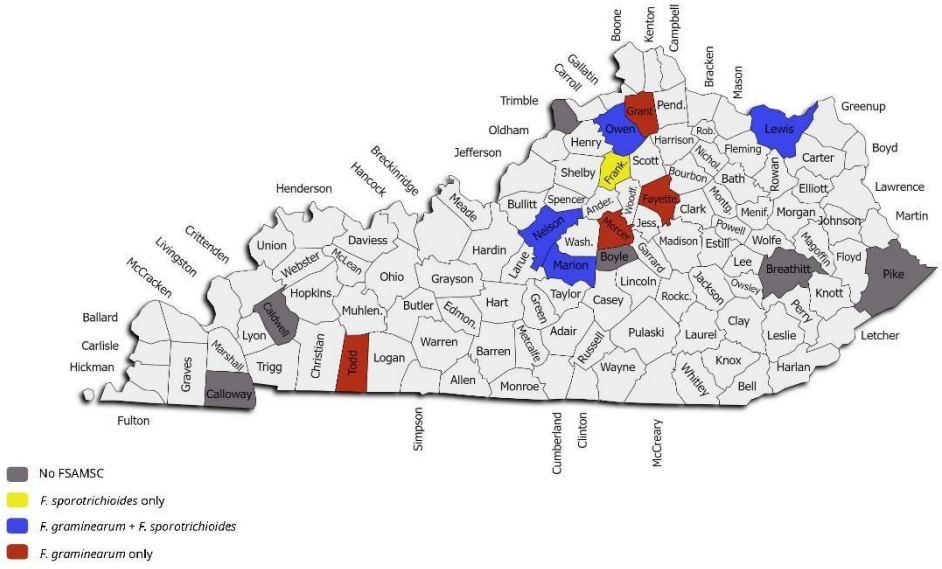
Since the reintroduction of commercial hemp production in the United States, many pathogens and pests have been identified. In Kentucky, Fusarium head blight (FHB) has emerged as one of the most commonly observed diseases in research trials. Multiple *Fusarium* spp. have been confirmed as causal agents of FHB, including major trichothecene mycotoxin producers *F. graminearum* and *F. sporotrichioides*, which fall within the Fusarium Sambucinum species complex (FSAMSC). During the 2022 growing season, a statewide survey was conducted to determine the incidence and distribution of FSAMSC associated with FHB on hemp. A total of 25 sites were surveyed, and a total of 750 symptomatic floral samples were collected. Floral tissue was plated onto Nash-Snyder selective medium following surface sterilization. A FSAMSC isolation rate of 8.5% from necrotic floral tissue was observed. The resulting isolates were speciated using PCR. Two species were confirmed: *F. graminearum* and *F. sporotrichioides*. Correlations of plant age and calendar period with isolation rate were investigated. A significant correlation between plant age and isolation rate was identified, while no correlation with calendar period was observed. Results from this survey will help guide future experiments and develop effective management strategies for FHB of hemp.



Evaluating Cultural and Biological Control Techniques for Hemp Pest Management

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Hemp, scientifically known as *Cannabis sativa* L, has a long history as one of the oldest cultivated plants. However, due to restrictive laws like the Marihuana Tax Act, commercial hemp production declined for several decades. The situation changed with the passage of the 2014 and 2018 Farm Bills in the United States, which legalized hemp production. CBD is widely used for human consumption and is often marketed as a wellness product. This shift has led to increased pressure on growers to reduce their reliance on chemical pesticides. To make informed decisions and avoid unnecessary costs, growers need accurate information about pest management in hemp. Various insect pests feed on different parts of the plant. The objective of this study was to explore the potential of cultural and biological control strategies on insect diversity in CBD hemp. Two field experiments were conducted at the E.V. Smith Research Farm in Shorter, AL. The first experiment involved planting four different CBD hemp varieties: BaOx, Southern Luck, Southern Belle, and Cat Daddy. The second experiment focused on using four different species of wildflowers: purple coneflower (*Echinacea purpurea*), butterfly milkweed (*Asclepias tuberosa*), red shade yarrow (*Achillea millefolium*), and black-eyed-susan (*Rudbeckia hirta L.*). The treatments included individual species of wildflowers, a mix of all four species, and an untreated control group. Arthropod sampling was conducted weekly via pollinator traps, drop cloth, and sweep nets for the variety trial. For the wildflowers biweekly arthropod sampling were conduct in for wildflower and hemp plots via yellow sticky traps and pit fill traps and sweep nets. All arthropods identified to the lowest taxonomic level possible and separated into four categories into four incidental, predatory, parasitoid and pest. The results revealed that Numerous pollinators and arthropods thrive among the hemp varieties. Wildflowers led to an increase in beneficial insects. This information will help identify potential management strategies for hemp growers, enabling them to make informed decisions and optimize their production practices.

Biological Control of Spider Mites using *Neoseiulus californicus* in Greenhouse Hemp

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Two-spotted spider mites (TSSM), or *Tetranychus urticae*, pose a significant threat to indoor and outdoor hemp cultivation, thriving in dry conditions and infesting the undersides of leaves. Their rapid reproduction in warm climates necessitates control measures, often involving chemical interventions that may contribute to pesticide resistance. Indoor cannabis cultivation, offering precise environmental control for all growth stages of hemp. *Neoseiulus californicus* is a promising biological control for hemp farming, targeting spider mites at all life stages and serving as a valuable component of integrated pest management. Greenhouse studies have demonstrated the success of *N. californicus* in controlling spider mite populations, highlighting a potential sustainable solution for hemp farming. Cherry Blossom hemp clones at the Ornamental Horticulture Research Center in Mobile, Alabama, were infested with two-spotted spider mites. The 32 plants, organized in a replicated complete block with 4 treatments and 8 replications, underwent pre-counts before *Neoseiulus californicus* release. Predatory mites were counted, placed in tubes, and released onto hemp plants in bug enclosures. Spider mite counts occurred every 3 days for two weeks, with leaves from the top, middle, and bottom thirds assessed in the laboratory for eggs, nymphs, and adult mites. Plant damage on a 0-5 scale was evaluated every 6 days. *N. californicus* didn't significantly affect spider mite numbers; time was the primary factor in reducing populations. All *N. californicus* treatments lowered spider mite damage, with the most effective treatment having the highest predatory mite count. Predatory mite treatments did not affect TSSM numbers, possibly due to altered mite behavior and reduced feeding activity. These findings emphasize the importance of informed decision-making in sustainable pest control for agriculture. Farmers can reduce reliance on chemical pesticides by optimizing the timing and dosage of predatory mite applications based on the dynamics of the interaction between time, treatment, and damage.

An Overview of Integrated Pest Management Practices for Corn Earworm, *Helicoverpa zea*, in Southeastern Hemp

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Corn earworm, *Helicoverpa zea* (Lepidotera: Noctuidae), has emerged as an injurious insect pest to hemp, *Cannabis sativa* L. One of the biggest challenges in managing corn earworm is the limited number of effective management tools for control. To aid in the control of this pest, field trials were conducted to evaluate the efficacy of insecticides against corn earworm. Field trials involved the application of biological insecticides registered for hemp and conventional standards used in other crops. Caterpillar counts, and damage ratings were collected. Results from the field trials showed no significant difference in the effectiveness of insecticide treatments, but conventional insecticides were more effective than biological insecticides. Due to the lack of pesticides allowed for use in hemp, exploring different management strategies is crucial to control corn earworm. Two field experiments were conducted to evaluate cultural control techniques against this pest. The first experiment utilized a sweet corn trap crop to reduce corn earworm damage in hemp. Different sweet corn planting dates were tested, and the trap crop showed potential for reducing damage to hemp. The second experiment assessed varietal preferences of corn earworm in four hemp varieties. Significant differences were observed in caterpillar numbers, and damage ratings. These findings highlight the importance of implementing cultural control strategies to manage corn earworm in hemp.

Assessing the Damages and Yields in Grain Hemp as Result of Corn Earworm Feeding

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Poster will show results on studies that evaluated the reduction of hemp grain yield caused by corn earworm (CEW) (*Helicoverpa zea*, Lepidoptera: Noctuidae) in grain hemp. Hemp were grown in Murray and Lexington in 2022, and Princeton, KY in 2023. Hemp shoots (20 cm in length) were taken to the lab from a commercial field in Murray (*cv.* Futura-83) and a UK-research plot in Lexington (*cv.* Felina-32) at seed maturity. In 2023, similar sampling procedures were completed in research plots in the UK's Research & Education Center at Princeton in 2023 (*cv.* Futura-83). In 2022, the numbers of grains produced in each node were tabulated. There were great reductions of grains in shoots that were heavily damaged by CEW. These reductions were of almost 1/4 in Murray and approximately ½ in Lexington. Cultivars for these locations were Futura-83 in Murray and Felina-32 in Lexington. The numbers of hemp seeds were affected by CEW feeding. There were reductions in seed numbers in the three locations. Percentages of seed damage by CEW were significantly higher in the high damages in Princeton in 2023($p<0.05$). Assessing damages of CEW is a difficult task. This study is an approach to evaluate yields in grain hemp caused by CEW damage using qualitative and quantitative variables. Injuries caused by CEW might reduce yields, grain quality, and facilitate infections of plants by fungi or other pathogens. Hemp cultivars might have different susceptibility to CEW attacks.

Control of Hemp Russet Mite Using Conventional and Organic Pesticides

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The hemp russet mite (HRM), *Aculops cannabicola* (Farkas) (Acari: Eriophyidae) was tallied through image-based sampling using handheld digital stereoscope pictures in outdoor grown hemp in 2021 and 2022. In 2021 we used Green Cleaner [Soybean oil +Sodium Lauryl Sulfate), TetraCURB MAX2 (Rosemary oil 50%)], Debug™ Optimo [Fats and Glyceredic oils, Margosa (15.4%) + azadiracthin (0.7%)], BoteGHA™ ES [(Beauveria bassiana strain GHA (11.3%)], SuffOil-X® [BW280 1%, a highly refined mineral Oil 80%], and the conventional miticides ABBA ULTRA™ (Abamectin), Fujimite™ SC (Fenpyroximate), Stifle™ SC (Etoxazole). In 2022 we used RM-1964K (Edible blended oils), BoteGHA™ ES, SuffOil-X®, and the conventional miticides ABBA ULTRA™ (Abamectin), Portal™ (Fenpyroximate), and Kanemite™ 15SC (Acequinocyl). All these products were compared with untreated water use as control. The most effective products in 2021 were Fujimite, ABBA Ultra, BoteGHA, and BW280 at 1% and these were significantly different from the water control during most dates tallies were conducted ($p<0.05$). However, Green Cleaner, TetraCurb Max2, DeBug Optimo, and the miticide Stifle were not significant different ($p>0.05$) from the control on most of dates where HRM were tallied. In 2022, the most effective products were Portal, ABBA Ultra, and BW280 (at 1%) and these were significantly different ($p<0.05$) from the water control on 13, 16, 21, and 27 September. However, RM-1963, BoteGHA and the miticide Kanemite were not significant different ($p>0.05$) from the control on most of dates when HRM were tallied. Phytotoxicity on plants were only observed in 2021 with Stifle showing easily observable chlorosis on tips; whereas plants sprayed with Debug Optimo showed a light chlorosis but hard to capture with photos. In 2022 phytotoxicity was not observed for any pesticide.

Using Green Lacewings (*Chrysoperla sp.*) for Biological Control of Two-Spotted Spider Mites (*Tetranychus urticae*) in Cannabis: Potential Inference with Intraguild Predation

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Two-spotted spider mites, *Tetranychus urticae*, are a prevalent pest in hemp, *Cannabis sativa* L. and are found hemp grown both in the greenhouse and field. Two-spotted spider mites feed on the underside of leaves; feeding damage results in the stippling of leaves and, in high numbers, can cause damage that mimics drought stress. Lacewings, *Chrysoperla* sp., will feed on two-spotted spider mites and can potentially be used as an integrated pest management strategy for control in hemp. However, lacewing larvae are susceptible to intraguild predation (IGP), which can interfere with successful biological control. Therefore, we sought to quantify the level of intraguild predation between lacewing larvae at different ratios of predatory lacewings to pestiferous spider mites in an attempt to identify an effective biological control strategy.

In a series of replicated experiments, lacewings were used at a rate of 0, 1, 2, 4, and 8 larvae with high (n=40) and low (n=20) populations of two-spotted spider mites. We assessed different numbers and instars of lacewing larvae and measured mortality caused by IGP. We also assessed population suppression of two-spotted spider mites. Results were analyzed using a generalized linear model in SAS 9.4.

The experiments showed that a ratio of 1 lacewing:4 two-spotted spider mites was the most effective for spider mite suppression. We observed IGP between lacewing larvae take place in our experimental arenas, as larva would often feed on other larvae, even when spider mites were present. However, we did not observe a decrease in mite mortality in arenas that had higher lacewing IGP as would be expected if lacewing predation did interfere with pest suppression. When higher numbers of lacewings were present in the arenas, regardless of IGP levels, there were lower numbers of spider mite eggs over the course of the experiment. We hypothesize that the presence of more predators acts as a deterrent for spider mite egg lay and results in overall lower egg numbers.

Our experiments give insight into the potential to use *Chrysoperla* species as biological control agents for two-spotted spider mites in greenhouse hemp. While IGP may occur in this system, it did not appear to limit pest suppression and as a result, more lacewings may not be necessary for successful control. The most effective predator:pest ratio in our treatments was 1 lacewing:4 spider mites, which highlights the importance of a proactive pest management program to limit pest populations before exponential growth is reached.

Exploring the Impact of CBD Content in Hemp Cultivars on Aphid Populations and Detoxification Gene Regulation

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Cannabis aphid (*Phorodon cannabis*) is a newly recognized pest species on hemp in North America. It causes feeding damage by primarily sucking sap from the plant's phloem using its piercing-sucking mouthpart, and it may potentially transmit viruses and other pathogens, causing indirect damage. Surveys from our preliminary studies in the greenhouse and field showed that populations of aphids are higher on fiber hemp cultivars Henola and Bialobrzeskie than on CBD hemp cultivars Citrus, BaOx, and Cherry Dwarf. A major difference between cultivars of fiber and CBD hemp is their CBD content. CBD hemp cultivars contain a significantly higher amount of CBD than fiber hemp cultivars. Thus, we hypothesized that the CBD content of different hemp cultivars mediates *P. cannabis* feeding preference, and indirectly affects *P. cannabis* gene expression especially detoxification genes such as Cytochromes P450 (P450), Glutathione S-transferases (GSTs), Glucuronosyltransferase (UDP), and Carboxyl-/esterases (CES). Our objective was to investigate the transcriptional response of cannabis aphids to different hemp cultivars and to see if CBD hemp triggers differential expression of the detoxification genes in cannabis aphids. In this study, adult cannabis aphids were collected from both fiber and CBD hemp cultivars and subjected to RNA isolation and RNA-seq analyses. The results showed that detoxification genes (such as CES and UDP) involved in hydrolysis of plant toxin (CBD) exhibited notably down-regulation in aphids that fed on CBD hemp cultivars as opposed to those on fiber hemp cultivars. While the regulation of detoxification genes (such as P450 and GSTs) involved in chemical insecticides did vary depending on the specific circumstances and hemp cultivars. Our research demonstrated that CBD might effectively reduce the cannabis aphid population by inhibiting specific pathway genes like CES and UDP and could be a potential botanical insecticide for aphid control.

Hemp cultivar	Aphids/10 plants*		CBD content
	7/19/22	8/5/22	
Bialobrzeskie	820	3250.	1-1.5%
Henola	230	2250	2-5%
BaOX	na	na	8-10%
Cherry Dwarf	10	5	11-12%
Citrus	10	9	8-12%