University of Kentucky
College of Agriculture, Food and Environment
Agricultural Experiment Station

SR-112

Science of Hemp: Production and Pest Management

Hemp (*Cannabis sativa* with <0.3% THC content) is grown for fiber, grain, and cannabinoid extraction in Asia, Europe, and the Americas. Until recently, *Cannabis sativa* has been classified as a Schedule 1 controlled substance in the US. The Agricultural Act of 2014 (Farm Bill) allowed for reintroduction of industrial hemp under a pilot research program. Acreage increases and addition of state legislation resulted in over 78,000 acres of hemp grown in 23 states by the end of 2018. Hemp became a legal commodity under the 2018 Farm Bill, and by the end of 2019, over 500,000 licensed acres were documented across 45 states. Canada re-introduced the crop in 1998, and in 2018, almost 78,000 acres of hemp were licensed and planted.

With this increase in acreage and the lack of modern scientific data, university and government agricultural specialists began to work on various components of production and a range of realized challenges. This new information, however, had either not been shared or was not readily accessible to the scientific community, especially early results and nonpublished data.

The first annual meeting of the Science of Hemp: Production and Pest Management was held on October 10-11, 2019 at the University of Kentucky in Lexington, KY. Ninety-two agricultural scientists attended a series of scientific presentations, breakout sessions, and discussion panels. Attendees presented 33 oral talks, 19 posters, one grower panel, and one outreach/education panel. Topics included discipline-specific presentations in agronomy, entomology, horticulture, and plant pathology, while general session topics included regulatory, pesticides, and economics. Other highlights included a networking social with a hemp-based dinner and an afternoon of thoroughbred racing at Keenland race track.

Organizers would like to thank the University of Kentucky College of Agriculture, Food, and Environment for making this meeting possible. We also want to thank the countless volunteers from within our College who made contributions great and small.

Sincerely,

Nicole Gauthier, Associate Professor, UK Department of Plant Pathology
Kimberly Leonberger, Extension Associate, UK Department of Plant Pathology
Cathy Bowers, Executive Assistant, UK CAFE Office of the Associate Dean for Research

Contents

Meeting Overview

Thursday Oct 10

8:00am	Registration, Coffee, Social Poster setup
9:00am	Welcome, introductions Successes and Growing Pains: Kentucky Dept of Ag (Doris Hamilton) Regulatory Variability in Postharvest Sampling (Frank Sikora) Effects of Defoliation on Yield (Kadie Britt) Seed Quality Issues in Industrial Hemp (Sabry Elias)
11:30am	Field trip. Box lunch included. Travel by bus* A Taste of the Bluegrass, Thoroughbred Racing at Keenland (tickets included)
4:00pm	Depart Keenland, wind-down time at hotel*
5:30pm	Bus pickup, return to campus for evening session*
6:00pm	Evening session. Beer and Wine. Trojan Horse or Golden Ticket: Hemp Economics (Tyler Mark) Floral Production of Hemp on Plastic versus Open Beds (Angela Post)
7:00pm	Catered dinner. Beer and Wine* Poster viewing. Social-Networking
9:00pm	Return to hotel by bus*

Friday Oct 11

8:00am	Registration, Coffee, Social
9:00am	Pesticide Regulations, Limitations, and Our Way Forward (Ric Bessin)
9:30am	Breakout sessions: Agro-Hort, Ent, Ppath oral talks numbered 1 thru 7
1:002noon	Lunch, Taco bar.
1:00pm	Breakout sessions: Agro-Hort, Ent, Ppath oral talks numbered 8 thru 11
2:30pm	Break, Coffee, Snacks
3:00pm	A Foot in the Furrow: Discussion Panel (moderator: Nicole Gauthier) panelists: growers, county agents, specialists
4:00pm	Roundtable: Let's Talk Outreach & Extension (moderator: Lindsey Thiessen)
5:00pm	Adjourn (don't forget your survey)

* Bus transportation on Thursday afternoon and evening, only.
Attendees are responsible for their own transportation Thursday morning, Friday morning, and Friday evening.

Breakout Sessions

PLANT PATHOLOGY			Time	
Sarah	Cochran	*Fusarium* on Industrial Hemp	9:40	MORNING
Desiree	Szarka	New Species of Bipolaris Infecting Hemp	10:00	
Ernest	Bernard	Hemp Cultivar Susceptibility to the Root-Knot Nematode *Meloidogyne incognita*	10:20	
Alan	Taylor	Hemp Seed Treatment Research for Damping-off	10:40	
Tyler	Schappe	Fungicide Efficacy on Hemp Diseases in North Carolina in 2019	11:00	
Nicole	Gauthier	Considering Crop Rotations & the Potential for Carry-Over Infection	11:20	
Gary	Bergsrom	An Early View of Diseases Affecting Hemp in New York	11:40	
Charles	Johnson	2019 Disease Observations on Industrial Hemp in Virginia	1:00	AFTERNOON
Zachariah	Hansen	Hemp Extension in Tennessee: Most Common Diseases of 2019	1:20	
Lindsey	Thiessen	Industrial Hemp Disease Pressures in NC	1:40	
Carlo	Cormier	Survey of Diseases and Pests Affecting Hemp in New Brunswick, Canada	2:00	
Open		Open Discussion		

AGRONOMY-HORTICULTURE			Time	
Margaret	Bloomquist	Optimal Planting and Harvest Dates for CBD Hemp for Western NC	9:40	MORNING
James	DeDecker	Grain & Fiber Variety Performance in Michigan	10:00	
Bob	Pearce	KY Agronomy Update	10:20	
Avat	Shekoofa	Industrial Hemp (*Cannabis sativa* L.) Cultivars and Water Management	10:40	
Bob	Pearce	Nitrogen Rate Impact on Hemp Growth	11:00	
Maggie	Short	Nitrogen and Potassium Rates for Industrial Hemp Following a Tobacco Production Model	11:20	
Angela	Post	Plant Population and Transplanting Depth in Hemp for Floral Production	11:40	
Eric	Walker	Yields, Yield Components, and Cannabinoid Profiles of High Essential Oil Hemp Varieties	1:00	AFTERNOON
Will	Wadlington	Hemp Variety Trial in Subtropical South Florida	1:20	
Chad	Cagle	Greenhouse Production and Propagation: A Grower's Approach	1:40	
Tim	Stombaugh	Considerations for Mechanical Harvesting of Hemp	2:00	
Shawn	Lucas	Certified Organic Hemp: An Opportunity for Growth	2:20	

ENTOMOLOGY			Time	
Brett	Highland	An Overview of the Use of the Biopesticides in Hemp Production, with Emphasis on the Insecticides	9:40	MORNING
Chad	Cagle	A Grower's IPM Approach to Pest Management in the Greenhouse	10:00	
John	Obryicki	Biological Control in Greenhouse and Field Situations: Potential for Hemp Production	10:20	
Raul	Villanueva	Hemp Russet Mite: A Threat to KY Hemp	10:40	
Marguerite	Bolt	Hemp-Insect Interactions, An Update of Pests in Indiana	11:00	
Amanda	Skidmore	Current Status of Hemp IPM in the Southwest (via Zoom)	11:20	
Katelyn	Kesheimer	Alabama Hemp: The First Year	11:40	
Raul	Villanueva	Kentucky Hemp Insect Update	1:00	AFTERNOON
Kadie	Britt	Hemp Insect Pest Management in Virginia	1:20	
Open		Open Discussion	1:40	

Discussion Panel

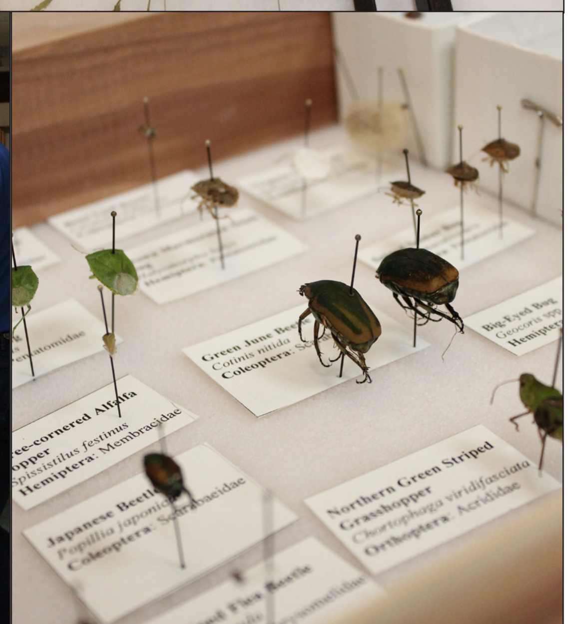
Foot in the Furrow Panel		
Margaret	Bloomquist	Agronomist, Field Research
Eric	Walker	Agronomist, Extension Specialist
Brenda	Kennedy	Pathologist, Diagnostician
Raul	Villanueva	Entomologist, Extension Specialist
Jessica	Barnes	Grower and County Agent
Chad	Cagle	Greenhouse Grower
Samantha	Anderson	Grower and County Agent

Posters

Poster Titles		
Margaret	Bloomquist	Effect of Colored Plastic Mulches on the Growth and Yield of Hemp in Western NC (Coneybeer-Roberts, M., Casebeer, G., and Davis, J.)
Kadie	Britt	Hemp Insect Pest Management in Virginia
Elizabeth	Bush	Hemp Diagnoses in Virginia in the First Year of Commercial Production (Bush, E.A., Hansen, M.A., Zhang, X., Adamo, N. and Johnson, C.S.)
Madison	Cartwright	Diseases of Hemp in Tennessee
Jacqueline	Coburn	Root-Knot Nematode Host Status of Different Hemp Cultivars
Kassie	Conner	Diseases and Insects of Hemp in Alabama (Kesheimer, K and Conner, C.)
Nicole	Gauthier	A Case for Extension Programming: 2019 Survey of Hemp Growers in the Southeast (Gauthier, N., Conner, K., and Kesheimer, K.)
Kimberly	Gwinn	Powdery Mildew in Field-Grown Hemp (Gwinn, K.D., Bernard, E.C., Hansen, Z.R. and Trigiano, R.N.)
Tyler	Mark	Hemp Production in Uncertain Markets
Louis	McDonald	Preliminary Results from WVU: Diseases, Mycorrhizae, Salts, Metals, and the Soil Microbiome
Michelle	McGinnis	Evaluation of Leaf Position on Foliar Nutrient Concentrations of 60 Hemp Cultivars at the Pre-Flowering Stage
Michelle	McGinnis	Survey of Foliar Nutrient Concentrations of 25 Foliar Hemp Cultivars at the Pre-Flowering Stage
Zealam	Mersha	Southern Blight and Foliar Diseases on Hemp in Southern and Central Virginia
Avat	Shekoofa	Industrial Hemp (*Cannabis sativa* L.) Cultivars and Water Saving Traits: Water Management. (Shekoofa, A., *Sheldon, K., and Walker, E.R.)
Kendall	Sheldon	Industrial Hemp (*Cannabis sativa* L.) Cultivars and Water Management
Desi	Szarka	Hemp Leaf Spot, A Major Disease Threat for Hemp, Is Caused by Haploid and Heteroploid Populations
Lydia	Tymon	Identification of *Golovinomyces spadiceus* as a Pathogen on *Cannabis sativa* in Kentucky
Raul	Villanueva	Arthropods Collected from Industrial Fields in Kentucky in 2019

Meeting Proceedings

Following are forty-two meeting abstracts, arranged in alphabetical order by author. Oral and poster presentation abstracts are included herein.



An Early View of Diseases Affecting Hemp in New York

Gary Bergstrom, Jennifer Starr, Kevin Myers, and Jaime Cummings, Cornell University, Ithaca, New York

Commercial and experimental fields and greenhouses with hemp (fiber, grain, and CBD varieties) were scouted for diseases in New York in close cooperation with Extension Educators during 2017-2019. Specimens were collected and laboratory diagnoses were conducted in Cornell's Field Crop Pathology Lab. Pythium damping-off is a significant problem and effective seed treatments will be essential for management. Sclerotinia white mold and Botrytis gray mold were prevalent and sometimes severe. White mold presents a significant challenge for potential rotations with soybean and several vegetable crops. Root, crown, stem and vascular wilts associated primarily with *Fusarium* spp. occurred at low incidence but resulted in plant deaths. Fungal leaf spots were diagnosed in association with more than eight genera of fungi. Bipolaris leaf spot (causal *Bipolaris* shows close sequence homology to *Drechslera gigantea*) is the most prevalent and severe leaf spot in New York. At harvest in 2019, a foliar rust was discovered on CBD varieties. The uredinial stage matched the morphological description of *Uredo kriegeriana* Syd. & P. Sydow, described from Sachsen, Germany in 1901. *Fusarium* bud blight associated with several *Fusarium* spp. was common and resulted in mycotoxin contamination of grain and floral tissues exceeding the FDA advisory of 1 ppm for food. Our group has initiated an active research program to better understand and mitigate the mycotoxin threat in hemp production.

Fusarium bud blight

Leaf Rust

Bipolaris leaf spot

Confusion and Uncertainty: Hemp Pesticides

Ric Bessin, University of Kentucky, Lexington, Kentucky, USA

Confusion has developed as state lead agencies are interpreting differently what products are allowed for use on hemp. This confusion is further compounded by growers in different states having different pesticides available for use on hemp. In addition to confusion, uncertainty abounds. The direction the FDA will go regarding classification of hemp as a food or drug is unclear. Uncertainty within the agriculture chemical industry also exists. Several large chemical companies are unwilling to pursue registration through IR-4 or will only pursue labels on hemp for fiber and non-food uses. Full registrant support is needed to get new product uses.

Pesticides labeled for hemp must comply with EPA regulations, individual states' Department of Agriculture, and the producer's hemp buyer. Applicators cannot use pesticides inconsistent with the label. Few pesticides are labeled for use on hemp. An August search on the Crop Data Management Systems (CDMS) website found that five pesticides were labeled for use on hemp or industrial hemp. Some minimal risk pesticides allow use on unspecified crops, and may be able to be used on hemp. In Kentucky, the Kentucky Department of Agriculture states that for a pesticide to be used on hemp it must: (1) have a label that allows use on unspecified crops, (2) allow application to the intended site, (3) not prohibit use on crops for human consumption, and (4) be applied by a licensed applicator.

Three types of pesticide registrations may be used to get products approved, and these include: (1) Section 3 – Standard registration (most common type), (2) Section 18 – Emergency Exemptions (limited in time to one year, limited by state, and not available for hemp), and (3) Section 24(c) – State Local Need (a food tolerance exists and issued by state, limited in time to five years). In order for hemp to be listed on pesticide labels, the Section 3 type of registration can be utilized. Pesticide registrants pursue adding a crop to the label through finding the IR-4 State Liaison, identifying a potential solution for a problem, creating a Pesticide Clearance request, and helping the project to be selected at FUW. Currently there are 10 pending petitions, for which the comment period ended September 23, 2019. The IR-4 Project also facilitates the registration of pesticides onto specialty food crops. This process usually takes three to four years for a crop to be added to the label. At the September IR-4 Food Use Workshop, Mike Bledsoe (Village Farms) provided hemp leadership. Forty two projects were selected out of 280 high priority projects, and include: 12840 Bromoxynil (selected), 12771 Azoxystrobin (selected), 12834 Flutianil (upgrade proposed), and 12704 Insecticide Integrated Solutions project (approved – Leps). However, uncertainty also exists in the IR-4 process as methods and protocols for residue testing are not defined. In the future EPA and IR-4 will work together to develop protocols for hemp testing. There are some insecticides that may have exemptions, and include: Petroleum oils, piperonyl butoxide, pyrethrins, *Bacillus thuringiensis*, HzNPV, C12-C18 potassium salts of fatty acids, Azadirachtin, *Beauveria bassiana* GHA, Capsacin, Kaolin clay, *Beauveria bassiana* #74040, *Beauveria bassiana* HF23, *Chenopodium ambrosiodes* near *ambrosiodes,* Cold pressed neem oil, *Metarhizium anisopliae* F52, *Beauveria bassiana* ANT-03, and *Beauveria bassiana* PPRI5539. For State Local Needs 24 (c) Labels, the EPA is willing to support this process, but support from registrants is still needed. This may be a way to get minimal risk tolerance exempted material approved. Moving forward minimum risk pesticides are available, and minimal risk pesticides are available through 24(c). However, the process to get conventional pesticides labeled is uncertain.

Optimal Planting and Harvest Dates for CBD Hemp in Western North Carolina

Margaret Bloomquist, Jeanine Davis, PhD, and Katherine Learn
NC State University, Department of Horticultural Science, Mills River, NC, USA

Hemp (*Cannabis sativa*) demonstrates tremendous potential as an emerging crop but there is little relevant regional production information available. Initiation of hemp flowering happens in response to photoperiod and other environmental factors; there is also a genetic component involved. Timing of harvest impacts the value and legality of the crop produced. Production of high quality, safe, THC compliant hemp is necessary for North Carolina (NC) farmers to compete in today's hemp industry.

In 2019, three planting and two harvest dates for two strains of floral hemp were evaluated at two sites. The objective was to maximize crop output through determining the optimal planting dates and harvest windows for hemp for the cannabidiol (CBD) market. Cherrywine and Baox vegetative clones were transplanted May 15th-16th, June 11th-13th, and July 9th on state owned research stations in the southern mountains (Mills River) and central piedmont (Salisbury) in NC. Variables evaluated included: flower initiation; time of 50% flowering; plant size, shape, and vigor; leaf and inflorescence number; color; pistil and trichome development; and yield. Harvest dates were September 18th-19th and October 2nd-3rd. There were three replications. Whole plants were cut and hung to dry in climate controlled conditions. Third party analysis on soil and plant tissue nutrients; floral analysis (THC, CBD, etc.); and microbial contamination, pesticides, heavy metals, and mycotoxins were ongoing at date of print. Results presented should be considered preliminary until further statistical analysis are done.

Initiation of flowering was chronological with transplant date; 42, 27 and 6-12 days for the May, June, and July plantings, respectively. Fifty percent flowering was observed for both strains across all planting dates within a two week period in August. The July planting resulted in lower yields than the two earlier plantings for both harvest times at both sites. Yield for the May and June plantings appear similar for both harvest dates, averaging 1.5 to 2.5 dry, destemmed pounds per plant. The Salisbury site yields appear to be larger than the Mills River site.

Final results and recommendations will be posted to: https://industrialhemp.ces.ncsu.edu/

Funding was provided by the NCDA&CS Bioenergy & New and Emerging Crops Program. Plant material was donated by East Coast Genetics.

Figure 1: Optimal Planting and Harvest Dates 2019. August 30, Mills River, NC Location.

Hemp-Insect Interactions, An Update of Pests in Indiana

Marguerite Bolt, Purdue University, West Lafayette, Indiana, USA

Hemp production expanded across the state of Indiana in 2019. While Indiana growers only planted around 3,500 acres, we were able to observe more insect pests attacking hemp because of this expansion. The most prevalent pests were found feeding on seed heads, flowers, and leaves. Not all of the pests observed caused damage that would lead to economic loss. Specifically, chewing insects found on leaves typically caused minor damage but were very noticeable by growers. Some of the most abundant insects found on hemp included; flea beetles, armyworms, aphids, spider mites, and corn earworm. Of these pests, corn earworm seemed to cause the most concern when it came to floral production because of the destruction of the marketable portion of the plant and secondary mold growth. Two other pests of concern were detected on hemp this year. Potato leafhopper (*Empoasca fabae*) and Eurasian hemp borer (*Grapholita delineana*) caused damage to hemp plants in several hemp fields across the state. Potato leafhopper caused its characteristic hopper burn damage and Eurasian hemp borer larvae bore into stalks and consumed floral material late in the growing season. The misconception about hemp having few pests has led to a false sense of security for many growers. Because we have observed insects attacking hemp since it was first planted in 2015, we have conducted studies to understand how growing practices could influence hemp pests through changes in plant chemistry. We observed that management practices, including; nutrient applications, cultivar, and planting date, can affect physical and chemical leaf traits in a way that affects an insect herbivore's growth. Greater amounts of nitrogen in a leaf lead to faster larval development, while greater ratios of carbon and cannabinoids to nitrogen, leads to slower larval development. We will be conducting studies to look at specific secondary compounds and how they affect larval development in the future.

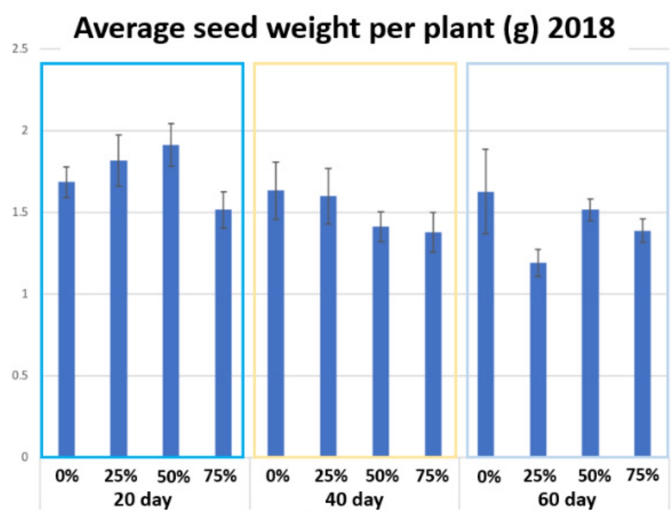
Figure 1. Hopper burn caused by potato leafhopper.

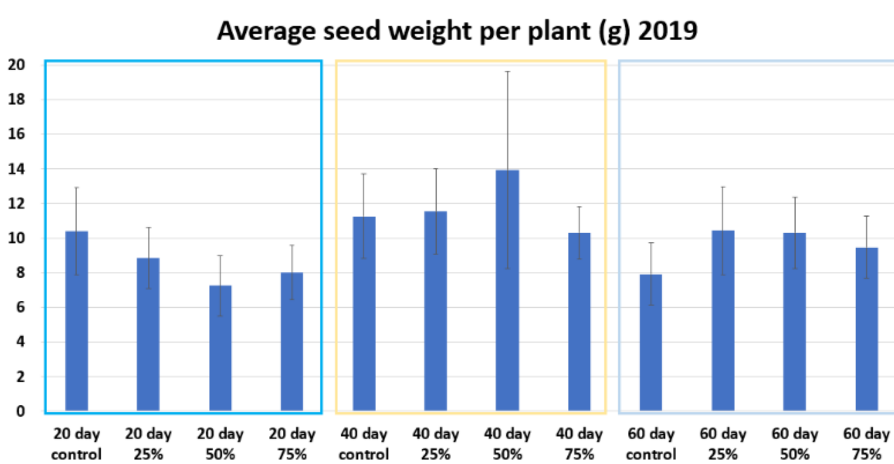
Figure 2. Eurasian hemp borer larva in stem, adult on leaf, and larva in floral material.

Effects of Defoliation in Grain Hemp

Kadie E. Britt and Thomas P. Kuhar
Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA

Chewing insects such as caterpillars, beetles, and grasshoppers are sometimes present in great densities on hemp plants and can often consume a considerable amount of foliar material. Very little is known about the impact of defoliation on hemp. In 2018 and 2019, an experiment was conducted to simulate insect defoliation on grain variety hemp plants ('Felina 32,' a dual-purpose grain/fiber variety) to determine whether a loss of foliar area could impact yield. This experiment was conducted at Virginia Tech's Kentland Research Farm in Whitethorne, VA. Hemp plants were manually defoliated with shears to remove varying levels of leaf material from plants at varying times throughout the season. Plants were defoliated at 20, 40, and 60 days post planting (to simulate early, mid, and late season insect infestations) at levels of 0%, 25%, 50%, and 75% (to simulate damage at no, low, medium, and high levels of insect infestation). 'Felina 32' variety hemp plants typically have a ~90 day growing season in the field. Seeding rate both years was 30 pounds of seed per acre. Planting dates for this study were 8 June 2018 and 30 May 2019. The results from both years of this experiment showed that average seed weight per hemp plant was not significantly affected by timing or amount of foliar area removed from plants. These results confirm the popular belief that hemp is an extremely durable and tolerant crop. However, it is possible that actual insect feeding injury rather than manual defoliation using shears could potentially elicit a different plant response. However, similar experimental methods have been conducted in many other crops using manual defoliation and showed that plant yield was significantly negatively affected. Also, although this experiment revealed that grain yield was not affected, it does not provide any information as to whether chemical production of THC (tetrahydrocannabinol) or CBD (cannabidiol) is altered. Future directions will explore potential chemical content alteration within grain and CBD variety hemp plants.





Hemp Insect Pest Management in Virginia

Kadie E. Britt and Thomas P. Kuhar
Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA

Many insects are present in indoor and outdoor hemp throughout Virginia and it is important to determine which species potentially pose a threat to production and yield. Since 2017, research efforts have been focused on addressing insect pest management concerns for growers in Virginia and beyond. Several generalist insects are present in fields, including Japanese beetle (*Popilia japonica*), a complex of stink bugs (brown marmorated stink bug, *Halyomorpha halys*; brown stink bug, *Euschistus servus*; and green stink bug, *Chinavia hilare*), and corn earworm (*Helicoverpa zea*), which has proven to be the most damaging pest for hemp production outside in Virginia. There are also a couple of specialist species found on hemp outside and indoors, including the cannabis aphid (*Phorodon cannabis*) and hemp russet mite (*Aculops cannabicola*). Ongoing research in Virginia has revealed that defoliation of hemp will likely not negatively affect yield and is not to be a great concern for growers. Additionally, our research has shown that stink bugs, although damaging to other crops, do not appear to be a concern for yield or quality loss in hemp.

Since corn earworm is the most damaging pest of hemp at this time, research efforts have largely focused on management options for this insect. Corn earworm feeding can lead to lower yield and quality of hemp; feeding wounds on plants can allow for greater incidence of bud rot, caused by opportunistic invasion of *Botrytis cinerea*, or grey mold. Lab and field assays have shown promising results for the insecticide Entrust (active ingredient Spinosad), although this product is currently not allowed for use on hemp in Virginia or other states. Certain other insecticides with the active ingredient *Bacillus thuringiensis* (Bt) are allowed for use on hemp in Virginia. Products with *Bacillus thuringiensis* var. *kurstaki* have shown lower efficacy against corn earworm, while at least one product with two Bt strains (*kurstaki* and *aizawai*) has shown greater efficacy in our studies (up to 75% mortality in a lab assay).

Moving forward, it will continue to be a challenge to manage insect pests in hemp due to legal restrictions surrounding pesticide use in the crop. Studies in Virginia will continue to address insect pest management in hemp.

Hemp Diagnoses in Virginia in the First Year of Commercial Production

E.A. Bush[1], M.A. Hansen[1], X. Zhang[1,2], N. Adamo[1,2], and C.S. Johnson[1,2]
[1]Virginia Tech, Blacksburg, Virginia, USA
[2]Southern Piedmont Agricultural Research and Extension Center, Blackstone, Virginia, USA

During the first year of hemp production in Virginia, diagnosticians and researchers at Virginia Cooperative Extension's Virginia Tech Plant Disease Clinic and the Southern Piedmont Agricultural Research and Extension Center diagnosed approximately 120 hemp samples by late September 2019. Very dry conditions generally prevailed in many Virginia locations during the 2019 growing season in Virginia, with hot conditions in late summer and early fall. The majority of Virginia's 2019 hemp production was for cannabidiol (CBD) oil and nearly all the hemp samples submitted for diagnosis were produced for CDB oil. A variety of fungal diseases were diagnosed, as well as diseases caused by the oomycete *Pythium* spp. On the abiotic side, girdling roots were common (Table 1). Given the generally dry weather during Virginia's 2019 growing season, disease pressure could be higher in future, wetter years. Looking forward, hemp diagnoses need to extend beyond the genus to species level to facilitate development of practical, effective, and economic disease control strategies. Hemp pest management will also require accurate assessments of disease incidence and severity in order to prioritize pest problems.

Table 1.

Diagnosis	Pathogen	Plant Clinic[1] Diagnoses	SPAREC[2] Diagnoses	Combined Diagnoses
Girdling Roots		9	6	15
Fusarium Foot Rot and Root Rot	*Fusarium solani*	3	9	12
Fusarium Stem Canker	*Fusarium* sp.	3	9	12
Abiotic (other than girdling roots)		12		12
Hemp Leaf Spot	*Dreschslera gigantea*	5	5	10
Southern Blight	*Sclerotium rolfsii*	5	4	9
Pythium Crown and Root Rot	*Pythium* sp.	3	2	5
Pythium Root Rot	*Pythium* sp.	2	2	4
Charcoal Rot	*Macrophomina phaseolina*	3		3
Botryosphaeria Twig Blight	*Botryosphaeria* sp.	1	1	2
Frogeye Leaf Spot	*Cercospora* sp.		2	2
Rhizoctonia Root Rot	*Rhizoctonia solani*	2		2
Brown Blight (on flowers)	*Alternaria alternata*	1		1
Powdery Mildew	*Oidium* sp.	1		1
Rhizoctonia Crown and Root Rot	*Rhizoctonia* sp.	1		1
Rust	*Uredo kriegeriana* (Putative[3])	1		1
Unspecified Pathology	*Cristulariella* sp.[4]	1		1
Insect/Mite		8	3	11
Negative for Disease		4		4
Insufficient Sample		13		13
TOTAL		**78**	**43**	**121**

[1] *Virginia Tech Plant Disease Clinic, Blacksburg, VA*
[2] *Southern Piedmont Agricultural Research and Extension Center, Blackstone, VA*
[3] *Currently being identified by the national fungal identifier at USDA.*
[4] *Abundant conidia of* Cristulariella *were found on leaves with hemp leaf spot and powdery mildew late in the growing*

Greenhouse Production and Propagation: A Grower's Approach

Chad Cagle, ColorPoint, Paris, Kentucky, USA

Greenhouse production and propagation of hemp is similar to those of ornamental crops, and numerous approaches should be employed for success. This overview of greenhouse production reflects basic integrated pest management strategies.

The growing environment should be kept clean and regularly disinfested. Crop debris and weeds should be removed. Sanitation protocols should be established. When entering a growing area, individuals should observe the following practices: (1) wash hands, (2) wear a protective clothing covers, (3) utilize a foot bath, (4) wear shoe covers. Work in the greenhouse should be conducted first in clean areas and end with dirty, infested, or infected areas.

Propagation of hemp can be achieved through sexual (seed) and asexual (clones) methods. With propagation via seeds, variation among seedlings occurs, as a result of recombination of genetics from two parents. Thus, asexual/vegetative propagation is common practice; cuttings are called clones. This method results in exact replicas of the plant, eliminating genetic variation. Vegetative propagation can be achieved through three methods, which include:

- Tissue Culture – Safest way to assure clean and virus free plants.
- Purchase Liners (clones) – All new arrivals, especially liners or unrooted cuttings, should be inspected. Seed should also be inspected. A quarantine period should be used to look for insects and/or fungus or disease issues. Once plants have passed inspection and completed the quarantine period, it is appropriate to introduce them into the facility.
- Stock Plants – Use of stock plants for cuttings requires planning. Labor to complete weekly maintenance and to generate and stick cuttings is necessary. A plan for stock plants should include: number of plants needed, space, varieties to be maintained, cuttings per plant, and peak weeks for production.

When growing stock plants, a number of factors should be considered: nutrients, weekly/biweekly tissue and soil analysis, temperatures, lighting, IPM scouting, training/maintenance, tracking, recording data, and environmental controls.

Cuttings require a process in which consistency is key. All workers should be educated on the process. Once a cutting has been, taken bottom leaves should be stripped from the cutting. When sticking cuttings, rooting hormones and media should be considered, in addition to tracking, sticking time, coolers, and misting. The propagation greenhouse environment should have appropriate mist, lighting, temperature, humidity, and nutrients.

During the propagation process, challenges can arise. Secondary and saprophytic *Erwinia* and *Botrytis* pathogens can be present, and improved water management must be immediately implemented. Sodium can build up and become toxic to plants. Uneven rooting, which may result from the stock plant, size of cutting, cutting process, or aeration, is also common. Other pathogens and pests such as powdery mildew, aphids, mites, thrips, fungus gnats, shore flies, white flies, leafminers, and corn earworms can also present problems during production. These challenges should be predicted and managed according to good agricultural practices.

A Grower's IPM Approach to Pest Management in the Greenhouse

Chad Cagle, ColorPoint, Paris, Kentucky, USA

Hemp growers need effective insect management for quality crop production. Several areas should be considered when developing an insect management plan. First, the environment needs to be assessed. Crop debris and weedy plant species should be removed regularly. The area should be cleaned and disinfected, as well. Sanitation protocols should be established. When entering a growing area, individuals should observe the following practices: (1) wash hands, (2) wear a protective clothing cover, (3) utilize a foot bath, (4) wear shoe covers. Work in the greenhouse should be conducted first in clean areas and end with dirty, infected, or infested areas.

A second step to an effective insect management program is scouting. Growers should implement an aggressive scouting program. All new arrivals, especially liners or unrooted cuttings, should be inspected. Seed should also be inspected. A quarantine period should be used to monitor insects and/or any fungal or disease issues. Once plants have passed inspection and completed the quarantine period then it is appropriate to introduce them to the facility. Each week, sticky cards can be placed every 1000 sq. ft., and analyzed 24 hours after the cards a set out. Yellow cards can be used to monitor populations of flying adult aphids, whiteflies, fungus gnats, leafminers, and other insects. Blue sticky cards are used to monitor adult thrips populations. Monitoring insect populations provides the opportunity to assess the efficacy insect management programs.

Plants should be scouted regularly for the presence of insects. Inspect both upper and lower leaf surfaces, root systems, and containers. Education and familiarity with common issues results in great ease and accuracy. While the presence of insects indicates an insect issue, other symptoms such as leaf spotting, leaf yellowing, wilting or curling of leaves, and webbing can also indicated problems. Tools such as a microscope, hand lens, and scouting sheet can aid in the scouting process.

Numerous insects are commonplace in hemp greenhouses. However, many predatory species and biological tools can aid in management. These include:

- Aphids - Proper identification is important prior to deploying management strategies. Predators such as *Aphidius ervi, Aphidius colemani, Chrysoperla* sp. (Green Lacewing), and *Aphidoletes aphidimyza* can be effective for aphid management.
- Mites and Thrips – Predators such as *Amblyseius californicus, Phytoseiulus persimilis, Amblyseius cucumeris,* and *Orius* spp. can be effective for management.
- Fungus Gnats, Shore Flies, & Whiteflies – Predators such as *Steinernema feltiae* (nematodes), *Atheta coriaria* (*Dalotia coriaria*), and *Amblyseius swirskii* can be effective for management.
- Leafminers – Diglyphus can be effective for management.
- Corn Earworms (caterpillar larvae) – Heligen has just been approved for use in Kentucky.
- Root Aphids – Botaniguard and Azadiractin drenches can be effective for management.

A plan of action should be developed for each growth stage of the crop. Management of insects in hemp can be challenging and requires numerous strategies for efficacy. Different growth stages of hemp often have different pests and thereby require predators and methods of application.

Root-Knot Nematode Host Status of Different Hemp Cultivars

Jacqueline D. Coburn and Johan Desaeger
University of Florida, Department of Entomology and Nematology, Gulf Coast Research and Education Center, Wimauma, FL, USA

Root-knot nematodes, ***Meloidogyne*** spp., are microscopic endoparasitic plant parasites with a wide host range. The nematode causes plant roots to form galls or knots within the roots by becoming sedentary in the vascular tissues, disrupting normal translocation of water and other nutrients, impairing plant growth and increasing susceptibility to other pathogens and pests. In Florida, because of the subtropical climate and often sandy soils, nematodes, especially root-knot (***Meloidogyne*** spp.) and sting nematodes (***Belonolaimus longicaudatus***), are considered one of the main limiting factors to crop production. Florida growers are increasingly interested in new alternative crops, as many of the traditional crops in Florida, such as citrus, fruiting vegetables, and strawberries, are facing more and more pressure due to disease issues and increasing competition from abroad. With the recent removal of hemp (***Cannabis sativa***) from the controlled substances list (2018 Farm Bill and 2019 Florida Statute, SB1020), hemp is now an agricultural commodity, and interest among Florida growers is high. To support the future viability and sustainability of hemp, and considering the importance of nematodes in Florida, it is critical to assess the impact that root-knot and other nematodes may have on this crop.

A greenhouse study was set up at the Gulf Coast Research and Education Center (GCREC) of the University of Florida to evaluate the host status and susceptibility of six hemp cultivars (Helena, Tygra, Fibranova, Eletta Campana, Carmagnola, and Carmagnola Selezionata) to a mixed population of ***Meloidogyne*** spp. (***M. javanica*** and ***M. arenaria***). Cultivars were evaluated with and without nematodes in 20-cm diameter clay pots filled with steamed soil from a local field (95% sand, < 1% OM). Seeds were presoaked in distilled water for one hour, placed in a moisture chamber, and four days later germinating seeds were planted. Germination ranged from 62% to 74% with Tygra having the highest germination rate. Root-knot nematode eggs were collected from infected tomato roots from a local field using the diluted bleach method, and pots were inoculated with 10,000 root-knot nematode eggs three days after planting pregerminated seeds. Each cultivar had ten replicates—five with nematodes and five without. Cucumber (cv. Dasher II) served as a control to ensure nematode inoculum was viable. The replicates with nematodes had two plants per pot, of which one was sampled after one week and roots were stained using 12 % red food dye for evidence of nematode invasion. Height measurements were taken bi-weekly. After 60 days roots were rated for root galls (0-10 scale), root-knot eggs were extracted from roots using diluted bleach, juveniles (J2) were extracted from soil, reproduction factors (Rf = Pf (eggs +J2s)/Pi) were calculated, and dry root and shoot weights were taken.

Root-knot nematode juveniles were found in all hemp cultivars after 1 week, ranging from 6 to 60 juveniles per root system, as compared to 45 juveniles in the cucumber roots. After 60 days, root-knot nematodes reproduced well on all six hemp cultivars, with roots showing small but numerous galls. Reproduction factor (Rf) was similarly high for all cultivars, ranging from 33 (Helena) to 52 (Tygra), as compared to 46 for cucumber. Plant growth (height and biomass) was not negatively affected by root-knot nematodes, but root dry weight was reduced by 44 - 52% in the cultivars Helena, Tygra, and Eletta Campana. More greenhouse and field nematode screening is planned, including testing other (root-knot) nematode species and hemp cultivars.

Fusarium spp. on Industrial Hemp

Sarah Cochran, Tyler Schappe, and Lindsey ThiessenNorth Carolina State University, Raleigh, NC, USA

North Carolina hemp production has rapidly increased from the onset of the pilot program in 2016. Diseases caused by *Fusarium* spp. have continued to cause economic damages to hemp produced in the state. Damages from *Fusarium* spp. have accounted for 18-31% of all problems diagnosed from samples submitted to the Plant Disease and Insect Clinic (PDIC) at North Carolina State University between 2017 and 2019. Of the diseases caused, *Fusarium* wilt (*F. oxysporum*), stem canker (*F. graminearum*), and flower blight (*F. graminearum* and *F. equisetti*) have been the most economically impactful species to date. *Fusarium* wilt symptoms included wilting and yellowing of leaves (Fig. 1, left) and vascular discoloration (Fig. 1, right). Stem canker symptoms include stem lesions that girdle the stem and cause plant lodging. *Fusarium* flower blight symptoms and signs include yellowing and necrosis of flower parts and abundant white hyphal growth over flowers (Fig. 2). Isolates were collected from the NC State PDIC, DNA was extracted, and the Internal Transcribed Spacer (ITS), elongation factor 1-alpha (EF1-a), and beta tubulin (BTUB) gene regions were amplified via PCR and sequenced via Sanger dideoxy sequencing. Species identity was determined by comparing to sequences with known isolates on NCBI via BLAST alignment. To confirm pathogenicity, Koch's Postulates were tested using 3 replicates of a representative isolate for each species by inoculation of *Cannabis sativa* var. *Carmagnola* in a sterile growth chamber. It was determined that *F. oxysporum, F. graminearum,* and *F. equiseti* are pathogenic on hemp and are potentially destructive pathogens for North Carolina growers. Disease pressures may be influenced by common rotational crops in the region, including wheat, corn, and cotton. Effective management for control of *Fusarium* spp. in hemp will require an integrated management strategy that relies on cultural and chemical practices as well as host resistance to limit losses.

Figure 1. *Fusarium* wilt caused by *Fusarium oxysporium* causes yellowing of leaves and whole plant wilting (left) and vascular discoloration (right).

Figure 2. *Fusarium* flower blight caused by *Fusarium* graminearum causes yellowing and necrosis of plant tissues and abundant hyphae may be observed growing over plant parts.

Diseases and Insects of Hemp in Alabama

Kassie Conner[1], Katelyn Kesheimer[2], Edward Sikora[2], and Joseph Kemble[3]
[1]Alabama Cooperative Extension System, Auburn University, AL, USA
[2]Dept of Entomology and Plant Pathology, Auburn University, Alabama, USA
[3]Dept of Horticulture, Auburn University, Alabama, USA

Hemp is a host to many pathogen and insect pests. Below are the diseases and insects observed in hemp across the state of AL in its first year of commercial production.

Pythium Damping-off (*Pythium* spp.) presents itself in two forms: pre-emergent (seeds or seedlings die before they emerge from the soil) and post-emergent (plants affected after seedlings emerge from the soil). Seedlings with post-emergent damping-off usually develop a brown rot at the soil line, then wilt and topple over. In older seedlings growth ceases, leaves turn pale yellow, and then seedlings wilt and topple.

Olive Leaf Spot (*Pseudocercospora cannabina*) arises as brown spots visible on the upper side of the leaves while sporulation is visible on the underside of the leaves olive in color. Leaves wilt, curl and drop off the plant. Damage escalates rapidly in August. Surviving plants are stunted with reduced yields.

Hemp Leaf Spot (*Bipolaris* sp.) appears to be present at low levels across the state. Over time, as populations build, hemp leaf spot has the potential to defoliate plants (possibly entire fields) resulting in stunted plants and reduced yields.

Southern Blight (*Sclerotium rolfsii*) arises during warm weather. Mature plants suddenly wilt, turn yellow and die. Stalks decay at the soil line, turning brown. A white hyphal mat radiates from the base of the stalk along the soil surface and sclerotia are produced within the mycelium.

Fusarium Stem Canker (*Fusarium* spp.) usually arises at mid-season on mature hemp plants. Lesions appear water-soaked and can girdle stems completely. Leaves on affected plants wilt and die, but stay attached to the plant. Slicing open a cankered stem reveals a reddish-brown discoloration in the vascular system.

Corn earworm (*Helicoverpa zea*) and Yellowstriped armyworm (*Spodoptera ornithogalli*) showed up later in the season feeding on the flower buds and causing serious economic losses, particularly in hemp grown for CBD oil. Both yield and quality reductions are possible. Feeding damage can also increase susceptibility to bud rot. Early-season defoliation by caterpillars did not appear to be a major issue in AL.

Fire ants (*Solenopsis invicta*) are problematic throughout Alabama in hemp grown in open fields, plasticulture, and pots. They build mounds near the base of the plant, strip the bark, and will tunnel into stems. Damaged plants will wilt, turn yellow, and can fall over. Young plants are especially at risk.

Hemp russet mite (*Aculops cannabicola*) is a cannabis specialist found on indoor and outdoor hemp plants. Damaged plants have leaves that curl upward, turn yellow and become brittle. Heavy infestations cause the buds to turn brown and render female plants sterile. Carmine spider mite (*Tetranychus cinnabarinus*) can also be a problem.

Survey of Diseases and Pests Affecting Hemp in New Brunswick, Canada

Carlo Cormier, Véronique Blanchet, and David L. Joly, Université de Moncton, Moncton, New Brunswick, Canada

Despite the fact that *Cannabis sativa* had been grown for millenia as a source of fibre, food and/or medicine, its cultivation became prohibited in Canada in 1923. Cultivation of industrial hemp was permitted again only in 1998 and is currently regulated by Health Canada under the Cannabis Act. In 2019, 125,000 – 150,000 acres were devoted to hemp cultivation. According to the literature, no survey of diseases and pests affecting hemp in Canada is available. The present work was designed to detect and identify diseases and pests affecting hemp in 11 fields across the province of New Brunswick. Between June and September 2019, 166 symptomatic tissue samples were collected and cultured in the laboratory for pathogen isolation and molecular identification. The Internal Transcribed Spacer (ITS) was then sequenced for 95 fungal isolates obtained from those samples. *Fusarium, Alternaria* and *Didymella* were among the most abundant genera. For *Fusarium*, at least 7 distinct species were identified, some of which are well-known mycotoxin producers (*F. graminearum, F. culmorum*, etc.). Two isolates of *Botrytis cinerea* were also identified causing stem and bud rot, which although they represented isolated cases were considered quite damaging. When considering the whole season, *Sclerotinia sclerotiorum* was the most destructive and rampant disease in four of the hemp fields, with up to 1 out of 30 plants that was highly affected by stem rot at the time of sampling (September). Abundance of wild mustard (*Sinapis arvensis*) in these fields could have favored inoculum buildup. Interestingly, insect larvae from an unknown species of Cecidomyiidae were also found in most stem infected with *S. sclerotiorum*, a situation that will be investigated in more details next year. On the pest side, no major problem was identified, apart from two fields were cannabis aphids (*Phorodon cannabis*) were found.

Examples of symptoms caused by *Sclerotina sclerotiorum* on hemp.

Grain and Fiber Variety Performance in Michigan

James DeDecker[1] and Kurt Thelen[2]
[1]Michigan State University – Upper Peninsula Research and Extension Center, Chatham, Michigan, USA
[2]Michigan State University, East Lansing, Michigan, USA

Researchers at Michigan State University received funding from MSU Extension and AgBioResearch to conduct a grain and fiber hemp variety trial at two locations in 2019. Nine Canadian and European varieties of grain and fiber hemp were planted in East Lansing and Chatham, MI. Here we report only information regarding the trial conducted in Chatham at the MSU Upper Peninsula Research and Extension Center (UPREC) – North Farm. Hemp varieties 103-125 days to maturity were sourced from Canada under the assumption that conditions there would be similar to the U.P., particularly in terms of day length and temperature. 1,500 lbs. per acre of 10-0-4 poultry litter and 321 lbs. per acre of 0-0-22 Kmag were applied pre-plant based on soil test results.

The trial was planted June 14th at 45 lbs. per acre. The experimental design was a RCBD with four replications. Plots were 4 ft. X 16 ft. with 7 inch row spacing. The trial was hand hoed once for weed control on July 1st. Observations of stand establishment, flowering date and height at flowering were recorded (Table 1). To help mitigate the risk of pollination for our neighbors growing cannabis, we took the unusual step of removing most male plants/flowers from our plots. Our plants were eventually pollinated by male escapes in the trial, but this likely influenced the timing of pollination and also yield. Flower samples were collected on August 25th and submitted to MDARD for THC analysis.

Plots were harvested on Sept. 5th (dioicous) and Sept. 12th (monoicous) based on maturity. We hand cut and separated flowers and stems from two 1 m² quadrats per plot. Flowers were oven dried at 140 degrees F and threshed using an Almaco small bundle thresher. Seed was cleaned using a Clipper seed cleaner, weighed and tested for moisture. Grain yields reported here are adjusted to the industry standard of 9% moisture (Figure 1). Stems were bundled and left in the field for four weeks to "ret". Stems were then oven dried at 140 degrees F and weighed. Fiber yields reported here are adjusted to the industry standard of 10% moisture (Figure 2).

Table 1. Hemp varieties and early observations.

Variety	Use	Habit	Maturity	Stand Est.	Stand Density (plants/m²)	Flowering Date	Height at Flowering (cm)
CFX-2	Grain	Dioicous	103 days	10.28%	47.48	7/12/19	81.48
CFX-1	Grain	Dioicous	105 days	8.64%	39.53	7/12/19	81.92
Grandi	Grain	Dioicous	110 days	13.95%	64.59	7/12/19	81.74
Katani	Grain	Dioicous	110 days	13.68%	62.24	7/11/19	81.99
Picolo	Grain	Dioicous	110 days	7.65%	35.32	7/11/19	71.32
X-59	Grain & Fiber	Dioicous	110 days	2.79%	12.83	7/14/19	93.27
Anka	Grain & Fiber	Monoicous	110 days	11.71%	53.24	7/20/19	139.90
USO 31	Grain	Monoicous	125 days	10.81%	49.83	7/23/19	137.92
Fermion	Grain	Monoicous	125 days	8.68%	39.95	7/30/19	164.34

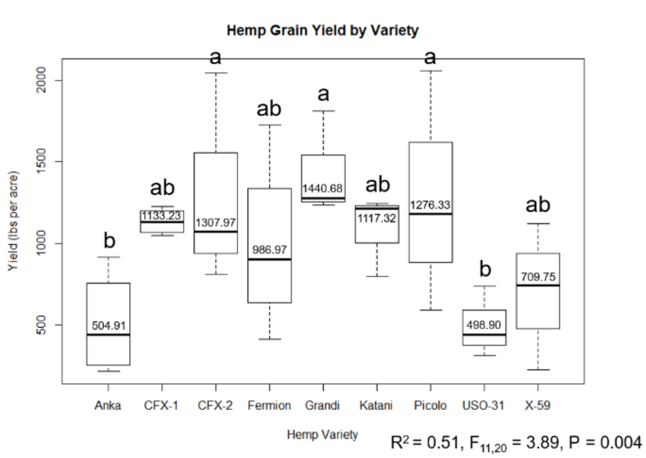


Figure 1. Hemp gain yields by variety. Varieties with the same letter are not significantly different. Numbers on bars are mean variety yields.

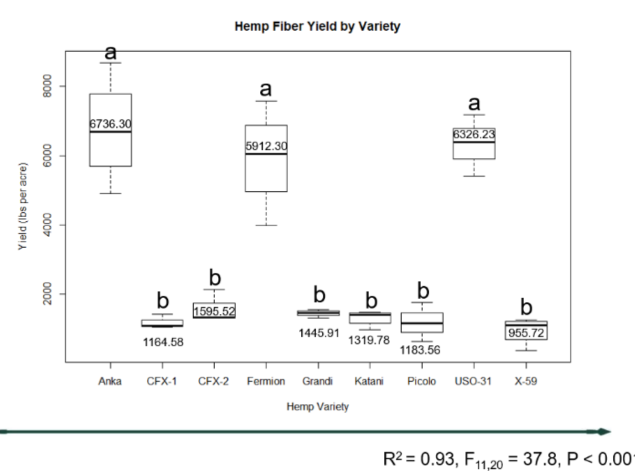


Figure 2. Hemp fiber yields by variety. Varieties with the same letter are not significantly different. Numbers on bars are mean variety yields.

Seed Quality Issues in Hemp Seeds

Sabry G. Elias and Yeaching Wu
Oregon State University, Corvallis, Oregon, USA

Hemp has a great potential to become a cash crop to many growers in the US because of its many uses in pharmaceutical, food, and industrial products, including CBD oils, protein source in diet, textiles, bioplastics, insulation, biofuel, and others. In 2019, 1,300 growers were licensed to plant nearly 50,000 acres of hemp in Oregon alone. As popular as it is becoming, hemp is not an easy crop to raise, especially after decades of suspended research before the 2018 Farm Bill legislation. Some of the issues in crop production of hemp include, auto-flowering (automatically switching from vegetative to flowering in approximately 4 week), feminized seeds (i.e., produce only female plants), photoperiodism, dormancy, and seed quality. The objectives of this study were to: 1) examine the extent of dormancy in freshly harvested hemp seeds and methods to break it, 2) the effect of having seeds of different ages in the same plant (i.e., indeterminate inflorescence) on the quality of harvested seeds, and 3) determine the suitable tests to measure seed viability and vigor. Two varieties with different seed sizes were included in the study. The quality of seeds harvested from the upper part of the plant (mature seeds) and the lower part (under-developed seeds) were compared. The length of dormancy in freshly harvested seeds were measured, and a dormancy breaking method was identified. Both varieties had a short-lived dormancy (30-45 days). Pre-chilling treatment (10°C for 5d) was effective in breaking dormancy. The difference in seed size between the two varieties did not impact seed quality. Seeds harvested from the upper 2/3 of the plants of both varieties had high quality as indicated by the viability and vigor tests. Seeds from the lower part of the plant need to stay an extra 7-8 days on the mother plant to reach similar quality to the seeds from the upper part, after which no significant difference in seed quality between seeds from the upper and the lower parts was detected. Tetrazolium test, standard germination test and accelerated aging test were suitable for measuring seed quality of hemp seeds. The findings of this study can increase hemp yield by 1/3 if harvest is delayed 7d. The current practice is to harvest only the upper 2/3 of the plants, with the assumption that the lower 1/3 includes only poor quality seeds.

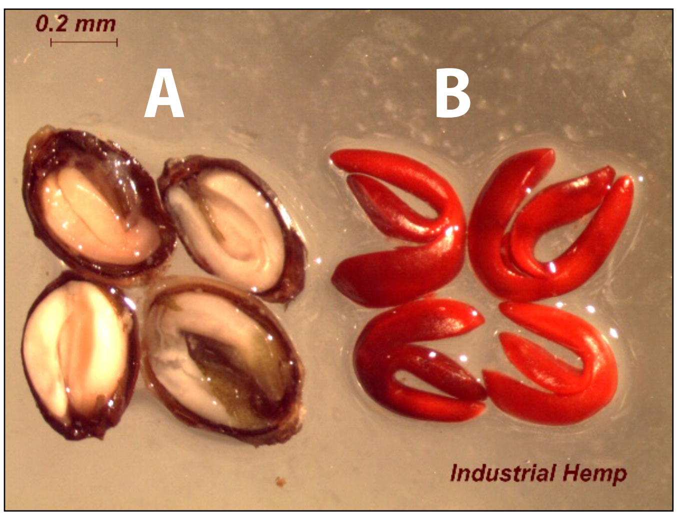


Figure 1. Tetrazolium viability test. A, non-viable seeds, seed of hemp *(Photo by S. Elias)*.

Figure 2. Normal hemp seedlings with different vigor B, viable levels, 7days after planting *(Photo by S. Elias)*.

Considering Crop Rotations and the Potential for Carry-Over

Nicole Gauthier, University of Kentucky, Lexington, KY, USA

Disease risk often lies upon the presence of pathogens in fields. Because hemp is a new crop and disease information is limited, it is important to consider previous crops and their diseases as potential for carry-over. Here, we present some of the most common diseases of hemp in Kentucky (2014 through 2019) and their typical host ranges. Confirmation and speciation are ongoing for many disease agents.

Anthracnose. *Colletotrichum fioriniae* (typical hosts: apple, honeysuckle, insects, poison ivy, wild brambles) was confirmed in Kentucky and the southeastern US. Historical literature reports two species on Cannabis: *C. coccodes* (typical hosts: corn, cucurbits, nightshade, and solanaceous vegetables) and *C. dematium* (typical hosts: beans, morning glory, pepper, sorghum, soybean, herbaceous and woody ornamentals).

Cercospora leaf spot. *Cercospora flagellaris* (typical hosts: aster, amaranth, citrus, hydrangea, johnsongrass, poplar, soybean) was confirmed in Kentucky. Historical literature reports two species on Cannabis: *C. cannabis* and *Pseudocercospora cannabina* (host: Cannabis, only); new cases pending in Kentucky and other southeastern states.

Hemp leaf spot. New disease. *Bipolaris gigantea*, syn *Drechslera gigantea* (typical hosts: cereals, corn, grasses, rice, other monocots) is widespread in Kentucky and eastern and midwestern US.

Fusarium. *Fusarium* diseases are widespread in Kentucky and the US. *Fusarium* head blight caused by *F. graminearum* (typical hosts: cereals, corn, grasses, rice); high mycotoxin risk. Damping off and stem & root rot caused by *F. solani* (beans, cucurbits, potatoes); host specificity (f. sp.) is not absolute, and cross infection potential is high. Wilt caused by *F. oxysporum*, typically host-specific. *F. oxysporum* f. sp. *cannabis* reported in historical literature. Wilt uncommon in Kentucky; speciation confirmation pending.

Powdery Mildew. *Golovinomyces spadiceus* (typical hosts: Asteraceae family) confirmed in eastern and midwestern US. Historical literature reports of *Leveillula taurica* (hosts: cannabis, peppers, squash, tomato) and *L. taurica* f. sp. *cannabis* (host: cannabis).

Pythium Root Rot and Damping Off. Several species confirmed in hemp in Kentucky and the US. *P. aphanidermatum*, aggressive with a wide host range (hosts: beans, cereals, cucurbits, legumes, spinach/amaranth, herbaceous ornamentals, weeds). *P. irregulare*, not aggressive (hosts: beans, brassica, cereals, corn, cucurbits, soybean, tomato, herbaceous and woody ornamentals, weeds). *P. myriotylum*, pre-emergent damping off (hosts: beans, brassica, cereals, corn, crucifers, cucurbits, peanuts, soybean, tomato, tobacco, herbaceous ornamentals). *P. ultimum*, common in field crops (hosts: brassica, cereals, corn, soybean, tobacco).

Rhizoctonia Crown Rot, Damping Off, and Web Blight. *Rhizoctonia solani* (typical hosts: beans, brassicas, cereals, cucurbits, rice, potato, soybean, tobacco, turf) is common in Kentucky and the southeastern US.

Septoria Leaf Spot. A common *Septoria* sp. in Kentucky has not been assigned or speciated. *S. cannabis* and *S. neocannabina* are reported in historical literature. *Septoria spp*. are loosely host specific.

Southern Blight. *Sclerotium rolfsii* (typical hosts: allium, apple, aster, beans, brassica, cereals, cotton, crucifers, cucurbits, grasses, morning glory, peanut, rice, solanaceous, soybean, sunflower, tobacco).

A Case for Extension Programming: 2019 Survey of Hemp Growers in the Southeast

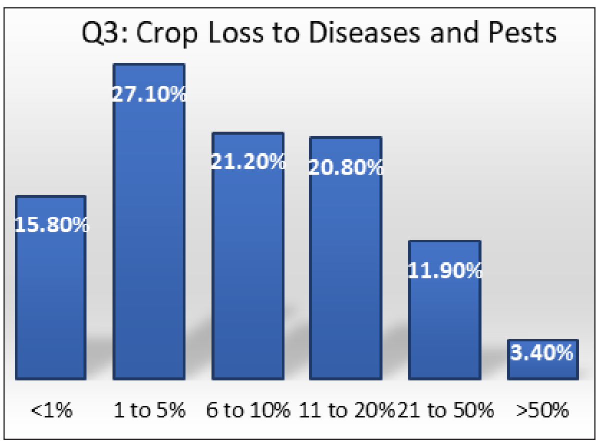
Nicole Gauthier[1], Katelyn Kesheimer[2], and Kassie Conner[2]
[1]University of Kentucky, Lexington, Kentucky, USA
[2]Auburn University, Auburn, Alabama, USA

Hemp acreage in the Southeast in 2019 totaled nearly 95,000 acres: Alabama (7,000), Arkansas (1,300), Kentucky (24,000), North Carolina (14,500), Oklahoma (21,000), South Carolina (2,000), Tennessee (22,000) and Virginia (2,500 acres).

Over 350 growers from the Southern Region were surveyed between September and November 2019.

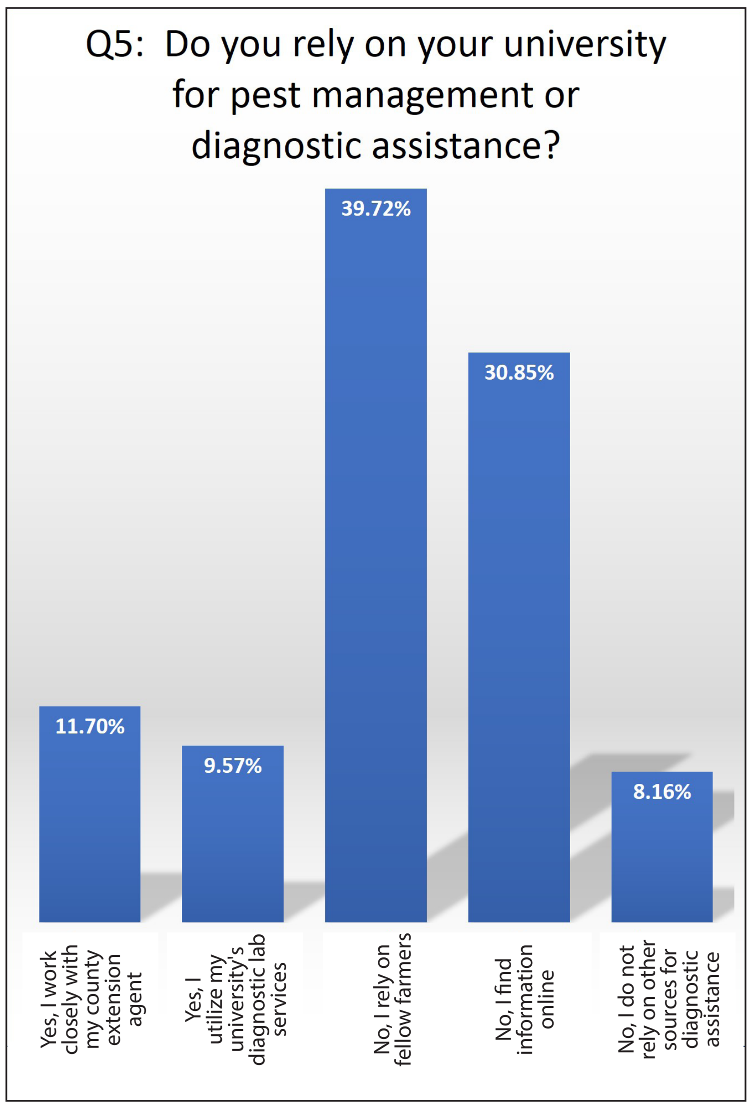
Expressed needs included: more grower guidance, scouting how-to, IPM grower schedules, pest identification assistance, assistance with insect trapping, more labeled products, more effective products, more preventative products, more fast-acting products, more OMRI-listed products, safe products, cost-effective products.

Reported losses from diseases and pests are significant, averaging 11.6%. Results confirmed that there is a critical need for support, but over 78% of respondents indicated that they did not seek help or information from their local Extension and/or university.



Q4: Top Diseases and Pests (grower ranking by importance)

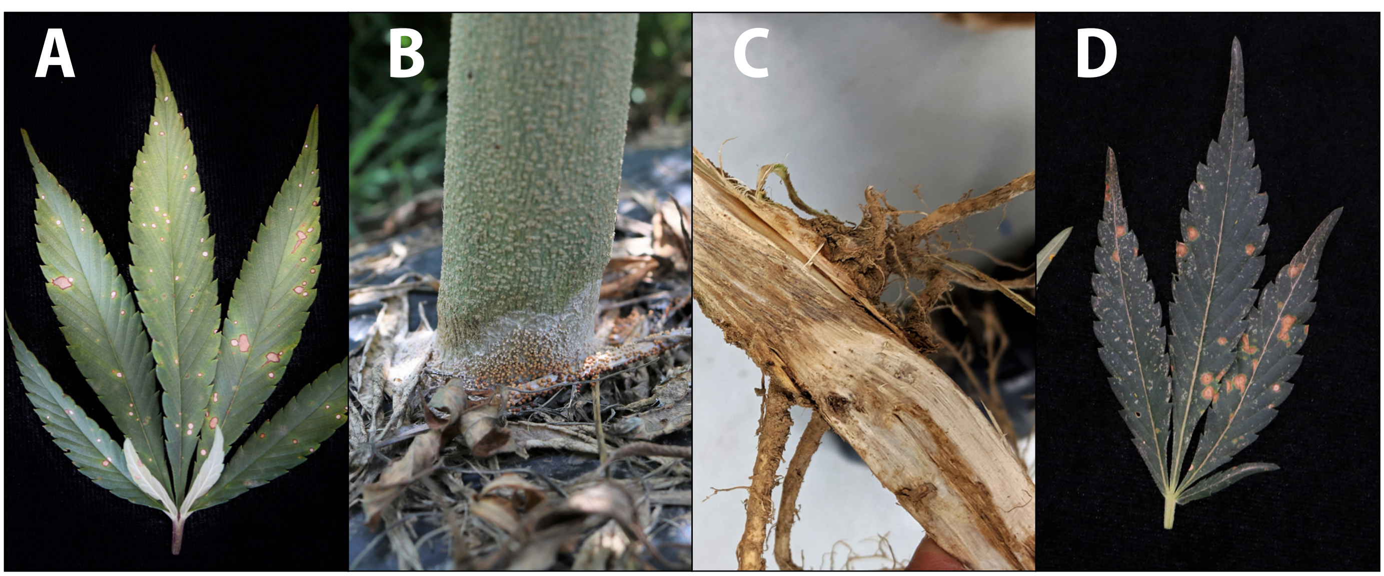
Caterpillars and worms	31.51%
Leaf spots	15.32%
Blights and wilts	12.32%
Bud rot	7.92%
Mites	7.75%
Aphids	5.99%
Grasshoppers	5.99%
Root and crown rot	4.40%
Insects, other	2.82%
Other problem, not listed	2.46%
Diseases, other	1.76%



Hemp Extension in Tennessee: Most Common Diseases of 2019

Zachariah Hansen[1], Tim Siegenthaler[1], Elgin Akin[1], Madison Cartwright[2], and Heather Kelly[2]
[1]University of Tennessee, Knoxville, TN, USA
[2]University of Tennessee, Jackson, TN, USA

Hemp production has risen sharply in Tennessee since 2015. In 2019 the TN Department of Agriculture granted approximately 3,700 licenses for 51,000 licensed hemp acres. Approximately half of the licensed acres (25,500 acres) were estimated to have been planted. Nearly all of the hemp grown in TN in 2019 was for cannabidiol (CBD) (i.e. extract) production. Several diseases of hemp were observed in 2019. Hemp leaf spots and southern blight were among the most common diseases observed by Extension pathologists (photos A and B, respectively). Several fungal pathogens were observed and cultured from hemp leaf spots, primarily from field-grown hemp, including *Cercospora* spp., *Alternaria* spp., and *Curvularia* spp. Leaf spot pathogen identifications were based on morphology and internal transcribed spacer region (ITS) DNA sequencing. Three *Curvularia* species were identified based on ITS sequence data: *C. americana*, *C. trifolii*, and *C. lunata*. Work is ongoing to complete Koch's postulates with each leaf spot pathogen and to confirm species identities through additional gene sequencing. Southern blight, caused by the pathogen *Athelia rolfsii* (syn. *Sclerotium rolfsii*), was also common in field-grown hemp. Symptoms were characterized by dramatic wilting, sometime associated with leaf yellowing, and a brown stem lesion at the soil line covered in a white mycelial mat with prolific production of tan/brown sclerotia. Several other diseases were less commonly observed, including several species of *Fusarium* which were recovered from plants showing wilt, crown rot (photo C), or bud rot symptoms. Associated pathogens were identified as *F. oxysporum*, *F. graminearum*, and *F. equiseti* based on ITS sequence data. Hemp rust was first observed in middle TN on August 26, 2019, and was subsequently observed in several locations across west, middle, and east TN (photo D). Rust severity was low at each location. Symptoms appeared as a yellow/orange spot on the upper leaf surface which eventually turned orange/brown. Orange uredia/urediniospores could be observed on the leaf undersides. Uredospore morphology matched descriptions of *Uredo kriegeriana*. Work is ongoing to complete Koch's postulates and to obtain ITS sequence data. Damping off, caused by *Pythium* spp., was observed in greenhouse seedling production, and powdery mildew was observed in greenhouse and field-grown hemp.



An Overview of the Use of the Biopesticides in Hemp Production, with an Emphasis on the Certis Insecticides

Brett Highland, PhD., Certis USA, Savannah, GA, USA

Certis USA which has an emphasis on biopesticides, has the broadest biopesticide portfolio in the industry, with 32 microbial, botanical, and biochemical products. Our market focus is on fruits and vegetables, some field crops, organic farms, and home and garden markets. In the eastern US, the majority of Certis products are used in conventional crops. We see hemp production as a crop which has a natural fit for our portfolio of products. Certis USA is involved in biological product development, screening, formulation development, and field development. We have a dedicated manufacturing base, with fermentation, formulation, and extraction activities, located at two US based manufacturing facilities, and a botanical extraction facility located in India.

The presentation will be an overview of some Certis insecticides that could be included in a management program for hemp pests. The information includes the modes of action, active ingredients, product characteristics, and pest spectrum, along with representative trial data in vegetable production. A list of the insecticides and miticides that were reviewed include:

- SilMATRIX (potassium silicate) for mites (spider, russet or ***Eriophyids***, broad), and some soft bodied insects such as aphids
- Javelin (representing the *Bacillus thuringiensis* insecticides) for lepidopterous worms such as corn earworm and various armyworms
- PFR-97 20% WDG (*Isaria fumosorosea* formerly known as *Paecilomyces fumosoroseus*) a mycoinsecticide for soft bodied insects, including aphids, thrips, and mites
- BoteGHA ES (*Beauveria bassiana)* a mycoinsecticide for soft bodied insects and mites
- Gemstar (nuclopolyhedrovirus) specific for corn earworm and tobacco budworm
- Trilogy (clarified neem oil), used for some foliar diseases, soft bodied insects, and mites.

The vegetable trials were conducted in- field in small blocks, replicated and randomized under normal growing conditions for the geographical areas under consideration Applications using standard commercial methods began when pest pressure was indicated or seasonally when normal applications would have begun in commercial growing situations. Insect or mite incidence and infestation levels were evaluated periodically in each plot as needed. All data were subjected to standard ANOVA and mean comparison procedures. SilMATRIX reduced two-spotted spider mites in strawberries by 83%, powdery mildew of grapes by 98%, while Javelin reduced tobacco budworm of strawberries by 89%. PFR-97 reduced two-spotted spider mites of strawberry by 50%, melon aphid of mustard greens by 71%, and diamondback moth of cabbage by 90%, while Gemstar reduced corn earworm damage by 11% in sweet corn.

These products provided control equal to standard chemical alternatives and consistently better than the untreated controls. They can be used in programs with other insecticides, and are suitable for use in hemp production due to exemption from required residue tolerances. They can be used in both organic and conventional hemp production, have unique modes of action so are useful for resistance management objectives, and have favorable environmental profiles.

The use of Double Nickel 55 WDG and Double Nickel LC Fungicide/Bactericides in Organic Plant Disease Programs for Fruit and Vegetable Production

Brett Highland, PhD., Certis USA, Savannah, GA, USA

Double Nickel (LC and 55 WDG formulations) are broad-spectrum, high potency, preventative microbial biopesticides for control or suppression of fungal and bacterial plant diseases. The active ingredient, ***Bacillus amyloliquefaciens*** strain D747 kills plant pathogens on foliage and other plant parts by producing antibiotic compounds (lipopeptides) which disrupt pathogen cell wall production. When Double Nickel is applied to the soil, it colonizes plant root hairs, preventing establishment of disease-causing fungi and bacteria. These unique and multiple modes of action are useful in resistance management. Double Nickel LC and Double Nickel 55 W, shows good shelf life stability, leave no visible residues, are non-phytotoxic, and are tank mix compatible with most products. Double Nickel products are exempt from residue tolerance, which is an important consideration in hemp production, and are approved by NOP and listed by OMRI for use in organic production. This poster will explain the modes of action of the products, their features and benefits, and present field trial information conducted in the US from 2010 to 2014 in vegetables and fruit crops. Hemp has many pathogenic organisms causing diseases similar to those found in vegetable and fruit production, including fungal leaf spots like powdery mildew and *Botrytis,* bacterial leaf spots, and soil borne diseases like white mold and *Rhizoctonia* root and stem rot. This poster attempts to present the information from field trials in vegetable and fruit production as an instructive tool for the use of Double Nickel in future hemp production.

The vegetable and fruit trials were conducted in- field in small blocks, replicated and randomized under normal growing conditions for the geographical areas under consideration Applications using standard commercial methods began when pest pressure was indicated or seasonally when normal applications would have begun in commercial growing situations. Disease incidence and severity levels were evaluated periodically in each plot as needed. All data were subjected to standard ANOVA and mean comparison procedures.

Results for replicated field trials showed that Double Nickel reduced *Rhizoctonia* stem rot and increased yield significantly in potato equal to the chemical standard, decreased white mold of soybeans by 71% equal to the standard, decreased soil borne diseases of onions (*Rhizoctonia, Pythium, Fusarium*) by 85%, decreased *Botrytis* of grapes, decreased sooty blotch and flyspeck of apples in 5 varieties when in a program with Cueva copper, reduced bacterial leaf spot of tomatoes by 78% when used in a program with Cueva copper, and reduced fire blight of pears by 82%.

Double Nickel LC and Double Nickel 55 WDG when used in replicated field trials provided control equal to standard chemical alternatives and consistently better than the untreated controls. This was true of both fungal and bacterial pathogens. Double Nickel should be considered as a viable alternative when considering fungicide/bactericide alternatives in any rotational spray program for disease control in organic or conventional hemp production.

2019 Disease Observations on Industrial Hemp in Virginia

Chuck Johnson, Virginia Tech, Southern Piedmont Agricultural Research and Extension Center, Blackstone, VA and School of Plant and Environmental Sciences, Blacksburg, VA

Approximately 20 industrial hemp fields were visited in southeastern and south-central Virginia during July, August and September of 2019 in order to assess the incidence and severity of plant diseases. Approximately 29 plant and soil samples were also received from industrial hemp fields during this same period of time for plant disease diagnosis. Field disease assessments did not quantitatively estimate disease incidence and severity, but focused on noting symptoms and signs of disease and increasing the accuracy and precision of hemp disease diagnoses based on standard laboratory analyses. Losses in plant stand were common early (July) in the hemp growing season. Plant mortality appeared to be caused by a range of abiotic and biotic factors. Root system development of hemp plants transplanted under dry conditions was usually poor, with plants possessing few fibrous feeder roots. "Girdled" or "girdling" roots were common, as were roots that never grew from the greenhouse plug media into surrounding soil. Wireworm injury was common, often resulting in plant death. Southern blight (*Sclerotium* or *Athelia rolfsii*) was also observed infecting multiple plants in many fields. However, incidence of *Fusarium* infection was even more common than that of *S. rolfsii*. Whether these infections were primary or secondary could not be determined, or whether these infections began in greenhouse transplant production versus occurring in the field at or shortly after transplanting. The potential influence of "sticking" depth at rooting during transplant production, or of planting depth at transplanting in the field, were raised based on the usual locations of infections at the bottom of diseased stems. Although reductions in plant stand were common and often significant during the first four to six weeks of the growing season, these problems did not appear to continue subsequently. A few cases of possible nematode parasitism were investigated and vermiform juveniles were observed within cleared roots stained with acid fuchsin. At least one cyst was also found attached to a hemp plant root that contained apparent nematode eggs, but the possible nematode parasite was not identified and confirmed. Individual plants exhibiting irregular chlorosis and deformed leaves were also found in multiple fields, but virus immunoassays of leaf samples were always negative. Hemp leaf spot (*Drechslera gigantea)* was commonly observed throughout the period that hemp fields were visited, although the proportion of infected leaves and of leaf area affected increased significantly, particularly as plants developed closer to the flowering stage. Some stem or twig dieback disease was also noted during flowering. Our 2019 observations strongly suggest that accurate and precise hemp disease diagnoses, based on the latest generally recognized techniques, and to pathogen species versus genus level, are urgently needed. Beyond these steps, the relationships between disease incidence and severity and hemp productivity (CBD production) are urgently needed in order to identify the diseases that must be controlled, and to what level, versus those that may damage the crop but not to an economically significant level. Our initial, tentative, 2019 observations suggest that problems that cause stand losses or cause die-back disease may influence crop productivity more than leaf spots (if these foliar diseases don't result in significant defoliation). Ideas on research topics to improve hemp disease management in 2020 include general improvements in transplant production methods; determining the cost/benefit ratio for raised beds and plastic mulches; identifying cultivar disease resistance/susceptibility; examining the role of proper hemp fertilization on hemp disease incidence and severity; and identification of reliably effective traditional and organic pesticides.

Alabama Hemp: The First Year

Katelyn A. Kesheimer, PhD, Auburn University, Auburn, Alabama, USA

Alabama became one of the most recent states to legalize agricultural hemp production in 2019. The state is currently finishing its first growing season, with more than 90% of the hemp produced grown for cannabidiol (CBD). The state had approximately 150 licensed growers and 50 licensed processors with 10,000 acres approved for hemp production in 2019. However, the Alabama Department of Agriculture and Industries (ADAI) estimates that only 7,000 of these acres were actually planted and we are still waiting to see how many acres were harvested. Interestingly, ADAI estimates that only half of the hemp growers in the state have any previous agricultural experience.

Little to no research has been done on hemp over the last century, so there exists a major knowledge gap on what insects pests are economically important. One of our major objectives moving forward will be to characterize which insects will infest hemp grown for CBD, fiber, and grain and identify the most sustainable management strategies. Given the prohibition on growing hemp for the last several decades, there exist only a handful of pesticides that actually have hemp on the label. This may change in the future, but currently, it has been left up to the states to determine what chemicals can legally be applied on the crop. In Alabama, there are approximately 75 products that producers can use to control insects, diseases, and weeds in hemp. However, we lack efficacy data on these products in hemp to recommend research-based information to growers.

The following are some of the common insects found in Alabama hemp this first year. Some will likely be inconsequential or only occur during outbreak years, but several will be major pests every year. Our program aims to establish uniform sampling protocols and economic thresholds as part of an integrated pest management strategy.

Figure 1. Banded cucumber beetle, Diabrotica balteata, (left, top) and Brown marmorated stink bug, Halyomorpha halys, nymphs (left, below)

Figure 2. Fire ant, Solenopsis invicta, damage on a hemp stem in a pot (left), Damage by hemp russet mites, Aculops cannabicola, (middle), Corn ear worm, Helicoverpa zea, in hemp buds

Certified Organic Hemp: An Opportunity for Growth

Shawn Lucas, Kentucky State University, Frankfort, Kentucky, USA

Industrial hemp is grown for three primary purposes: fiber, grain, and flower for cannabinoid extraction. Passage of hemp provisions in the Farm Bills of 2014 and 2018 have generated significant interest from producers looking to capitalize on the potential opportunity of this resurgent crop. Consumer interest in organic products continues to rise, with sales of organic products reaching over $52 billion in 2018. Organic products generally command 22 to 35% greater profit for producers than comparable non-organic products. Similar or greater price premiums can potentially be realized with organic hemp. To maximize producer success with this opportunity, there is a need for development of best management practices for hemp in certified organic production systems. Additionally there is a need for development of regionally appropriate varieties that are both productive for their end use and compliant with respect to the 0.3% tetrahydrocannabinol (THC) threshold dictated by federal guidelines. New research at Kentucky State University attempts to provide information for producers on production of hemp for fiber or grain in a 3 year organic crop rotation. Research at KSU is also examining four varieties of hemp in organic production systems for their productivity (flower yield and cannabinoid content), compliance with the THC threshold, responses to OMRI listed biofertilization products. This research is ongoing and results will be disseminated in future presentations and publications.

Trojan Horse or Golden Ticket

Tyler Mark and Jonathan Shepherd, University of Kentucky, Lexington, Kentucky, USA

The passage of the 2014 Farm Bill set in motion the Industrial Hemp Pilot Program and the reintroduction of hemp into the United States. Commercial hemp production had not occurred in the United States since 1957 and was illegal to grow since the 1970 Controlled Substance Act. In 2014, the first year of U.S. commercial production, approximately 1,849 acres of hemp were produced. Since 2014, the hemp industry has expanded rapidly. The signing of the Agricultural Improvement Act of 2018 on December 20, 2018 has ushered commercial hemp production back into the country after a 61-year hiatus.

Hemp has the potential to be utilized in 25,000 plus products that range from food products to industrial products to cannabinoids. This has generated a lot of interest in the crop, and estimates of market size range from 13.03 Billion in 2026 to 26.6 Billion in 2025. As you can see, there is not a consensus on where the industry is going at this point. However, these markets are still in their infancy stage, and there is little to no information available on demand for these products currently. The supply of hemp in the United States has slightly more information available, with acreages being reported by State Departments of Agriculture, Vote Hemp, and Farm Service Agency. Figure 1 shows an example of the discrepancies that exist between estimates from the State Department of Agriculture and the Farm Service Agency. As we move forward with standardization in the industry, these will fade away.

The interest in this crop has also generated a significant amount of misinformation around the production and profit potential of this crop. In a Wall Street Journal article entitled "Farmers Start to Get High on Hemp" discusses how a farmer expects to make $75,000 per acre. This is significantly above the revenue potential for traditional commodity crops (e.g. corn, soybeans, wheat, etc.) and given the low margin environment that traditional commodity producers in the United States are facing this makes hemp, especially for the production of essential oils (e.g. CBD, CBG, CBN, etc.). However, the rapid growth in hemp acreage for the United States has put downward pressure on hemp prices. When we entered 2019, producers were signing contracts and expecting $4.00 to $5.00 per %CBD. Now, as we approach harvest, this price as fallen to less than $1.50 per %CBD. According to the University of Kentucky hemp budgets, this would be at or below the cost of production for CBD hemp, depending upon what the %CBD is of their hemp. In addition to an oversupply of hemp, we are also seeing a lack of processing capacity and processors not having funds available to meet contract obligations.

As with many infant industries, there will be growing pains within the industry and there is no reason to expect anything different for the hemp industry. However, the hemp industry is not the Jerusalem Artichoke, Emu, or Vermiculture industry. A couple of reasons for this is the amount of investment that has flowed into the industry and the wide variety of products that can be made from hemp and its derivatives. As the market continues to expand in 2020 with additional states passing hemp production legislation, international competition heating up, and spread of misinformation there will continue to be downward pressure on prices. In other words, hemp is between a Trojan Horse and a Golden Ticket but is going to take time for the market to work its way to an equilibrium where supply and demand are balanced.

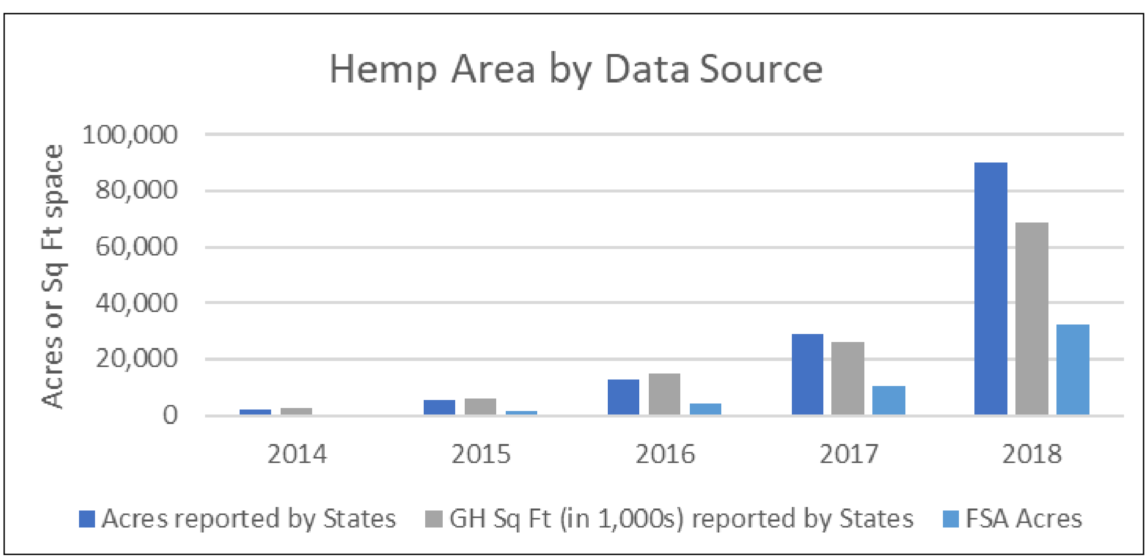


Figure 1. Reported hemp acreage and greenhouse area

Foliar Nutrient Concentration of Floral Hemp Cultivars Compared to Published Nutrient Survey Values

Michelle McGinnis, Ph.D.[1], Angela Post, Ph.D.[2], Jeanine Davis, Ph.D.[3],
Margaret Bloomquist[3], and Brandon Poole[1], Georgia Love[1], and Carla Pugh[1]
[1]NC Department of Agriculture & Consumer Services, Agronomic Division, Raleigh, NC, USA
[2]NC State University, Department of Crop and Soil Sciences, Raleigh, NC, USA
[3]NC State University, Department of Horticultural Science, Fletcher, NC, USA

Plant leaf tissue nutrient analysis is used to diagnose nutrient disorders and to identify "hidden hunger" when nutrient levels are low and may affect growth, but visual symptoms of nutrient deficiency are not expressed. The principle is to compare essential plant nutrient concentrations in most recent mature leaves (MRMLs) to published sufficiency ranges or survey values to determine if nutrients are low, in-range, or at potentially toxic levels. Sufficiency ranges and survey values differ in that sufficiency ranges have been established through scientific evaluation whereas survey values are based on observational data. In the absence of established sufficiency ranges for hemp, the survey values published in the Plant Analysis Handbook IV (Bryson and Mills, 2014) are a reference guideline used by many agronomic labs across the country, including the NCDA&CS Agronomic Division. While research is conducted to establish yield-based and symptomology-based sufficiency ranges, a comparison of plant tissue results from different varieties grown at different locations to the Plant Analysis Handbook survey values can be used to ground truth these guidelines before making nutrient application recommendations.

The objectives were (1) to compare foliar tissue nutrient concentrations of ~30 floral hemp cultivars grown in two floral hemp variety trials at two NCDA/NCSU Research Stations, each using a different fertigation program and (2) to compare foliar nutrient concentration of the cultivar trial samples as well as samples collected by NCDA Field Agronomists from commercial farms to the Plant Analysis Handbook survey ranges.

There was no apparent difference in foliar nutrient levels among cultivars. In fact, differences in foliar nutrient levels were greater for the same cultivar grown at different locations under different fertility management than different cultivars grown at the same location with the same fertility management.

Our findings from this survey and experience of NCDA Field Agronomists and NCSU Hemp Extension Specialists, are as follow. The N survey values (3.3-4.8%) seem reasonable at later growth stages; however, adjustment of the upper N value may be warranted for early growth stages. The K survey range (1.8-2.4%) is too narrow both the upper and lower K values are likely too low. An upper K value of 3.5% is not unreasonable. The Ca survey range (1.5-4.4%) is unusually broad, and the upper Ca value is higher than almost any other crop. The upper Ca value may need lowering to discourage excessive use of Ca products by growers when unnecessary. The lower B value (56 ppm) is too high based on field observations. Most agronomic crops have the lower end of the B sufficiency range at less than 30 ppm. The survey values for P (0.24-0.49%), S (0.17-0.26%), and Zn (24-52 ppm) seem reasonable, while the values for Mg (0.4-0.8%) and Mn (41-93 ppm) seem too high. The survey value ranges for iron (100-150 ppm) and copper (5-7 ppm) seem too narrow, and the survey ranges for iron seem too high.

Bryson, G.M, and H.A. Mills (Eds). 2014. ***Plant analysis handbook IV e-edition. A guide to sampling, preparation, analysis, and interpretation for agronomic and horticultural crops***. Athens, GA: Macro-Micro Publishing Inc.

Southern Blight and Foliar Diseases of Hemp in Central Virginia

Zelalem Mersha, Maru Kering, Ramesh Dhakal, Alireza Rahemi, and Shuxin Ren
Virginia State University, Petersburg, Virginia, USA

Foliar and soil-borne diseases were observed in samples collected from a farmer field as well as on hemp research plots at Virginia State University (VSU) Randolph farm during the months of June to September 2019. Prevalence of southern blight, caused by the soil-borne fungal pathogen *Sclerotium spp.*, was confirmed during a visit to a hemp field in Dinwiddie County in August 2019. Infected plants showed typical yellowing and wilting symptoms leading up to a final collapse within days to weeks, depending on weather favorability. The abundant white, at times fan-shaped, mycelium and distinct mustard seed like sclerotia from the soil-line up to few inches above the crown area were clearly discernible on symptomatic hemp plants grown in raised beds with plastic mulch. *In vitro* experiments using acidified potato dextrose agar revealed fast growth of the fungus when it started from mycelium than a sclerotium. Mycelial growth was fastest (85 mm in 90 hours) and sclerotium formation was shortest (7 days) when the isolated *Sclerotium spp.* started from mycelium and incubated at 30°C followed by 25°C, 35°C, and then 20°C. However, 40°C was detrimental with no mycelial growth at all. Leaf and stem spots caused by Bipolaris, Septoria, Alternaria and other yet to be identified organisms have caused visible damages on the five grain and three fiber hemp varieties grown at VSU Randolph Farm. Stem lesions were very frequent on the two fiber type varieties; Carmagnola and Fetura 75. Additional disease observations and concerns were reported by growers during the 2019 hemp field day at VSU. Whereas hemp diseases and pests are becoming a growing concern to farmers in the state, there is a very limited information on prevalent diseases and their prevention strategies. Fact-based best management practices including registered organic and conventional chemistries are lacking. VSU hired a hemp breeder to partly address the agronomic challenges including selection of best performing lines. Growers are highly encouraged to submit samples to the plant diagnostic clinic at the Virginia Polytechnic Institute and State University for an accurate diagnosis. Such information would also help establish a database for frequently observed and economically important diseases of hemp in the Commonwealth of Virginia.

Figure 1. Field symptom of southern blight on a hemp plant grown on plastic mulched raised beds (left) and signs of the disease easily discernible as one opens the canopy e.g. the fan-shaped mycelium on the soil surface (middle) and brownish colored mustard seed-like sclerotia seen at the crown area (right).

Agronomic Production Practices for Hemp: Nitrogen Rate Trials

Bob Pearce and Tom Keene, University of Kentucky, Lexington, KY, USA

A commonly suggested attribute of hemp is that it requires little or no fertilizer for economically viable production. Studies have been initiated at the University of Kentucky to evaluate the nitrogen response of hemp in field production scenarios. A study of 4 plant populations (3 transplanted and 1 direct seeded) and 3 rates of nitrogen fertilizer (0, 100, and 200 lbs. N/Ac. demonstrated that straw (fiber) yields were much greater for the higher plant population direct seeded systems than for the transplanted systems. Straw yields in the direct seed systems increase by approximately 1 ton per acre for each 100 lbs. of nitrogen added (Figure 1). Similarly, the floral component yield also increase with increasing plant population and increasing nitrogen (Figure 2). A study of nitrogen rates and timing of application showed that grain yields increased with increasing nitrogen rates. A split application with half the nitrogen applied pre-plant and half applied 4 weeks post mergence was not consistently better than applying all nitrogen up front (Figure 3). Much more work is needed to determine best management practices with regards to nitrogen fertilization of hemp in different production scenarios, but these studies clearly show that hemp does respond positively to added nitrogen fertilizer.

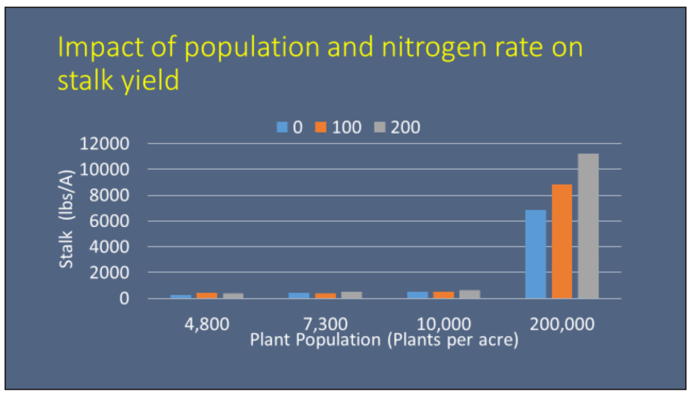


Figure 1

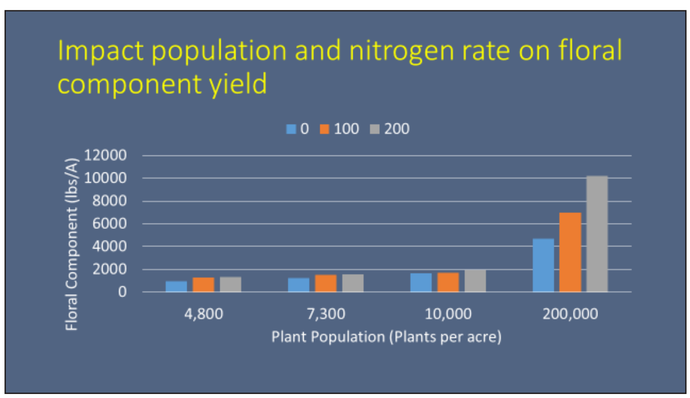


Figure 2

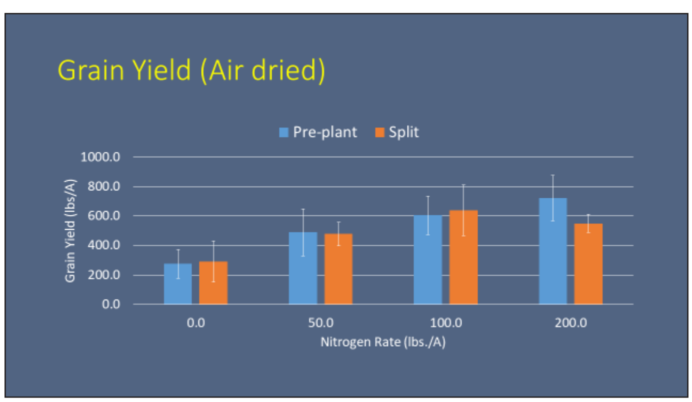


Figure 3

Overview of Agronomic Research on Hemp in Kentucky

Bob Pearce and Tom Keene, University of Kentucky, Lexington, KY, USA

Agronomic research has been conducted at the University of Kentucky since the 2014 Farm Bill allowed states to conduct research programs on hemp. Some agronomic challenges to commercial scale production of hemp that have been identified include but are not limited to: 1) A lack of appropriate cultivars adapted to regional soil, climate and day length conditions. 2) Poor stand establishment from seed due to poor seed quality and soil surface conditions. 3) No locally established best management practices for fertilization. 4) A lack of registered crop protection agents for appropriate pest management. 5) Limited information on harvest and post-harvest processing methods to preserve the quality and value of fiber, grain, and floral components. Agronomic research is underway at the University of Kentucky to address some of these challenges.

Variety trials for fiber and grain production have been conducted every growing season with results reported on the University of Kentucky hemp agronomic research web page https://hemp.ca.uky.edu/ . Poor stand establishment from seed has been a consistent concern throughout the early trials on hemp. In the 2019 grain/fiber variety trial, the percentage of live seed that emerged and established a plant ranged from 27% to 57% (figure 1). More research is needed to identify the seed and soil factors that contribute to poor establishment. Results for the 2019 fiber/grain variety trials will be posted on the webpage linked above.

An herbicide tolerance trial was established following an IR-4 herbicide protocol for hemp. Five pre-plant and 3 post-emergence herbicides were evaluated at 2 or 3 rates for each product. Phytoxicity impacts were rated on both direct seeded (cultivar USO 31) and transplanted (clones from Otto II) hemp. Early results indicate some active ingredients resulted in unacceptable crop injury and stand loss, while other showed promise for further evaluation (figure 2). Much work remains to be done to develop best management practices for hemp.

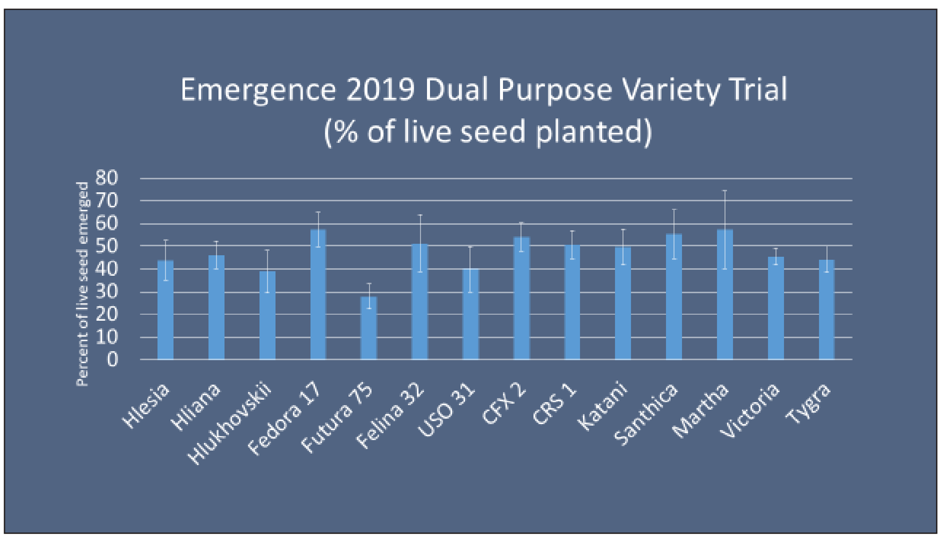


Figure 1. Emergence of hemp from seed.

Figure 2. Herbicide injury on germinating hemp.

Fungicide Efficacy on Foliar Hemp Diseases in North Carolina in 2019

Tyler Schappe and Lindsey Thiessen, North Carolina State University, Raleigh, NC, USA

Foliar fungal disease on industrial hemp diagnosed by the North Carolina State Plant Disease and Insect Clinic increased 10-fold between 2017 and 2019. Despite the increased acreage and reports of disease, there are few chemistries legally available to hemp growers in the state for the control of foliar fungal pathogens. During the 2019 growing season, we tested the efficacy of 13 chemistries, including conventional, organic, and low-risk products, for controlling foliar pathogens on *Cannabis sativa* var. 'BaOX.' Our results show that only Microthiol Disperss, a micronized sulfur treatment, significantly reduced both foliar and flower disease severity relative to the control plants; the disease levels in all other chemistries were not significantly different from the control. Given the relative drought stress and the confounding effects of apparent stem canker disease during this field season, more trials at several locations are needed to support the conclusions of this study.

Methods

The study was a randomized complete block design with 14 treatments, 8 plots per treatment, and 7 plants per plot (n=784). Foliar lesion percentage was collected in the field at two time points and AUDPC was calculated. Two inflorescences per plant were sampled and stored in moist conditions for 24 hours before flower disease rating. A multilevel linear model was used to estimate marginal treatment effects accounting for nested correlation structure.

Table 1. Chemistries and rates used in this study. * denotes same treatment.Methods

Product	Active Ingredients	Company	Applications	Interval (days)	Rate	Vol. (Gal/A)
Quash	Metconazole	Valent	2	14	2.5 lb/A	20
Headline	Pyraclostrobin	BASF	2	14	12 fl oz/A	20
Revysol	Mefentrifluconazole+Pyraclostrobin	BASF	2	14	7 fl oz/A	20
Priaxor Xemium	Fluxapyroxad+Pyraclostrobin	BASF	2	7	4 fl oz/A	20
Oxidate	Hydrogen dioxide+Peroxyacetic acid	Biosafe	5	7	1%	100
Serifel	Bacillus amyliloquefaciens	BASF	3	7	16 oz/A	20
Serenade Opti	Bacillus subtilis	Bayer	3	7	20 oz/A	20
JMS Stylet Oil	Horticultural oil	JMS Flower Farm	8	14	77 fl oz/A	30
Microthiol Disperss	Micronized sulfur	UPL	3	7	6 lb/A	30
TriTek	Mineral oil	Brandt Organics	3	7	0.6 gal/A	30
Aleo	Garlic oil	Brandt Organics	3	7	12 fl oz/A	20
PerCarb	Sodium carbonate peroxyhydrate	Biosafe	5	7	3 lb/A	100
Oxidate 2.0*	Hydrogen dioxide+Peroxyacetic acid	Biosafe	1	7	1%	100
OxiPhos*	Phosphorus acid + hydrogen peroxide	Biosafe	1	7	5 qt/A	100
Pvent*	Gliocladium ctenulatum Strain J1446	Biosafe	5	7	1.98 oz/A	100

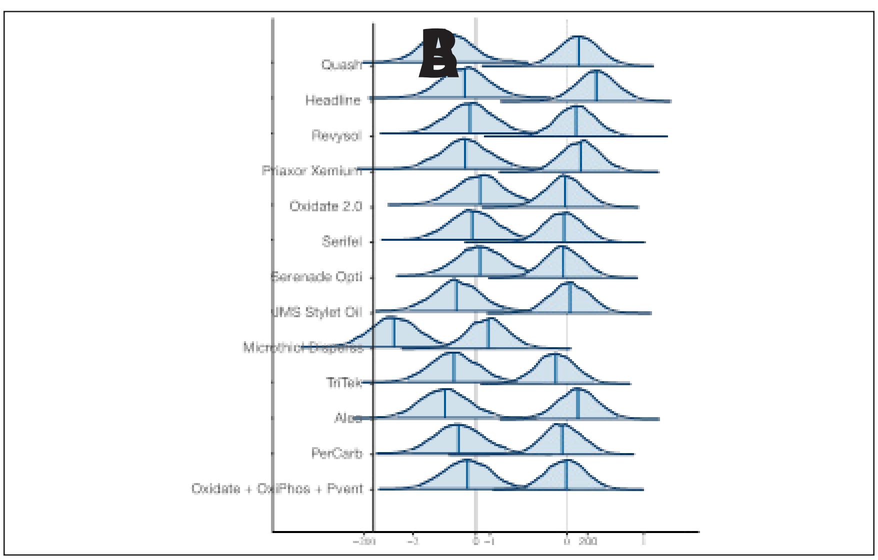


Figure 1. 95% posterior credible intervals for difference in means relative to control for a) percent flower disease and b) foliar AUDPC.

Industrial Hemp (*Cannabis sativa* L.) Cultivars and Water Saving Traits: Water Management

A. Shekoofa, K. Sheldon, and E.R. Walker
Plant Sciences Department, University of Tennessee,
West TN Research & Education Center, Jackson, TN, USA

Drought condition is one of the most common environmental factors that negatively impact crop yield. Identification and integration of genetic traits enabling increased water conservation in plants could provide increased water availability and plant performance during drought, ultimately improving plant yield and quality. Industrial hemp production in the United States has continued to drastically increase after federal and state provisions legalized its cultivation in 2014 and 2018. But due to strict regulations in the past, agronomic research, necessary for adapted cultivars and best management practices, is severely lacking. Therefore, the objective of this study was to identify the water saving traits including fraction transpirable soil water (FTSW) threshold and limited transpiration (TR_{lim}) among hemp cultivars. Two controlled environmental studies were conducted at the University of Tennessee during 2019: 1) to confer drought tolerance involves the response of transpiration to progressive soil drying, seven hemp cultivars underwent a progressive soil drying treatment after they were grown in a representative Tennessee soil for four weeks. 2) a sensitivity of transpiration rate to high vapor pressure deficit (VPD) was evaluated among eight cultivars of four-week-old hemps in a walk-in growth chamber for two consecutive days under three different VPD levels at 32°C. In experiment one, there were substantial differences among the cultivars. The cultivar, 'Delores,' with $FTSW_{threshold}$=0.81, showed the earliest stomatal closure and highest water saving under soil drying, whereas 'Canda' with $FTSW_{threshold}$=0.16, showed the latest stomatal closure and maximum water loss early in growth. Five out of eight cultivars expressed the TR_{lim} trait with their VPD thresholds ranging from 2.00 to 2.60 kPa, in experiment two. Identifying one or both traits in a range of genetic backgrounds and environmental conditions and selecting for these traits in future hemp cultivar development efforts can potentially improve production Industrial hemp for water-limited environments.

Keywords: hemp, drought, fraction transpirable soil water, limited transpiration, vapor pressure deficit

Nitrogen and Potassium Rates for Floral Hemp Following a Tobacco Production Model

Maggie Short[1], Michelle McGinnis, Ph.D.[2], Matthew Vann, Ph.D.[1], and Keith Edmisten, Ph.D.[1]
[1]North Carolina State University, Raleigh, NC, USA
[2]North Carolina Department of Agriculture and Consumer Services, Raleigh, NC, USA

North Carolina is the leading producer of flue-cured tobacco in the United States; however, reduced demand has growers seeking other agricultural ventures. In 2015, a pilot program was established in the state, which afforded licensed farmers the opportunity to grow industrial hemp. Many farmers are currently producing hemp for floral cannabidiol (CBD) production; however, fertility recommendations tailored to North Carolina have not been established by NC State University Extension. In 2019, two separate trials were conducted to evaluate the effects of nitrogen and potassium rates on the yield, CBD concentration (% dry weight basis), CBD content (mg/plant dry weight basis), and foliar tissue nutrient concentrations of floral hemp following a tobacco production model. Trials were conducted at four different locations: the Piedmont Research Station in Salisbury, the Sandhills Research Station in Jackson Springs, the Lower Coastal Plains Research Station in Kinston, and at a commercial farm in Bertie County. These locations provided a variety of soil types, from clay to deep sand. The research station trials were transplanted mid-May and the on-farm trials in early-July. Both trials consisted of five treatments: 0, 50, 100, 150, and 200 pounds of N or K_2O/acre. Treatments were replicated four times at each location and were arranged in a randomized complete block design.

Beginning at four weeks after transplanting, growth index measurements and most recently mature leaf (MRML) tissue samples were collected every two weeks until 16 weeks after transplanting. Growth indices were determined as the average of the width of a plant at its widest point and the width of the plant perpendicular to the widest point, multiplied by the height of the plant. Leaf tissue samples were analyzed by NCDA&CS Agronomic Division for nutrient concentration. Floral samples were collected from the 100 pounds N and K_2O/acre at three trichomes maturity stages, clear, 50% milky, and 50% amber and at harvest from every treatment. Floral tissue samples were analyzed by Avazyme, Inc. for cannabinoid concentrations. At the conclusion of the season, five plants per plot were harvested at approximately 50% amber trichome. Plants were bagged individually and dried for two to three days at 150°F in tobacco curing barns. The plants were debudded and non-stem material was weighed to determine yield as measured by floral dry weight.

Initial data from the nitrogen trials shows a consistent decrease in leaf nitrogen concentration (%) across all treatments from four to sixteen weeks after transplanting at the research station locations. Leaf concentrations ranged from 4.3-6.4% nitrogen at four weeks after transplanting and 1.8-3.7% nitrogen at sixteen weeks after transplanting. Similarly, initial data from the potassium trials shows a consistent decrease in leaf potassium concentration across all treatments from four to sixteen weeks after transplanting at the research station locations. Leaf concentrations ranged from 2.1-3.4% potassium at four weeks after transplanting and 0.6-1.7% potassium at sixteen weeks after transplanting. Additionally, the plant tissue N and K concentrations of the 0 pounds N and K_2O/acre treatments were less than the 200 pounds N and K_2O/acre through at least 12 weeks after transplanting at all three research station locations. Both trials will be replicated in 2020.

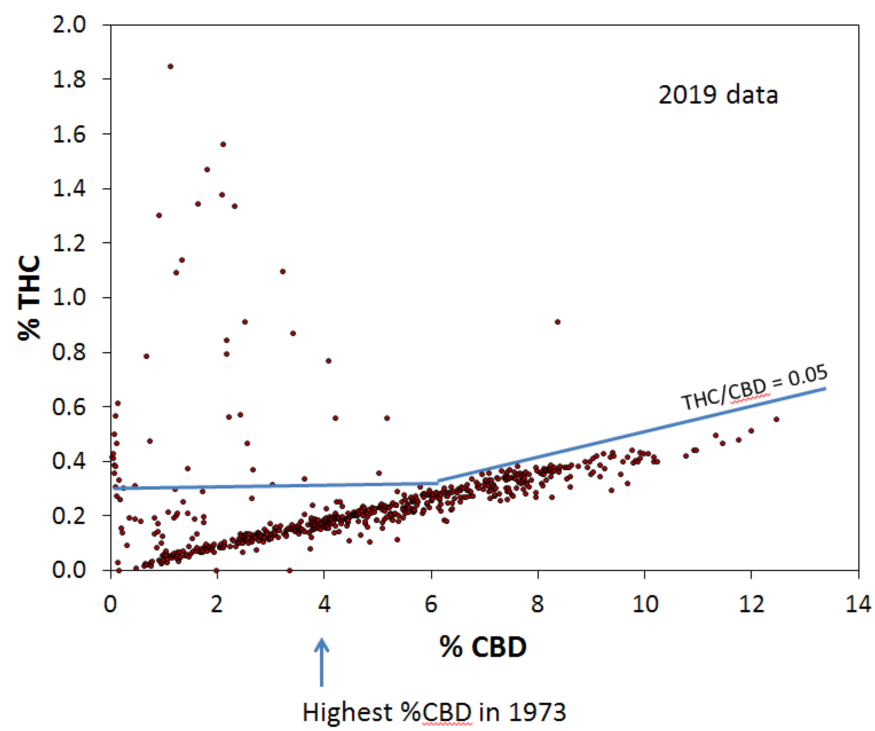
Hemp Testing for Regulatory Compliance

Frank J. Sikora, Univeristy of Kentucky, Lexington, KY, USA

The Division of Regulatory Services has been involved with testing hemp for the Kentucky Department of Agriculture for 3 years to ensure tetrahydrocannabinol (THC) concentrations in hemp plants were at the legal level. The 2014 Farm Bill defined hemp as any part of a *Cannabis sativa* L. plant with a Δ-9 THC concentration not more than 0.3 percent on a dry weight basis. There was confusion on what to measure because there are two molecular forms of THC. The molecule that is psychoactive is Δ-9 THC. An acid form of THC (Δ-9 THCA) exists that is not psychoactive but is converted to psychoactive Δ-9 THC upon heating which occurs when smoking or baking the plant. Gas chromatography measures total THC because Δ-9 THCA converts to THC at the sample inlet which is at high temperature. Liquid chromatography measure Δ-9 THC and Δ-9 THCA separately. Some states measured just Δ-9 THC and other states measured total THC THC (Δ-9 THC + Δ-9 THCA x 0.877). The 2018 Farm Bill clarified the confusion with a definition that includes both THCA and THC.

A proficiency testing program was started in 2018 by our Division to help labs developing methods to test THC and to determine variability existing amongst laboratories. The same sample is sent to several laboratories, laboratories report their results, and data is summarized in individual lab reports and summary reports. Summary reports are available at www.rs.uky.edu by clicking on Hemp PT in the menu items on top of the page. With a sample that had an average close to 0.3% total THC, laboratories with reported values within 3 standard deviations of the average had values from 0.2 to 0.4%. This high variability is likely due to several factors such as the newness of the technique to the labs, no standard method for analysis, and differences in methods employed. The 2018 Farm Bill tasked the USDA to develop a national regulatory framework for hemp production. The USDA has been advised of measurement uncertainty observed amongst the laboratories and the need to include it in deciding whether a crop violates the 0.3% THC limit.

The current standard is to define hemp as having a total THC concentration less than 0.3% THC. Although this is the current standard, it is worth asking the question where this limit came from and the potential for modifying it in the future. This limit was developed from a 1973 study on various varieties of hemp and marijuana (Nature, Vol. 245, p. 147, 1973). There were good correlations between THC and CBD for marijuana and hemp. Marijuana had high THC/CBD ratios and hemp had low THC/CBD ratios. All the hemp varieties were well below 0.3% THC. However, the highest CBD concentration was just under 4% CBD. Today's hemp varieties can be much higher at approximately 10% which results in a greater likelihood of exceeding the 0.3% THC. A more reasonable approach for defining hemp may be to define it when THC/CBD ratio is less than 0.05 at higher CBD levels as shown in the graph on the right.



Current State of Hemp in the Southwest

Dr. Amanda Skidmore, New Mexico State University, Las Cruces, New Mexico, USA

Industrial hemp is a new crop for many states within the southwestern United States, with the exception of Colorado. This region commonly encompasses 8 states (Arizona, California, Colorado, Nevada, New Mexico, Oklahoma, Texas, and Utah), although due to climatological similarities New Mexico, Arizona, Nevada, and Utah share the most production similarities. Currently, each state has different regulatory, testing, and licensing requirements that make navigating the current status of hemp production challenging. An overview of current state regulations was presented alongside data estimates of total acreage under industrial production and total license holders. Challenges facing industrial hemp production in the Southwest were also presented, including: climatological differences, water availability and irrigation types, soil quality, border security concerns, and concerns about liability of extension recommendations. An overview of hemp insects and arthropods (both pest and beneficial) was provided along with a summary of leading arthropod management concerns. Current research projects within the region were summarized and presented, including projects focused on hemp agroecology, phytoremediation, economic viability, breeding, and disease management. A summary of current needs within the region and possible solutions was provided. Overall, industrial hemp production in the Southwest will be an evolving industry with a unique set of challenges for extension educators and researchers within the region.

Hemp Leaf Spot, New Disease of Hemp Caused by *Bipolaris gigantea*

Desiree Szarka, Bernadette Amsdem, Christopher Schardl, and Nicole Gauthier
University of Kentucky, Lexington, Kentucky, USA

Hemp leaf spot (HLS) was first reported in July of 2014 at a single site in Eastern Kentucky. Since then, there have been new cases every year; within at least 18 counties in Kentucky and 15 known states. Symptoms appeared as early as July, while plants were in a vegetative state, and appeared as 1-2 mm lesions that rapidly spread throughout entire fields. Lesions were randomly dispersed across leaf surfaces and were of two colors; a darker brown-tan and a lighter tan-white. Necrotic tissue often formed between lesions without distorting the borders of the original lesion. Heavily infected plants became stunted or rapidly blighted. Some cultivar susceptibility has been observed, with more disease reported on CBD cultivars than fiber or grain cultivars. Growers have experienced a range of severity, with some experiencing total yield loss.

Morphological examination documented disease and pathogen descriptions. Conidiophores were dark-brown, large, and multi-septate. They formed within lesions, both on the under and upper sides of leaves. Conidiophores typically produced a single macroconidium, but occasionally two or three. Conidia were hyaline, multi-septate and could germinate from any cell, producing multiple germ tubes. Conidia were wider than conidiophores, averaging 304 µm by 22 µm. Conidiophores averaged 263 µm by 9 µm. Microconidia developed on older leaves or cultures and formed on the ends of macroconidia, on their conidiophores, and on hyphae. Some isolates produced dark brown-black, round structures – suspected to be a proto-perithecia. These structures formed above or within leaf tissue. The inner contents were hyaline and bared no resemblance to asci or ascospores.

Identification included molecular comparisons. Whole genome and single gene sequencing of ITS, 28S, TEF1, and RPB2 were used to identify the pathogen as *Drechslera gigantea*. Phylogenetic analysis grouped all isolates into a single clade within the genus *Bipolaris*. Isolates were identical or nearly identical to several GenBank accessions labeled as *D. gigantea* or *Bipolaris* sp., suggesting that *D. gigantea* should be reclassified as *Bipolaris*. To better understand the population makeup and to study the potential for sexual reproduction, isolates were examined for mating types. Some isolates were found to have either MAT1-1-1 or MAT1-2-1, while others were determined to have both mating types. This suggested a more complex population than previously thought. The presence of both mating types and the possible proto-perithecia within the population suggests that sexual reproduction may occur in the field.

Since several *Bipolaris* species are known to be transmitted by seed, seeds were investigated as a possible source for inoculum. No infection was detected in any embryos separated from seed coats. However, approximately 4% infested seed coats were observed. Since development of HLS is so rapid within a field and develops with no visible pattern, seeds are unlikely to be the primary source of inoculum. Nearby vegetation of infected fields was also investigated as a potential source for inoculum. Six alternative hosts have been identified with *D. gigantea*, four of which are dicots. This is of interest, as all previous known hosts of *D. gigantea* were monocots. With hemp acreage increasing, it becomes crucial to understand HLS and other diseases that may impact the burgeoning hemp industry. Increased knowledge helps educate agents, diagnosticians, and specialists about the disease so that they may help growers achieve the best yield from their crop.

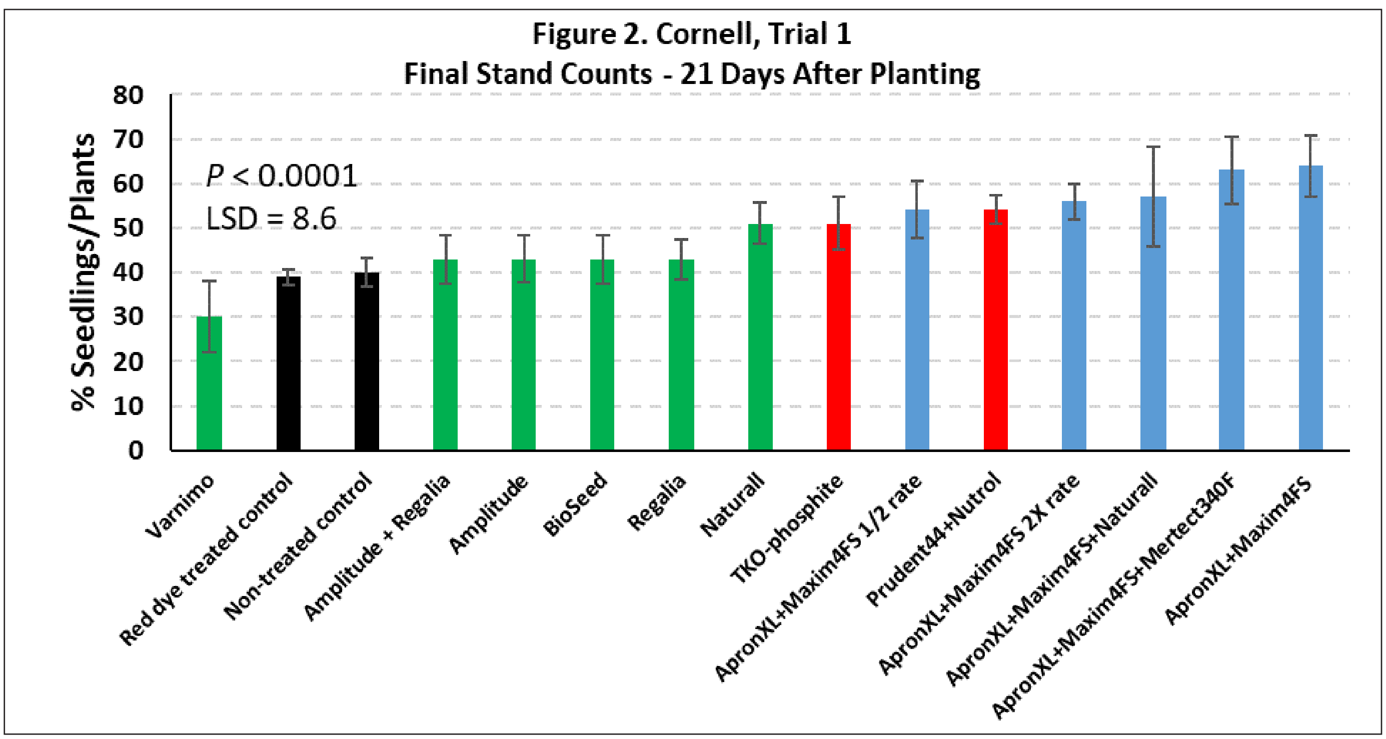
Hemp Seed Treatments for Damping-off

Alan Taylor[1], Hilary Mayton[1], and Gary Bergstrom[2]
Cornell University, Geneva[1] and Ithaca[2], NY, USA

The purpose of this research was to develop and collect efficacy data on biological and chemical fungicide seed treatments on hemp for the management of damping-off caused by several pathogens (*Pythium, Fusarium and Rhizoctonia*). All seed treatments were applied with rotary pan technology (Figure 1). Seed coating technology was developed for uniform application of seed treatments over the seed surface and from seed-to-seed (Figure 1.) Chemical treatments included Mefenoxam + Fludioxonil, biochemical treatments contained Phosphite and four biological products that contained strains of *Trichoderma*, *Bacillus* and other beneficial biocontrol agents. Seed treatments were evaluated in three states but only a summary of one Cornell field study will be presented. Overall, chemical seed treatments (in blue) and biochemical, phosphite seed treatments (in red), performed better, in terms of final stand counts, than biologicals and non-treated controls (in black) (Figure 2.).

Acknowledgement: Support from IR-4, NYS Ag and Markets, multi-state project W-3168.

Figure 1. From left to right. Cornell Agri-Tech, lab-scale, rotary pan coater. Noncoated seed, coated with conventional coating material and coated with new seed coating formulation from Incotec, Salinas, CA.



Industrial Hemp Disease Pressures in North Carolina

Lindsey Thiessen, North Carolina State University, Raleigh, NC, USA

North Carolina initiated an industrial hemp pilot program in 2016 to begin research into the value of industrial hemp for the state. While hemp was initially expected to be grown for grain or fiber, flower production has become the leading market niche for the state. There continue to be many unknowns for growing hemp in the state, but many hemp diseases emerged as an economical limitation for production. In the first couple of years, disease caused by *Fusarium* spp. were the most economically challenging. *Fusarium* root rot (*F. oxysporum*), stem canker (*F. graminearum*), and flower blight (*F. graminearum* and *F. equiseti*) caused the majority of disease losses in 2017 and 2018. In 2019, *Fusarium* root rot (*F. oxysporum*), tip dieback (*Lasiodiplodia theobromae*), pythium root rot (*Pythium* spp.), southern blight (*Sclerotium rolfsii*), and Helminthosporium leaf spot (*Exserohilum rostratum*) were of economic concern to hemp producers.

These pathogens can directly impact yield and quality; however, we have limited information on how plant stress will impact cannabinoid production. An additional complication is that pathogens may also have potential human health risks. For example, *Fusarium* spp. are capable of producing mycotoxins that affect human and animal health. Management strategies that reduce disease are limited in hemp; there are no labeled fungicides for controlling these pathogens. Though many states have a list of acceptable products, North Carolina has strict rules for pesticide use that restricts use of registered products. There is also no known host resistance given the lack of standardized varieties; however, some strain response has been observed with susceptibility to *Exserohilum rostratum*. Successfully managing hemp diseases will require heavy reliance on cultural practices until fungicides and varieties are developed.

Identification of *Golovinomyces spadiceus* as a Pathogen on *Cannabis sativa* in Kentucky

Lydia Tymon[1], Desiree Szarka[2], and Nicole Gauthier[2]
[1]Washington State University-Mount Vernon NWREC, Mount Vernon, WA, USA
[2]University of Kentucky, Lexington, KY, USA

Industrial hemp (*Cannabis sativa*) was reintroduced to the US as a pilot research program under the 2014 Farm Bill. Currently there are over 25,000 acres of industrial hemp in the US, with KY having the second highest acreage in the US. Hemp is processed for fiber (4%), grain/seed (4%), and cannabidiol (CBD, 92%), and grosses $7.5M for Kentucky growers. Between 2014 and 2019, powdery mildew was observed in numerous greenhouses, in multiple locations, and on several varieties.

Morphological Features

- Mycelia were amphigenous and occasionally caulicolous.
- Foot cells were cylindrical, measuring (42 to) 57 to 107 (to 120) µm × 9 to 11 µm, followed by one to two shorter cells (Fig. A).
- Conidiophores were hyaline, singular, and erect, measuring (80 to) 115 to 187 (to 209) µm in length, followed by two to three immature conidia forming a crenate outline ((Fig. A).
- Conidia were catenescent and ellipsoid to ovoid, measuring (29 to) 30 to 39 (to 41) µm × (13 to) 15 to 20 (to 22) µm (Fig. A).
- Chasmothecia were round and dark brown at maturity, measured (96 to) 109 to 138 (to 159) µm in diameter, and displayed nondescript myceloid appendages (Fig. B-C).
- Mature chasmothecia contained five to 15 ovoid-saccate asci, most with short stalks (Fig. C).
- Asci measured (52 to) 56 to 75 (to 78) µm × (25 to) 29 to 43 (to 50) µm, and each ascus contained two ovoid ascospores measuring (15 to) 18 to 27 (to 32) × (9 to) 11 to 18 (to 19) µm.

Identification

- Conidial measurements were similar but not identical to *G. ambrosiae*, which is reported to have a longer conidial length/width ratio (2.0) than *G. spadiceus* (1.5 to 2.0) (Braun and Cook 2012, Szarka et al. 2019).
- Isolates had conidial length/width ratios consistent with *G. spadiceus* (Braun and Cook 2012).
- Identification was confirmed by sequencing the 28S and internal transcribed spacer (ITS) regions with
- primers PM5G/NLP2 for the 3' half of ITS and 28S and ITS5/PM6G for the 5' half of ITS (Bradshaw et al. 2017).
- All samples collected during this period were consistent; no other powdery mildew species was identified.
- Determination is consistent with those of powdery mildew fungi collected from *Cannabis* in Canada (Pépin et al. 2018).

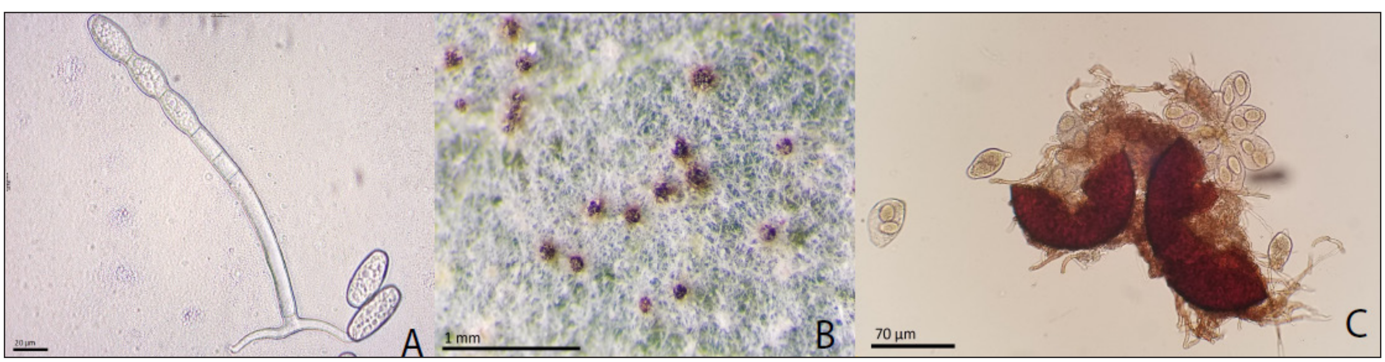


Figure 1: Conidia and conidiophore (A), chasmothecia (B-C), and asci (C) of *Golovinomyces spadiceus*.

Hemp Russet Mite: A Threat to Hemp in Kentucky

Raul T. Villanueva, University of Kentucky's Research and Education Center, Princeton, Kentucky, USA

The hemp russet mite (*Aculops cannibicola*) was found in many hemp fields and in greenhouses in Kentucky in 2019. However, this pest does not prosper in western states of the United States (i.e. OR, CO, CA), once plants are established in open fields. This note provides observations on the abundances and symptoms caused by the hemp russet mite in Kentucky and compared with other species of russet or broad mites (*Polyphagotarsonemus sp.*) in other crops; and through environmental factors that may increase its densities in Kentucky.

Damages observed

The hemp russet mite is a quasi-microscopic eriophyid that feeds only on hemp plants. Damages found in Kentucky are consistent with previous descriptions found elsewhere: leaves curl up at the edges; yellowing or bronzing spots in leaves and stems. Sometimes symptoms include virus-like-mosaic and deformations of leaves similar to damage caused by broad mites. Leaves may twist or drop as response to heavy infestations (Figure 1). In citrus, the pink rust mite causes similar kind of damages in seedlings. Hemp russet mites also affected stems and flower buds. This pest is greatly attracted by the oils on buds. Recently transplanted plants infested with russet mites showed reduced growth rate and stunted appearance (Figure 2). They seem stressed or affected by mineral nutrient deficiency .

Management

The management for hemp russet mites should include planting seedlings free of this pest (plants should be purchased from a reliable nursery). Natural enemies of this pest may be scarce. This year phytoseiid predacious mites were observed in hemp plants but there is not a direct link on the predation of russet mites for many of this species. The majority of commercially available phytoseiid mites are specific for control of spider mites, scale insects, whiteflies or thrips in greenhouses. Release of predatory mites in hemp grown outdoors might not be an efficacious action as it is done in greenhouses for control of other pests. In Florida, most of the predacious phytoseiid mites do not prey on citrus russet mites even when they were starved (personal experience). In 2019, minute pirate bug nymphs (*Orius* sp.) were observed in heavily infested plants with russet mites. The abundance of russet mites outdoors in Kentucky compared with western states (CO, OR, CA) may be influenced by environmental factors. For instance, percentages of relative humidity in Kentucky are greater than western states. The severe drought in most areas of Kentucky from August to mid-October in 2019 might be a fortuitous factor that reduced hemp russet mites later in the season. Miticides to control russet mites are used in other crops however; none are registered in Kentucky. Many oils are used to control russet mites in other commodities, the oils registered by the KDA have not been tested yet.

Figure 1: Symptoms of plants infested by hemp russet mite.

Figure 2: Stuned plant infested by hemp russet mites.

An Update in Hemp Insects: Emphasizing Key Pests in Kentucky in 2019

Raul T. Villanueva, University of Kentucky's Research and Education Center, Princeton, Kentucky, USA

This report compiles insect pests observed, collected, and identified through visits to hemp fields in Graves, Lyon, Caldwell, Fayette, and Mason Counties (Kentucky); and samples received for identification at the University of Kentucky in Princeton and Lexington.Materials and Methods: Insect pests causing damage to hemp were observed and collected in commercial hemp fields grown for CBD oil in Graves, Lyon, Caldwell, and Mason Counties (Kentucky) between mid-July to September in 2019. Also, specimens from hemp grown for grain and CBD oil at the University of Kentucky's Spindletop research farm in Fayette Co. were included in this pest report. Figure 1 shows the most common insects that feed on flower buds, seeds, foliage, stems or roots that were found in Kentucky.

Results and Discussion

In order of importance, the key insect pests of hemp in Kentucky were: (1) Corn earworm: feeds on flower buds causing significant damages in 2019 across all visited areas in Kentucky. Corn earworms may have moved from corn fields after corn has passed the green silk period. (2) Japanese beetle and June bugs were abundant from mid-July to mid-August in hemp in eastern or central KY. In western KY, hemp planting was later that in central or eastern KY, thus these species were not observed in great numbers. (3) Euroasian hemp borer: only one sample was received by mail from Oldham Co. Specimens of this pest were not collected because our sample was not destructive to hemp plants, and this borer might had been present in stem or flower bud tunnels. (4) Cannabis aphid: in Kentucky this pest was observed in most locations and present in low numbers. This insect can be disseminated from greenhouses to fields (probably this happened in KY). In the north west USA or Colorado this pest does not prosper in hemp grown outdoors. (5) Tarnished plant bug: this insect is included here because is the most ubiquitous and present throughout all the period assessed, damages to hemp foliage, buds, or seeds need to be evaluated.

This is an initial approach to identify insect pests of hemp grown outdoors, many procedures need to be developed for sampling and damage ratings. Destructive sampling in commercial fields was difficult to conduct as an average price of a clone plant was $4. Pheromones, sticky cards or baits may be use in the future. Pests of roots were only observed from greenhouse samples. Hemp russet mites were observed in most areas and it may be a key pest in KY. See a report on russet mites in hemp in this proceeding.

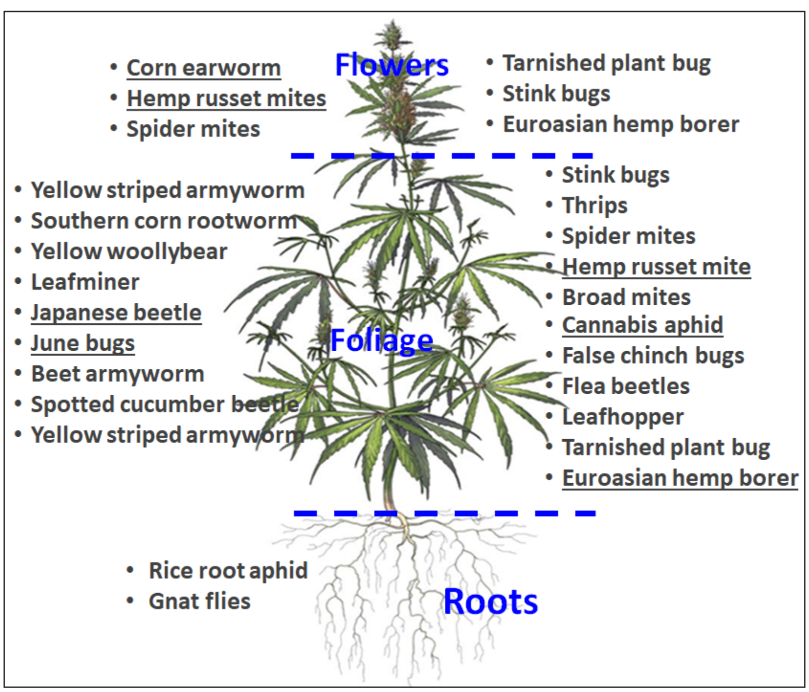


Figure 1: Insect and mite pests found in hemp affecting flower buds, foliage and roots in KY in 2019. Key potential pests are underlined.

Arthropods Collected in Industrial Hemp Fields in Kentucky in 2019

Raul T. Villanueva[1], Samantha Anderson[2], Colby Guffey[3], and Susan Fox[4]
[1]Research and Education Center at Princeton
[2]Graves, [3]Clinton, and [4]Lyon County Extension Offices, KY

This report presents a brief information on arthropods (insects, mites and spiders) collected between mid-July to the end of September in commercial and research hemp fields of Kentucky in 2019. Counties surveyed were located in Mason, Fayette, Caldwell, Lyon, and Graves.

Collection of specimens

There is little information about insect sampling or scouting in hemp for research. Hemp farmers paid an average of $4 per clone plant. Therefore, collection was completed with minimal damage to plants, without net sweeps or buckets. Also, pheromones, sticky cards or baits were not used; and tallies were not recorded. The table included here depicts only specimens that were captured by hand and identified in 2019.

Table 1. Insects, mites, and spiders found in industrial hemp in KY in 2019. Organized classified as pest, beneficial and other arthropods.

Common pest name	Scientific name	Part of plant affected
Bean leaf beetle	*Cerotoma trifurcata*	Foliage
Brown marmorated stink bug	*Halyomorpha halys*	Foliage and seeds
Brown stink bug	*Euchistus servus*	Foliage and seeds
Cannabis aphid	*Phorodon cannabis*	Foliage
Common gray moth	*Anavitrinella spp.*	Foliage
Corn earworm	*Helicoverpa zea*	Foliage and buds
Euroasian hemp borer	*Grapholita delineana*	Stem and buds
Golden mottled tortoise beetle	*Deloyala guttata*	Foliage
Green June bug	*Cotinis nitida*	Foliage
Green peach aphid	*Myzus persicae*	Foliage
Green stink bug	*Chinavia hilaris*	Foliage
Japanese beetle	*Popilia japonica*	Foliage
Leafhopper	*Graphocephala versuta*	Foliage
Leafminer fly	*Agromyza sp.*	Foliage
Green striped grasshopper	*Cortophaga viridifasciata*	Foliage
Palestripped flea beetle	*Systena blanda*	Foliage
Rice root aphid	*Rhopalosiphum rufiabdominale*	Roots
Spotted cucumber beetle	*Diabrotica undecimpunctata*	Foliage
Striped pigweed beetle	*Disonha glabrata*	No feeding on hemp
Tarnished plant bug	*Ligus lineolaris*	Foliage and seeds
Thrips		Foliage
Tree cornered alfalfa hopper	*Spissistilus festinus*	Foliage
White butterfly	*Pieris sp.*	Foliage
Wireworm	*Hemicrepidius sp.)*	Stems
Yellow striped armyworm	*Spodoptera ornithogalli*	Foliage
Yellow woollybear caterpillar	*Spilosoma virginica*	Foliage
Common beneficial name	**Scientific name**	**Activity**
Assassin bugs		Predator
Asian lady beetle	*Harmonia axyridis*	Predator
Bumble bees		Pollinator
Big eyed bug	*Geocoris spp.*	Predator
Convergent lady beetle	*Hippodamia convergens*	Predator
Firefly	*Photinus carolinus*	Predator
Honey bee	*Apis mellifera*	Pollinator
Minute pirate bug	*Orius sp*	Predator
Pink spotted lady beetle	*Coleomegila maculata*	Predator
Seven spotted lady beetle	*Coccinella septepunctata*	Predator
Spined soldier stink bug	*Podisus maculiventris*	Predator
Syrphid flies		Predator
Tachinid flies		Parasitoid
Common mite/spider name	**Scientific name**	**Part of plant affected**
Broad mite	*Polyphagotarsonemus sp.*	Foliage
Hemp russet mite	*Aculops cannibicola*	Foliage and buds
Phytoseiids		Predator
Two spotted spider mite	*Tetranychus urticae*	Foliage
Wolf spiders and crab spiders		Predator

Hemp Variety Trial in Subtropical Florida

Will Wadlington, Luis Monserrate, and Zachary Brym, University of Florida, Homestead, FL, USA

Florida is climatically and latitudinally distinct from other major hemp growing regions in North America and Europe. In particular, South Florida has relatively short summer days compared to the rest of the United States, which may affect photoperiod sensitive flowering behavior. We conducted a summer season variety trial in South Florida to discover varieties which may match in Florida's unique light environment. We used a diverse set of 23 hemp varieties of hemp from Southern Europe, Northern Europe, the Balkans, the Canadian Prairies, as well as North, Middle, and South China. The full collection of 23 varieties was planted May 22, 2019. To supplement the variety trial, eight varieties representative of the diversity in our seed collection were planted at 3 other dates in the summer season. Those eight varieties ('Carmagnola Selezionata,' 'Eletta Campana,' 'Yuma-2,' 'Bama,' 'Puma-3,' 'Tygra,' 'Berry Blossom,' and 'Cherry Blossom x T1') were planted May 1, June 21, and July 18, 2019, in addition to being included in the May 22 variety trial.

It was found that emergence efficiency dropped between the May 1 and May 22 plantings. This depression in emergence coincided with the onset of the summer rainy season when soil temperature and soil moisture increased. The emergence of June 21 and July 18 plantings were of similarly low efficiency to the emergence of the May 22 planting. Because emergence was low in the June 21 and July 18 plantings no yield data was collected. However, the May 1 and May 22 plantings developed well enough to harvest for yield evaluation.

Varieties were harvested for fiber if they flowered after the solstice (June 21) and as grain if they flowered before. Three varieties from the May 1 planting were harvested for fiber: 'Yuma-2,' 'Bama,' and 'Puma-3,' all from South China. Harvest of 1 m^2 was taken from four replicates. 'Yuma-2,' 'Bama,' and 'Puma-3' had an average yield that would be scaled to 12156, 11598, and 9278 lb/acre of dried straw respectively. These yields are high compared to average harvests for fiber in traditional production regions. These fiber varieties have high yields when harvested in August, which may be ideal for avoiding Florida's hurricane season peaks, however planting density and stem size must also be addressed. Three varieties from the full collection planted in May 22 were harvested for grain: 'Han NE,' 'Han FQ, and 'Carmagnola Selezionata.' Harvest of 1 m^2 was taken from four replicates. 'Han NE,' 'Han FQ, and 'Carmagnola Selezionata' had an average yield that would be scaled to 1570, 465, and 289 lb/acre of dried grain seed respectively. Despite plots being ~20% of the desired plant density, 'Han NE' had much higher yield than average harvests for grain in traditional production regions (~800 lb/acre). We speculate 'Han NE' had such high yield because it ramified after flowering, which increases area for seed development and closes the canopy to reduce weeds. Because dry straw yield and grain yields were acceptable for some varieties in this first trial, further cropping system optimization may result in a profitable industry for those types of hemp in Florida.

Yields, Yield Components and Cannabinoid Profiles of High-Essential-Oil Hemp Varieties

E. Walker, P. Della-Franca, V. Sykes, H. Kelly, Z. Hansen, J. Munafo, N. Labbe, and L. Schneider
University of Tennessee, Knoxville, TN, USA

Most of the hemp (*Cannabis sativa* L.) currently produced in the United States is produced for its essential oils, namely cannabidiol (CBD), due to actual and perceived net profit margins greater than hemp for fiber or grain. In order for *Cannabis sativa* L. to meet the federal definition of hemp, its delta-9 tetrahydrocannabinol (THC) concentration cannot exceed 0.3 percent on a dry weight basis. Therefore, most of the hemp varieties currently used in the U.S. for essential oil production have been bred and selected for maximum CBD production and minimum THC production, then are managed in a way to remain under the delta-9 THC threshold. There are many hemp varieties available, but very few are registered. Often, the origin of the genetics is unknown, and some varieties are extremely variable in phenotype. These varieties are sold throughout the country and grown in regions in which these varieties may not be adapted. Thus, their responses to production environments are unknown and could result in low CBD yields and, worse yet, excessive delta-9 THC concentrations that transform the crop from hemp to marijuana, a Schedule I controlled substance under the Controlled Substances Act, 21 U.S.C. 801 *et seq*. Due to the newness of the production of hemp for essential oils in the United States, there has not been enough time to generate data on these varieties and their production practices, yet many people throughout the country are producing this crop with high production costs and a market about which its stability and longevity are unknown but without the guidance of research-based variety and production recommendations. Therefore, it is imperative that research is conducted to thoroughly evaluate currently available high-essential-oil hemp varieties.

A field study was conducted in 2018 at the University of Tennessee Highland Rim Research and Education Center in Springfield, TN, to evaluate yields, yield components, and cannabinoid profiles of high-essential-oil hemp varieties. Hemp varieties A2, ACDC, Canna Boost, Cherry Blossom, Cherry Wine, Stout, Sweetened, and T1 were transplanted on June 20 and harvested on October 20. Although mean separation identified differences among varieties for dry flower and leaf yields and THC and CBD concentrations, there was significant plant variability within variety for these parameters, as well as plant phenotype, height, canopy diameter, and flower to leaf ratio. Across varieties, combined dry flower and leaf yields ranged from 0.6 to 1.6 lb per plant, CBD concentrations ranged from 4.6 to 9.3%, and total THC concentrations ranged from 0.21 to 0.43%.

Field observations in 2018 and 2019 of plant variability within variety, variability among varieties from different suppliers, and yield and cannabinoid potency variability as influenced by harvest timing, environment, and possible other factors were widespread. These inconsistencies limit the confidence and reliability of inferences from this study for future production decisions. Finalized and standardized federal and state hemp production rules, standardized procedures for sampling and testing for cannabinoid potency, and varieties developed, registered, and enforced according to established crop certification standards are needed to comprise a solid foundation on which to build sound multi-year, multi-location research efforts. These will yield the reliable hemp production and management recommendations that the industry desperately needs.

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