USDA NIFA Hatch Multistate Research Project S-1084
Annual Meeting conducted via Zoom due to COVID-19 restrictions on March 19, 2020

Recording of the Zoom meeting available at: https://youtu.be/A-iVWSxhBXw

S-1084 Membership Attendees:

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Dr. Larry Smart, Chair, called the meeting to order by thanking the efforts of Abdel Berrada of Colorado State University to organize the conference that was to be held in person in Ft. Collins, CO, but was converted to online format due to COVID-19 restrictions. The group was welcomed by Dr. Gene Kelly, Deputy Director of the Colorado State Ag Experiment Station.

Comments were then provided by the REE-NIFA representative (Meagan O'Reilly on behalf of Bill Hoffman) and Administrative Advisor for S1084 Lesley Oliver, University of Kentucky, who provided an overview of joining the project in NIMSS and completing a Project Initiation in REEport in accordance with individual land-grant policies.

Given the move of NIFA to Kansas City, the agency is ramping up capacity with the hiring of administrative staff and program leaders. Over 60% of employees did not make the move. NIFA is behind on work but trying to rapidly catch up. There are multiple potential opportunities within NIFA's programs to support industrial hemp work. They include:

Plant Health and Production and Plant Products Program Area
Crop Protection and Pest Management Program
USDA Announces $15.1 Million for Research on Renewable Energy, Biobased Products, and Agroecosystems
Small Business Innovation Research Program (SBIR)
Organic Agriculture Program
Bioeconomy, Bioenergy, & Bioproducts (B3) Programs
AFRI Sustainable Agricultural Systems
Beginning Farmer and Rancher Development Program (BFRDP)
Family & Small Farm Program

There are others that could be a good fit, depending on the focus of the project. Search the website and sign up for "NIFA Updates" to get announcements from NIFA.

Abdel Berrada discussed plans for the National Hemp Research and Education Conference rescheduled for Aug. 3-5 in Ft. Collins, CO.

The research objectives of the S-1084 project are summarized below:

1. **Agronomic practices** -Determine effects on grain, fiber, or dual-purpose productivity as functions of:
   * Cultivars
   * Soil types
   * Establishment practices
   * Fertilization practices
   * Canopy management
   * Water use and demand
   * Insect, pathogens, and other pest management.
   * Weed management
   * Harvest and handling practices
   * Suitability for crop rotations
2. **Crop quality** - Assay plant material from above for corresponding fiber, grain and cannabinoid traits
   * Stem and stem fiber properties
   * Grain quality,
   * Other potential uses (e.g., as a biofuel feedstock, as chemical adsorbents or as fresh/ensiled forage crops for livestock)
   * NIRS equation development for rapid quality assessment
3. **Genetics**- Identify genes for advanced traits of interest including
   * Photoperiodicity
   * Yield components
   * Pest and pathogen resistance
   * Abiotic stress
   * Relatedness of existing hemp varieties and genetic diversity
4. **Economics** - Assess crop value when grown for different uses and in different cropping systems
   * Production budgets refined for specific end uses and production schemes
   * Market scale/potential

Results of 2019 efforts to address <u>Objectives 1 and 2</u> through coordinated multistate field trials and grain quality analysis were summarized by Bob Pearce, Univ. of Kentucky.

There were 11 states that participated in the 2019 trials. Five of the 11 states have reported 2019 data; those who have not contributed their data should contribute to the report. The faculty member from the University of Tennessee has since left the university so if colleagues could get access to any results for their trials, please send to Bob.

Bob has generated valuable data on germination rate, seed size, and emergence from 10 varieties that were included in the multistate project. There is a wide range in the percentage of

plants that emerge which is partly attributed to soil crusting. This is a trend among those reporting in-field emergence with ranges between 28 and 57%. Hemp is very susceptible to soil crusting. Heavy rains after seeding can create a crust that is an issue. Soil health should be a priority for this crop.

Hemp is known to self-thin. Most counts represent stands at harvest and since hemp is known to self-thin it may not be a good representation of what the emergence rate was in that field.

Fiber only yields (lbs/A) ranged quite considerably but again variable stands lead to variable yields. Grain yield showed highly significant cultivar by location interaction. This information will be really useful to farmers wanting to grow grain in different locations across the U.S. Another issue that needs to be dealt with is harvest timing to reduce shattering and bird losses. Quality assessments have yet to be completed but will include protein content, mycotoxins and seed oil testing.

Hard to project what will happen this season especially in light of COVID-19. There have been many challenges such as being able to obtain seeds from Europe for this growing season. If interested in participating send an email to Bob (rpearce@uky.edu).

There was further discussion of protocols especially in regards to standardizing the parameters and procedures for data collection. Although everyone agreed on the measurements the actual measurements were taken in a variety ways depending on the site. Larry Smart suggested establishing protocols through developing short YouTube videos. No further discussion on how to implement.

New in 2020 to work towards objective 1 and 2….Jay Noller, Oregon State will work with project participants to develop and implement an Essential Oil Hemp Variety Trial in at least 10 sites that represent ecoregions in the U.S.

Jay presented the proposed protocol for essential oil hemp (EOH) trials. Looking for 10 locations as a core set of sites to represent the breadth of US. It has already been determined that 3 of the 10 sites would be Oregon, Imperial valley CA, and a site in the Southeastern us (interest previously expressed by Alabama A&M). Other sites will be up for discussion.
Field trial specifications (that may be up for negotiation):

- About 0.25 acres. 4’x40” rows on-center x 100’
- Six varieties x four replication
- Direct seeded at about 2 seed per foot
- Pollen exclusion trial area (5 km isolation)
- Fertilizer management based on pre-plant soil tests and plant tissue samples
- Supplemental irrigation available, applications based on soil-water content. Wants no plastic or drip tape. He has been growing cherry wine direct seeded with I guess overhead irrigation.

Data collection includes at this time emergence counts, plant height, inflorescence count per plant, the inflorescence, leaf and stem dry weight three times pre-harvest, 20’ of row harvested

at maturity (center 20' as edge effects can be strong). Sites only need to dry and shuck to take appropriate subsamples; oil analysis will be done by the lab at Oregon State University. A powerpoint presentation outlined the trial protocols.

The six cultivars are as yet to be named but both autoflower and full season varieties will be included in the trial. There was a question about the definition of essential oils? Jay said essential oils include terpenes, cannabinoids as well as other compounds that get extracted.

There was some discussion about variety selection to minimize their likelihood for non-compliance with the THC limits. Jay indicated he would only provision out those varieties that were likely to be under 0.3% THC.

Results of 2019 efforts to address Objective 3 by collecting and analyzing feral hemp populations were summarized by Larry Smart, Cornell University, who then asked Gan-Yuan Zhong, USDA ARS Geneva, NY to introduce plans for the National Hemp Germplasm Repository located at the Plant Genetic Resource Unit at Cornell AgriTech in Geneva.

Larry Smart, Cornell – Objective 3
Genetics – Work continues to identify genes for traits of interest.
Feral hemp collections continue to be strong but not everyone was able to gain approval to collect hemp. Larry has collections from NY, WI, MO, NE, and ND. Collections have between 30 – 100 g seed and in a few cases just 2 g of seed. All of the seed/collections are being grown to increase seed production. May be able to include collections already made by George in MN and other accessions can also be added as collection continues over time. Larry showed several slides about groupings of hemp based on genotype.

If you are interested in participating, please send Larry and email (lbs33@cornell.edu)
Larry also discussed the hemp germplasm repository that will happen at Cornell AgriTech in Geneva NY. www.eddmaps.org is the website Larry used to develop his hemp map.

Gan-Yuan Zhong – USDA ARS hemp germplasm repository
Funding was just received to start national hemp germplasm repository. The ARS crop team guidelines are completed for hemp, and he is waiting for final approval of the guidelines.
They are in the process of recruiting a curator and the position should be posted soon. He is also going to hire support personnel as well.
Currently they are assessing what type of facilities are needed. Established a formal agreement with Cornell.

What are the key activities that the repository will have? Acquisition, maintenance and distribution. Can only receive germplasm after guidelines are approved, but at that time Gan-Yuan would like germplasm. How will you prevent cross pollination? That is a challenge. Crosses will be done indoors in segregated rooms to isolate populations.

Tyler Mark of University of Kentucky provided an overview of activities to address <u>Objective 4</u> through economic modeling of hemp production and markets.

Tyler estimates that roughly, 25-30 economists now working on hemp topics. Report on economic viability of industrial hemp in the US completed for ERS: a review of state pilot programs https://www.ers.usda.gov/publications/pub-details/?pubid=95929 .

Also compiled budgets from different states- currently dominated by CBD and essential oil production practices, so this group may want to help expand those available for fiber & grain.

Crop insurance & contracting – pilot program for 21 states; based on whole farm revenue protection.

Lots of comments in chat box about other states working on economics and crop insurance.
Potential plans for 2020:

- Work to establish consistent budget formats (input costs needed)
- Costs/benefits of agronomic methods being examined (based on work in Obj1-3)
- Supply chain identification and development
- Market development- just now getting some of these data
- Consider developing an official dual purpose budget
- Consider evaluating the impact of regulatory issues on the industry, (e.g., impact of international trade agreements that have 0.2% THC requirements)

Participant reports:

Ernie Cebert	Alabama A&M University
No report	Alabama State University
Katelyn Kesheimer	Auburn University
Van Butsic	University of California, Berkeley
Emma Aronson	University of California, Riverside
John McKay	Colorado State University
Gerry Berkowitz	Univ Connecticut
Zack Brym	University of Florida
Karla Gage	Southern Illinois University Carbondale
Allen Parrish, Phil Alberti	University of Illinois
Marguerite Bolt	Purdue University
Jason Griffin	Kansas State University
Shawn Lucas	Kentucky State University
Bob Pearce	University of Kentucky
Ted Gautier	Louisiana State Univ
Anand Dhekney	University of Maryland Eastern Shore

Andrew Ristvey	University of Maryland
Kurt Thelan	Michigan State University
George Weiblen	Univ of Minnesota
Randy Little	Mississippi State University
Chengci Chen	Montana State University
David Suchoff	North Carolina State University
Raul Cabrera	Rutgers University
Larry Smart	Cornell University
Craig Schluttenhofer	Central State University
Jay Noller	Oregon State Univ
Alyssa Collins	Penn State University
Jerome Grant	University of Tennessee
Calvin Trostle	Texas A&M University
Bruce Bugbee	Utah State University
Sam Morton	James Madison University
John Fike	Virginia Tech University
Mike Timko	University of Virginia
Heather Darby	University of Vermont
David Gang	Washington State University
Shelby Ellison	University of Wisconsin-Madison
No report	West Virginia University

A discussion of the next time and venue for the annual meeting ensued – Jay Noller offered to host at Oregon State University around Feb. 2021, Andrew Ristvey offered to host at University of Maryland-College Park in November 2020, and a proposal was made to hold the meeting as a satellite to the Tri-Societies Meeting (American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America) to be held in Phoenix, AZ on Nov. 8-11, 2020. The decision was tabled for discussion at a later time among the potential hosts.

Next, Larry Smart restated the agreed upon procedure for the installation of officers. Briefly, the elected officers (Chair, Vice-Chair, and Secretary) will serve two-year terms, with the Vice-Chair automatically moving up to the position of Chair after two years. According to these rules, Vice-Chair Dr. John Fike agreed to assume the role of Chair on October 1, 2020.
Larry Smart called for officer nominations, which were made and accepted by the members as follows: Chair: John Fike, Virginia Tech
Vice-chair: Heather Darby, Univ of Vermont
Secretary: Tyler Mark, Univ. of Kentucky

Summaries of State Reports:

Alabama A&M – Ernie Cebert
Primarily conducting field trials for fiber and grain varieties appropriate for Northern Alabama, comparisons of planting methods and cultural practices to reduce weeds, some retting work
Send a list of all cultivars that might be included in trials so that there is no duplication? Both Jay and Bob are working with seed companies but we don't yet know the complete list.
Ernie has a question about what is OK to include in the S1084 report. Yes, please include and strengthen analyses from field and product. Food sci folks are doing approximate analysis.
Plans to participate in 2020 variety trials

Alabama State – no separate report, collaborating with other AL universities

Auburn – Katelyn Kesheimer
4 participants, Kassie Conner (plant path); Joe Kemble; and two others
4 key goals (connect with growers; create a budget; work with ADAI to create list of 'acceptable' pesticides; identify pest management needs)
96% of people growing for CBD in AL
2020 – CBD variety trial; phytotoxicity trials; insecticide, fungicide and herbicide trials in field and greenhouse.
This will be their first year of research

UC Berkeley – Van Butsic
Joined 3 months ago
Have a cannabis research center – started with high THC cannabis (which UC is not permitted to grow) – policy, communities and environment, not plants.
Are working now more with hemp and where it intersects with non-hemp cannabis production (land use issues and socio-economic impact)
Nice website
Have extension folks and Eric Bieber from law school

UC Riverside – Emma Aronson
Key participants and Goals – Emma, Houston Wilson, and Emma Gachomo
Focus on hemp-associated organisms (insects and microbiome)
No results yet – sampled for insects. Aronson and Gachomo have sampled for rhizosphere and bulk soils. Collected unplanted soil as control. They have extracted DNA for sequencing. Found low purity and low microbial load.
Plans for 2020-21: Amplification has begun. All efforts halted due to COVID-19
Will look for bacteria, archea and well as fungi and mycorrhizae.
Will also look at root endophytes

Colorado State – John McKay
Hemp Genome Collaboration – funding from governor assembling 2 hemp genomes (Carmagnola and USO31)

Getting genomes together.
About 30,000 genes. Nice slide of MAKER annotation with RNS-Seq data
Genetic mapping population – mapping QTL for cross between USO31 (pollen donor) x Carmagnola (female)

UConn – Gerry Berkowitz
Has quite a few folks working on hemp.
Feminized seed; polyploid breeding; molecular genetics; tissue culture and much more!

UFL – Zach Brym
10 or 11 folks mostly agronomy working in hemp at UFL.
Website is up to date: https://programs.ifas.ufl.edu/hemp/
Working on planting date, spacing, fertilizer
Had 45 varieties entered into his trial. No winners because of short days in summer. Nothing did well at less than 40 degrees latitude.
2020 – building resources page. Looking at commercialization in the state and working with farmers.

Southern Illinois – Karla Gage
Cannabis Science Center at SIU Carbondale. Lots of collaborations.
Her lab is the only lab cultivating plants.
Seed/Fiber/CBD; Best management practices; weed competition; allelopathy, rotational challenges, pollen flow.
2019 – they were part of the dual purpose variety trial and did field retting.
2020 – continue dual purpose variety trial and want to improve field retting. New field site and herbicide effects/interactions.
What is best way to share data? Is there a way to upload?
Side note: this prompted a discussion of platforms the group might use to share data and information. Dropbox, Basecamp and Open Science Framework were all mentioned. Larry agreed to look into Basecamp.

University of Illinois – Allen Parrish
Lots of folks involved- Allen and Phillip Alberti are the primary folks.
Develop BMP for hemp; applications and processing for products and identify limitations of crop development.
Plans for 2020 – focus more on CBD production.
Hemp variety trial is pay to enter.
Also someone from the U Illinois extension team (I did not catch his name).

Indiana – Purdue – Marguerite Bolt
Hemp extension specialist. Have a fairly large team working on hemp
2019 research – fungicide treated seed project; nitrogen and seeding rates; 2019 on farm research reports and surveys being consolidated.
All growers have to have a detailed research project to grow, and those are all in connection

with a university in IN
2020 working on a Rodale project. Three year rotation plan. 8 treatments. Planting after vetch or oat cover crop then rotating into wheat, rye, soy, corn

Kansas State - Jason Griffin
Large team of folks in production/extension; economics; lab analysis; engineering; animal nutrition (got a NIFA seed grant); human nutrition; pharmacokinetics in animals
Showed data from 2019 trials. Helena was by far and away the best cultivar. Reports are available online- https://newprairiepress.org/kaesrr/vol6/iss1/2/
2020 – variety trials, water usage, high tunnel production, economics, lab analysis to expand test offering

Kentucky State – Shawn Lucas
Organic hemp production and research. 28 extension presentations on hemp in KY and elsewhere.
Organic cannabinoid variety trial and biofertilization
Organic hemp crop rotations – three year rotation. Hemp before wheat may improve wheat yields.
Third wave Farms is funding.
Four varieties American feral, Baox, Cherry Kandy (third wave farm) and Cherry wine.Evaluating yields, terpene, and cannabinoid profiles.
Looking at impacts of inputs and environmental conditions on cannabinoid levels (looking at Soil set and grain set).
Marcus Bernard, ag economist looking at labor inputs

University of KY – Bob Pearce
Reminds us about the role David Williams has played in hemp. Aerosmith is awesome!!
Key Personnel – about 10 key folks.
Garrett Owen will be starting in KY in May and has done analysis related to greenhouse production
2019 results – coordinated dual purpose trial; identified diseases, insects and published biofuel manuscript, economic viability
2020- continue dual purpose trials; essential oil trial; fiend trials with fungicide and biocontrol agents; IR-4 trial for azoxy; control mites and aphids and earworms; economics; crop insurance; fibers for bioplastics; effects of drying on cannabinoid and terpene levels; management of indoor growing environments.

Louisiana State Univ – Ted Gauthier
Limited info, but they did have hemp legislation pass in 2019. Have 60 licensees in LA
Will participate in S1084 trials in 2020. Have seed of 10 or so varieties and are doing preliminary work in greenhouses.
Have a hemp working group at LSU with folks working on many aspects of hemp- www.lsuagcenter.com/industrialhemp
Hope to have a field day in 2020, one near Baton Rouge, and another in the Northern part of

state.

University of Maryland Eastern Shore – Anand Dhekney
Started pilot program in 2019. Had 11 growers that signed up for pilot program.
Screening CBD hemp for eastern shore.
Collected hemp germplasm from growers, and are maintaining germplasm. They will screen the germplasm this year.
Lots of disease issues – apparently had viral pathogens?
Micropropagation for producing disease free plants
Have a plant pathologist – characterize fungal and bacterial pathogens, collaborating with the NV dept of ag
Identifying viral diseases and detection kits
Entomologist Simon Zebelo – identifying insects. Aphids, thrips, and others.

University of Maryland – Andrew Ristvey
Key members Nicole Fiorellino and Andrew
2019 – focused on agronomic practices Obj. 1. Focused on Nitrogen rates (50-250 lbsN/A). change point between 100 and 150 lb/A. Will confirm with year 2 of data.
Provide general production guidelines to MD growers.
2020 – year 2 of N fertilization trial; Soil phosphorus phytoremediation. Looking a X59 cultivar; plan to participate in dual purpose variety trial.

Michigan State University – Kurt Thelen
Team of folks at MSU (agronomist, entom, plant path, and extension)
Participated in dual purpose trial. Not a great deal of separation between varieties. All pass the 0.3 threshold.
2020 – will continue with dual purpose. Focus on quality analysis – total oil and fatty acid profile.

Mississippi State Univ – Randy Little
Some progress towards legalizing hemp production in State legislature; provided some information to them last fall.
Done some early drafts at some cost of production budgets. From tried to get some idea what it would take for hemp production to be competitive with commodity crops in Mississippi (cotton, corn, soybeans).

Montana State Univ –Chengci Chen
Limited research on hemp. Three participants.
Focusing on objectives 1 and 2 (agronomic and crop quality)
2019 – seeding rate study at three locations with two varieties (CRS1 and Katani). Planted May 8 and May 29 under sprinkler irrigation.
Bob presented data earlier, and the two varieties from Canada work very well in Montana. CRS1 = 73 inches tall; katani = 52 inches tall.
CBD very low (0.8 – 1%)

2020 – continue second year of study with seeding date and variety. And he would like to participate in the S1084 dual purpose trial.

NC State – David Suchoff
Key participants – Jeannine Davis, Hannah Burrack, Grant Ellington, David, Lindsey Thiessen, Brian Whipker
2019 – fertilization, grain/fiber variety trials; insect and disease control; harvest dates; floral variety trials; open bed vs closed bed; nitrogen/potassium recs.
No differences in black vs white mulch, but increasing per plant yield with larger spacing.
Night interruption lighting effective in keeping plants vegetative
2020 – lots of experiments really too many to type in. Basically, similar to what was done in 2019

New Jersey – **Rutgers** – Raul Cabrera
Core team - Jim Simon and Raul are two point people. 2020 will be the first year they have trials
Plans for 2020 – field evaluation trials in northern NY; Horticulture in southern NY; Analytics & postharvest on main campus
Can organic certified seed be obtained?
Fitting greenhouse with black out curtains and light.

Minnesota – George Weiblen U of Minnesota
New to multi-state. Has been working genetics of cannabinoid production since 2002 under DEA registration
Also some grain and fiber variety trials
Prior hemp results – There is a fiber trial report economic feasibility; cannabis genome and cannabinoid inheritance with sunrise genetics (Grassa et al in review) this is a segregating mapping population for cannabinoid production and this is leveraging a genome assembly. Preprint available on biorx
Minnesota Dept of Ag focused on feral cannabis genetics – manuscript in review.
2020 – phase 2 of hemp economic feasibility study and feral hemp on their tribal trust land
Funding from state (AGRA) genetic tests for regulatory compliance
Environment& natural resources trust fund to investigate claims about hemp as a nitrogen scavenger being let by Central Lakes College.

New York – Cornell – Larry Smart
Core team – lots of folks
S1084 dual purpose trial in 2019 – good yield of grain in NY. Ukrainian varieties did not do as well in NY. 2020 – will participate in dual purpose trial and hopefully the essential oil trial. Will also characterize autoflower cultivars and high CBG cultivars.

Ohio – Central State University – Craig Schluttenhofer
Have 6 folks on the hemp team. Craig started at CSU in 2019.
Identifying grain, fiber and metabolite varieties suited for Ohio
Initiate selections for developing improved hemp cultivars.

2019 – planted on Aug 5. 4 varietied; Hanma, Felina 32, Futura 75, USO-31
2020 – Fiber, grain and metabolite trials; 3 fiber varieties, 4 grain varieties, and 3 metabolite varieties.

Oregon State University – Jay Noller
2019 report – 6 extension bulletins and papers
Hemp equity program- have a coordinator to engage underrepresented populations
Field trials
Oregon 9 sites EOH, 1 site multi-use hemp
California site EOH
International; China (3sites) fiber, 2 sites EOH, 1 grain site); Europe (7 sites fiber, grain, EOH, dual and multipurpose)
Post-harvest to market – developed 7 co-labs in hemp products companies globally
Global hemp Innovation center – over 60 faculty in 25 disciplines
2020 – about 15 consortia with about 20 faculty per consortium

Penn State University – Alyssa Collins
Participants – Alyssa (agronomy and pathology) and John Kaminski (horticulture) – lots of faculty and extension educators involved at PSU
2019 Grain/fiber varieties trail with S1082 – but had very bad emergence.
Has a nice chart of 2019 data – Canadian varieties did not do as well as European and in particular Ukrainian varieties.
2020 – applied for many hemp funding opportunities – assessing risk management assessment and will participate in fiber/grain and EOH variety trials.
Animal science folks working to get hemp seen as GRAS for animals.
Also looking at residual herbicide programs on hemp establishment.

Tennessee – UTenn – Jerome Grant
Jerome is an entomologist – replacing Eric Walker. Others are Zach Hansen and Avat Shekoofa
Heavy in pest management
Key goals – agronomic practices an crop quality
2019 – fertilization did not affect corn earworm; there was a correlation between variety maturity and corn earworm damage
5 varieties that were highly resistant to corn earworm and leaf spot severity (T-rex; late Sue; Super CBD; CBD Therapy; and one other)
2020 – repeat experiments; expand research to define impact of earworm/disease on yield and quality; Expand water studies; multistate dual purpose hemp trial and conduct feral study and much more.

Texas A&M – Calvin Trostle
Calvin is in Lubbock – has had 18 educational seminars across the state. There is decreasing interest in producing hemp because of the decline in CBD prices.
There is a list of 200 varieties that can be grown in Texas in 2020
This is the first year for production if I understand directly.

Interested in seeing how the photoperiod in southern Texas affects hemp.
Straight run seed – no effort to remove males from the field.
Detailed protocol for variety testing. These are required to pay a fee for variety. I'd love to know the charge.
Is there a document called 'How a hemp plant grows?
He would like to help develop such a document.

Utah State – Bruce Bugbee
Medical hemp research at Utah State – funded by NASA to do crop production in controlled environments. Utah has a network of large greenhouse growers.
Use controlled environmental chambers to look at plant x environment interactions

1. Hemp tolerates drought during vegetative growth but not reproductive growth. Huge difference in water stress based on vegetative vs reproductive. Does water stress modify cannabinoid synthesis?
2. Elevated phosphorous is not beneficial.
3. Currently studying the effect of water stress on cannabinoid synthesis. So far there is no big effect. In some of his studies stress has elevated cannabinoid synthesis.
4. Degradation or dilution? Declines in CBD ad THC concentration toward the end of flowering period. Once possible explanation is growth dilution. Alternatively, degradation could be happening faster than synthesis.

Virginia
James Madison University – Sam Morton
He is a chemical engineer; Michael Renfroe (cultivation), three other colleagues – analytical testing, market analysis and economics.
Started in 2015 – exclusively on-farm research because they don't have any university research farms.
Goals – farmer/grower experience, cultivation technique development; understanding cultivation practices and challenges. All work is on grain and fiber varieties. Great photo of harvesting!
2020 – complete 2019 analyses. Sequential planting timing study (April – August); Collaboration with Virginia Tech activities.
Continuing programmatic activities on life-cycle system analysis; hemp utilization; environmental applications; outreach and education.

Virginia Tech University – John Fike
Large number of folks working on hemp.
Complete 2019 analyses
2020 goals – Establishment and management – seed protectant; till/no-till; cover/mulch crops; biostimulants
Varietal evaluations – flowers (archetypal research) also grain/DP and fiber
Pesticide (weed/insect) trials
Lots of outreach
Nice data on germination and emergence of different cultivars and seed lot.

Just released pest management guide: https://www.pubs.ext.vt.edu/ENTO/ENTO-349/ENTO-349.html

Univ Virginia – Mike Timko
Breeding and selection for field and greenhouse varieties – genotype stability
Use of mutagenesis to put value into hemp by changing composition of seed, fiberor cannabinoids.
Integrating feral material into breeding program.

Univ Vermont – Heather Darby
Second year for hemp winter conference. About 350 in person attendees plus online option. Four concurrent sessions. Heather plans to hold conference in future.
Nice website. Research mostly on grain and fiber hemp. All info is posted on website. Outreach materials are also posted on website (www.uvm.edu/extension/nwcrops/hemp).
Essential oil variety trials are very hard to do and takes lots of time. Heather has lots of data from her variety trials.
2020 – hope to work on essential oil trials as well as grain and fiber trials.
Where is Vermont headed? NE IPM grant to work on pest management and weed management as well as SARE funding. Also a NE risk management grant
With Colarado State and UK, Heather will look at economics.
Larger USDA SAS CAP grant application was submitted with project partners.

Washington state University – David Gang
Hemp Research at WSU
New to hemp. This hemp research is now encouraged.
Lots of interest in research and growers. Lots of folks involved.

University of Wisconsin – Madison – Shelby Ellison
Lots of researchers and extension educators.
2018 was the first year for research at UW. Headed by Rodrigo Werle.
2019 – Dual purpose variety agronomic study. Seeding rates, nitrogen rates, 1084 variety trial.
Pre and post emergence application of herbicide.
Essential oil variety trial.
Organic production system
Hemp harvest recommendations
Feral hemp collection
Hemp national needs survey
Wisconsin hemp marketing survey
Gene editing
2020 – year 2 of variety trials
Continue to collect feral hemp
Characterization of feral collections and fiber varieties – building a decorticator
Creating mapping population utilizing feral hemp populations. Genetic characterization of traits including flowering time, plant architecture, fiber traits

IR-4 trials.

West Virginia University – no folks on call

S-1084 project outcomes – the potential for hemp broomrape – parasitic invasive plant.
Contact Mike Timko at UVA if you find it in your fields
Variety vs cultivar – should we clean up our nomenclature? Bob also prefers to use cultivar, but many of the 'varieties' are not stable.

University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

Multi-State Dual Purpose Variety Trial

S-1084 Multi-State Project Meeting
March 19, 2020

2019 Participants

State	University	Contact(s)	2019 data reported
Illinois	Southern Illinois University	Karla Gage Eric Miller	Yes
Kansas	Kansas State	Jason Griffin	Yes
Kentucky	University of Kentucky	Bob Pearce	Yes
Michigan	Michigan State	Kurt Thelen	No
New York	Cornell	Larry Smart Jamie Crawford	Yes
North Dakota	North Dakota State University	Burton Johnson	Yes
Pennsylvania	Penn State	Alyssa Collins	No
Tennessee	University of Tennessee	Eric Walker	No
Virginia	Virginia Tech	John Fike	No
Virginia	James Madison	Sam Morton	No
Wisconsin	University of Wisconsin	Rodgrio Werle	No

2019 Entries

	Lab Germination	Seed Size	KY Field Emergence
Variety	%	Seeds/pound	% live seed
CFX 1	96	24310	54
CRS 1	95	22843	51
Fedora 17	96	25996	57
Felina 32	93	25546	51
Futura 75	69	23473	28
Hlesia	84	22723	44
Hliana	90	22537	46
Hlukhovskii 51	85	24633	39
Katani	89	26716	50
USO 31	92	27282	40

Plant Population (Plants/ac)

	Illinois	Kansas	Kentucky	New York	North Dakota
Variety					
CFX 1	55,176	73,855	394,679	623,176	
CRS 1	26,479	63,738	347,368	473,614	
Fedora 17	95,044	132,029	445,726	554,627	
Felina 32	74,534	119,382	393,434	599,807	
Futura 75	12,828		195,472	288,219	
Hlesia	35,557	51,260	298,811	400,391	
Hliana	41,019		311,261	388,446	
Hlukhovskii 51	64,780	72,843	287,605	478,288	
Katani	33,007		397,169	543,721	
USO 31	62,923	100,160	326,202	484,519	

Soil conditions impact stand establishment from seed

- Hemp is susceptible to soil crusting losses
  - Emergence like soybean
  - Heavy rains after seeding can create a crust

“Self-Thinning” of fiber hemp

Parameter	Kompolti Hybrid TC			
	Initial density (plants m^{-2})			
	10	30	90	270[a]
Density (m^{-2})				
H 1	10.0	30.2	90.6	254.9
H 2	9.8	29.6	83.1	176.0
H 3	9.6	28.7	70.7	111.2
H 4	9.1	29.0	68.9	111.2
Dry matter (t ha^{-1})				
H 1	0.36	0.80	1.37	1.86
H 2	12.0	13.3	13.8	13.5
H 3	13.8	17.4	17.5	15.1
H 4	12.3	16.6	16.0	15.3

[a]230 in 1992. [b]65 in 1992. [c]NS: $P > 0.05$.

Plant density and self-thinning affect yield and quality of fibre hemp (*Cannabis sativa* L.)

H.M.G.van der Werf[abc] M.Wijlhuizen[a] J.A.A.de Schutter[b]

https://doi.org/10.1016/0378-4290(94)00103-J

Straw Length (cm)

	Illinois	Kansas	Kentucky	New York	North Dakota
Variety					
CFX 1	41.1	28.6	71.7	138.4	
CRS 1	49.8	40.2	83.0	145.3	
Fedora 17	73.7	52.2	93.5	140.4	
Felina 32	76.5	65.3	101.5	150.6	
Futura 75	94.7		106.9	142.3	
Hlesia	76.2	52.5	80.0	118.4	
Hliana	72.4		79.4	143.5	
Hlukhovskii 51	69.6	51.4	80.1	128.6	
Katani	36.8		65.5	102.5	
USO 31	71.1	42.5	80.2	129.6	

Straw Yield (lbs./A)

	Illinois	Kansas	Kentucky	New York	North Dakota
Variety					
CFX 1	542	347		1,519	
CRS 1	588	620		1,823	
Fedora 17	1,847	1135		4,584	
Felina 32	1,489	1862		4,786	
Futura 75	999			3,090	
Hlesia	1,470	819		2,355	
Hliana	1,310			3,242	
Hlukhovskii 51	2,233	975		3,191	
Katani	567			810	
USO 31	1,826	1088		3,520	

Grain Yield (lbs./A)

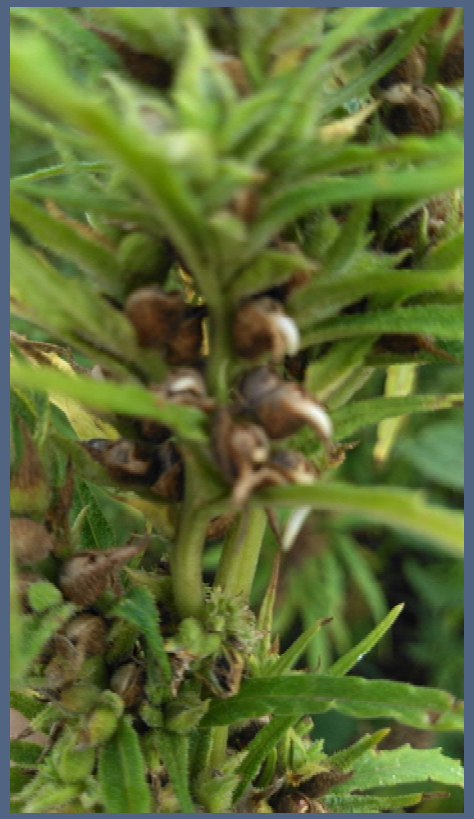
	Illinois	Kansas	Kentucky	New York	North Dakota
Variety					
CFX 1	322	830	1298	1386	1539
CRS 1	222	1212	1307	1222	1675
Fedora 17	534	1191	858	1332	1516
Felina 32	394	1458	394	1318	1328
Futura 75	227		494	1232	997
Hlesia	208	798	370	366	1314
Hliana	239		384	408	1267
Hlukhovskii 51	279	805	396	394	961
Katani	256		1120	1074	1319
USO 31	456	1202	569	722	1183

Quality Assessments

- Protein
  - Jamie Crawford
  - Need 75 to 100 g (can run with as little as 50g)
- Mycotoxins
  - Gary Bergstrom
  - Need 30g (can come from sample after protein analysis)
- Seed Oil Testing
  - Kurt Thelen
  - Need 10 g seed

Challenges

- Stand Establishment
- Seed Procurement
- Weather
- Consistent Protocols
  - When to take stand counts
  - Harvest timing
    - Grain Shatter
    - Bird Damage
    - Premature Germination
- Appropriate Statistical Analyses
  - Cultivar x Location Interactions
  - Missing data



2020 Plans

- Number of cultivars to include
- Seed procurement???
- If interested in participating send and email to rpearce@uky.edu

National Essential Oil Hemp Genetics Trials

Jeffrey Steiner, Ph.D.
Associate Director
Global Hemp Innovation Center
541-602-7404

Uniform Hemp Trials: EOH Variety Testing

Partnering network institution requirements (general):

- University partners indicate interest in participating in hemp essential oils national trials
- Ability to host a standard set of six EOH varieties and agreeing to uniform production and time-course data collection methods
- Pollen exclusion from trial area (5 km isolation)
- Ensure IP of varieties used in the trials is protected
- Participate if selected as one of 10-16 locations representing a range of latitudes and unique ecogeographies

Uniform Hemp Trials: EOH Variety Testing

Study services contributed by Oregon State University:

- Seeds for six hemp varieties with QA/QC indicators tested
- Shipping costs of all sampled plant materials
- Provide instrumentation for ETc and soil moisture determinations (details in progress)
- Full-spectrum hemp essential compound analyses
- Organization and analysis of data, manuscript preparation, and publication costs
- Legal protection costs

Uniform Hemp Trials: EOH Variety Testing

Field trial specifications (being discussed):

- Research plot configurations (approx. 0.4 acres total):
  - Each experimental unit: 4 x 30-40” rows on-center x 50’
  - Six varieties x four replications
  - Direct seeded at approximately 2 seeds per foot (1,600 seed per entry per location)
  - Thinned to one or two foot spacings between plants

Uniform Hemp Trials: EOH Variety Testing

Field trial specifications (being discussed):

- Fertilizer management based on pre-plant soil tests and plant tissue samples during growing season
- Supplemental irrigation available, applications based on soil-water content monitoring
- Weed management by mechanical cultivation and hand weeding

Uniform Hemp Trials: EOH Variety Testing

Field trial specifications:

- Data collection:
  - Plant seedling emergence counts, weekly to establishment
  - Plant height, weekly or bi-weekly
  - Inflorescence count per plant, 20’ of row, weekly or bi-weekly
  - Six-10 plants sampled for inflorescence, leaf, and stem dry weight 2-3 times pre-harvest, and at harvest
  - 20’ of row harvested at maturity

Uniform Hemp Trials: EOH Variety Testing

Field trial specifications:

- Data collection:
  - Plant seedling emergence counts, weekly to establishment
  - Plant height for 20 plants, weekly or bi-weekly
  - Inflorescence count per plant, 20 plants, weekly or bi-weekly
  - Six-10 plants sampled for inflorescence, leaf, and stem dry weight 2-3 times pre-harvest, and at harvest
  - 20’ of row harvested at maturity

Uniform Hemp Trials: EOH Variety Testing

Field trial specifications:

- Data collection:
  - Standard site physical data including seasonal and historic weather – recognized weather station
  - Soils data including class, nutrient profile, organic matter content, …
  - Monitor soil moisture content
  - Specified other(s)

Uniform Hemp Trials: EOH Variety Testing

Field trial specifications:

- Data analyses:
  - Determine G x E performance effects (bounds of ecogeography for future variety testing)
  - Full spectrum analyses for hemp essential compounds
  - Determine of optimal production deployment for EOH genetics
  - National S-1084 complementary hemp grain and fiber genetics evaluation trials

Uniform Hemp Trials: EOH Variety Testing

Input to be provided from genetics companies:

- Hemp type: auto flower or full-season
- Variety growth description
- Feminized seed assurance
- Compliant genetics Certificates of Analysis
- Seed germination test results
- Donation of 30,000 seeds per variety

Uniform Hemp Trials: EOH Variety Testing

Volunteer institutions for EOH trials ranging in latitude, ecoregion, and farm resource region representation (under consideration):

University of Illinois
Rutgers University
Montana State University
West Virginia University
University of Wisconsin
Alabama A&M University
Virginia State University
Louisiana State University
Virginia Tech University
University of Kentucky
University of Vermont
University of Tennessee
Cornell University
Kansas State University
University of California
Colorado State University
Oregon State University

S-1084 Location Network

Uniform Hemp Trials: EOH Variety Testing

Regional filters for placing national trial locations:

Bailey U.S. Ecoregions

USDA-ERS Farm Resource Regions

Uniform Hemp Trials: EOH Variety Testing

Domain	Division	Province	Section	Latitude	Longitude	Consideration	Organization
Dry	Temperate Steppe	Great Plains-Palouse Dry Steppe	Northern Glaciated Plains	47.73	-104.15		Montana State University
Dry	Temperate Steppe	Great Plains-Steppe	Arkansas Tablelands	38.05	-103.72		Colorado State Univeristy
Dry	Tropical/Subtropical Desert	American Semi-Desert and Desert	Sonoran Colorado Desert	32.96	-115.56		Imperial Valley Conservation Center
Humid Temperate	Hot Continental	Eastern Broadleaf Forest (Continental)	Interior Low Plateau, Highland Rim	34.90	-86.56		Alabama A&M University
Humid Temperate	Hot Continental	Eastern Broadleaf Forest (Continental)	Interior Low Plateau, Bluegrass	38.12	-84.51		University of Kentucky
Humid Temperate	Hot Continental	Eastern Broadleaf Forest (Continental)	Erie and Ontario Lake Plain	42.88	-77.01		Cornell University
Humid Temperate	Hot Continental	Eastern Broadleaf Forest (Continental)	Southwestern Great Lakes Morainal	43.06	-89.53		University of Wisconsin
Humid Temperate	Hot Continental	Eastern Broadleaf Forest (Oceanic)	Central Ridge and Valley	35.96	-83.86		University of Tennessee
Humid Temperate	Hot Continental	Central Appalachian Broadleaf Forest-Coniferous Forest	Northern Ridge & Valley	37.23	-80.41		Virginia Tech University
Humid Temperate	Hot Continental	Eastern Broadleaf Forest (Oceanic)	Southern Unglaciated Allegheny Plateau	39.65	-79.97		West Virginia University
Humid Temperate	Hot Continental	Eastern Broadleaf Forest (Oceanic)	Northern Appalacian Piedmont	40.48	-74.44		Rutgers University
Humid Temperate	Mediterranean Division	California Dry Steppe Province	Great Valley Section	36.34	-120.11		University of California
Humid Temperate	Mediterranean Division	California Dry Steppe Province	Great Valley Section	38.54	-121.76		University of California
Humid Temperate	Mediterranean Regime Mountains	Sierran Steppe-Mixed Forest-Coniferous Forest-Alpine Meadow	Klamath Mountains	42.33	-122.94		Oregon State University
Humid Temperate	Prairie	Prairie Parkland (Temperate)	Central Dissected Till Plains	38.92	-94.80		Kansas State University
Humid Temperate	Subtropical	Lower Mississippi Riverine Forest	Mississippi Alluvial Basin	30.41	-91.17		Louisiana State University
Humid Temperate	Subtropical	Outer Coastal Plain Mixed Forest	Middle Atlantic Coastal Plain	37.23	-77.44		Virgina State University
Humid Temperate	Warm Continental	Laurentian Mixed Forest	St. Lawrence Valley	44.43	-73.20		University of Vermont

Uniform Hemp Trials: EOH Variety Testing

Example uniform management for determining G x E effects with direct-seeding and mechanical cultivation

Precision Planted

Cultivated

Established

Jeffrey Steiner, Ph.D.
Associate Director
Global Hemp Innovation Center
Oregon State University
541-602-7404

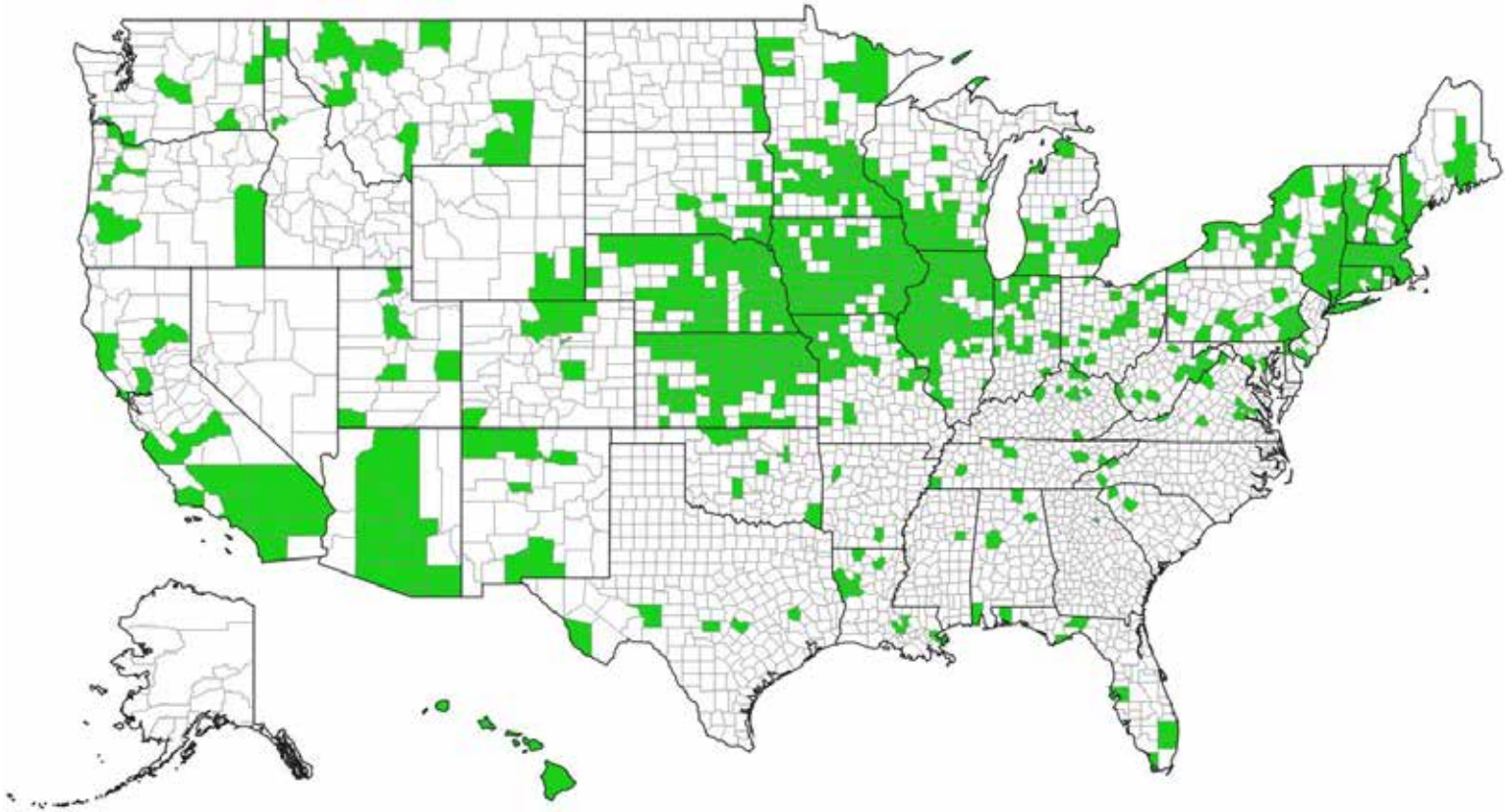
Objective 3: Genetics

Genetics- Identify genes for advanced traits of interest, including:

* Photoperiodicity
* Yield components
* Pest and pathogen resistance
* Abiotic stress
* Relatedness of existing hemp varieties and genetic diversity

https://www.nimss.org/projects/view/mrp/outline/17716

Assembling hemp germplasm



plants.usda.gov, www.eddmaps.org

Assembling hemp germplasm

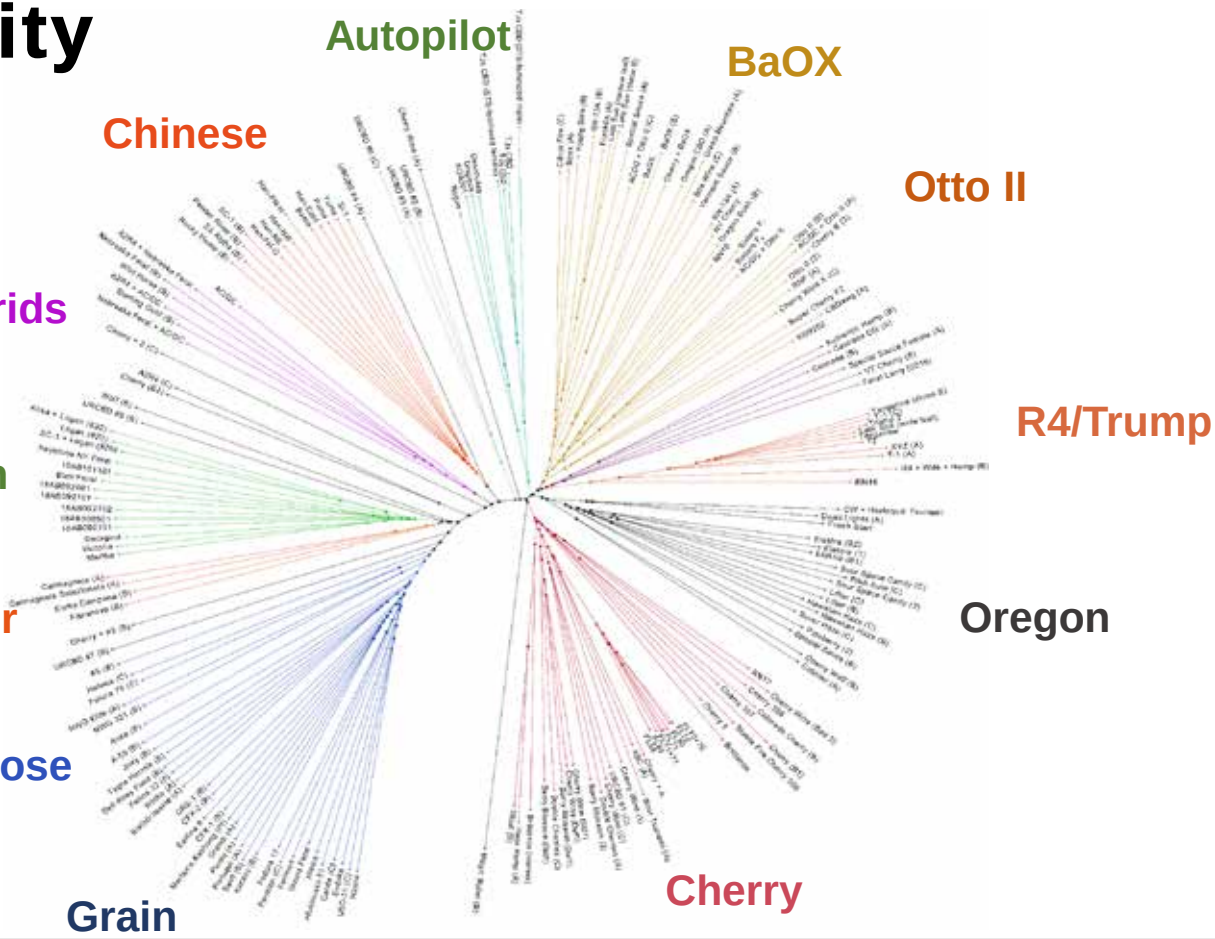
CornellCALS College of Agriculture and Life Sciences

Collections by Shelby Ellison, John Fike, Seth Carlson, Jacob Bish, Kitty O'Neil

Hemp diversity

NJ-Tree

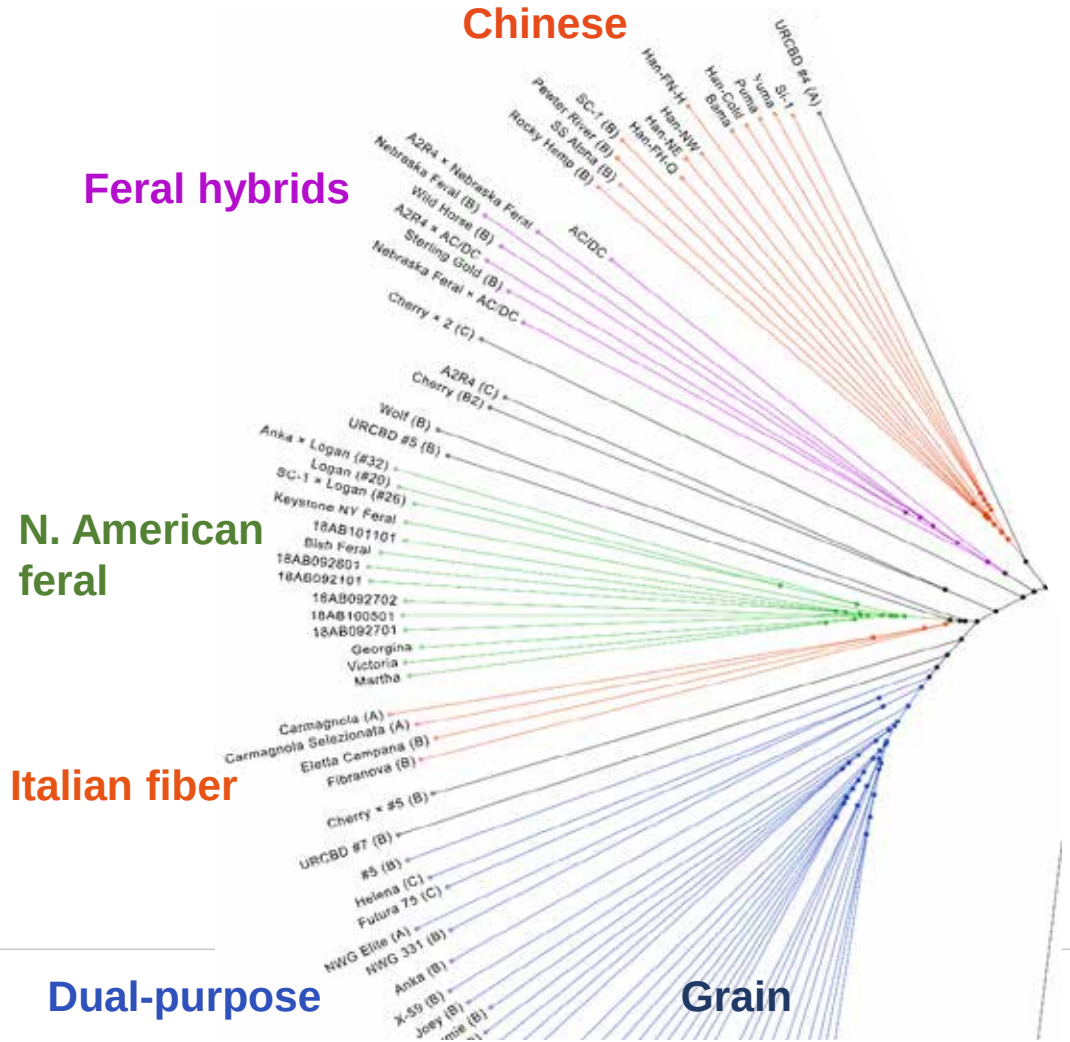
192 samples



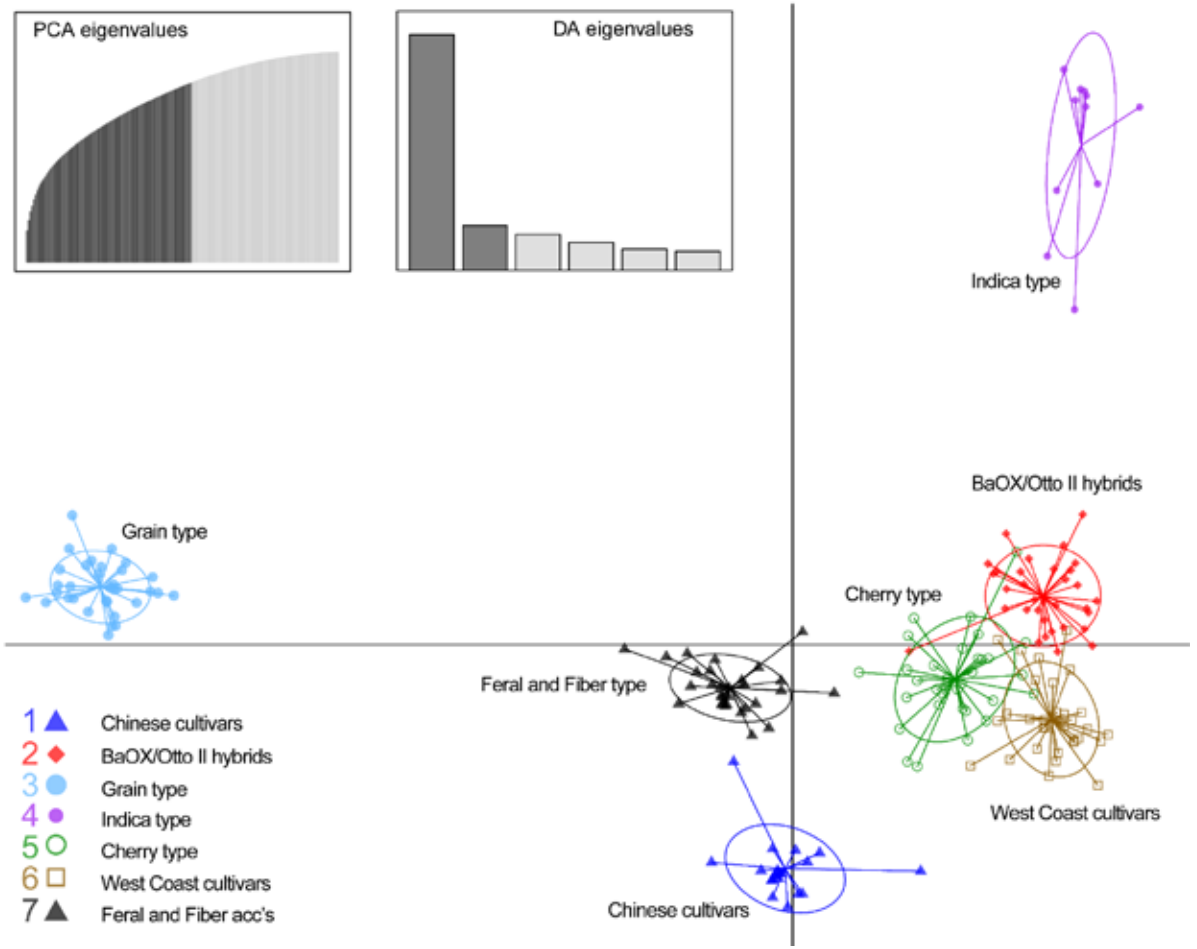
Hemp diversity

NJ-Tree

192 samples



Discriminate Analysis of Principal Components



Assembling hemp germplasm