2023

IMPACT REPORT

HEMP RESEARCH CONSORTIUM

A FFAR® Consortium

Hemp Research Consortium Vision Statement

The Hemp Research Consortium creates discoveries that advance a sustainable and profitable hemp industry through a commitment to translational research and application among university and industry partners. The Consortium does this through maximizing the synergy of participants' strengths and diversity of approaches.

The research foci include:

- Hemp breeding and genetics
- Hemp production systems, including pest and disease management
- Controlled environment production systems
- Novel product development and engineering
- Training of a diverse workforce

Letter from David Suchoff, Director

Dear Hemp Research Consortium Members:

Thank you for your continued support and engagement in our Consortium. Year two of the Hemp Research Consortium was a year of both changes and constants. Dr. Jeff Rosichan, director of the Crops of the Future Collaborative at the Foundation for Food & Agriculture Research (FFAR) and driver for the development of the Hemp Research Consortium, stepped down from his position in June. We are forever grateful to Jeff for his hard work and dedication. In his absence we worked closely with Catherine Maxwell, director of Strategic Partnerships, as we continued to meet new potential industry and academic members. We are pleased to welcome Dr. Kathy Munkvold, who joined FFAR as scientific program director of the crop-specific portfolio in December.

Seven research projects continued from the year one phase into year two. Additionally, two new projects were submitted for review near the end of 2023 and will likely start during the 2024 field season. Our initial research projects were heavily focused on cannabinoid hemp, though as markets shift from cannabinoids to more industrial applications (e.g. fiber and grain) so, too, are our research efforts.

I am excited to see that much of the initial research conducted in year one is now bearing fruit and making a tangible, positive impact on the hemp industry. Year three of the Consortium will no doubt continue in this trajectory. Thank you for your continued hard work and collaboration.

Sincerely,

David H. Suchoff, Ph.D.
Director, Hemp Research Consortium
North Carolina State University

Table of Contents

Executive Committee Members

Dr. David Suchoff
North Carolina State University

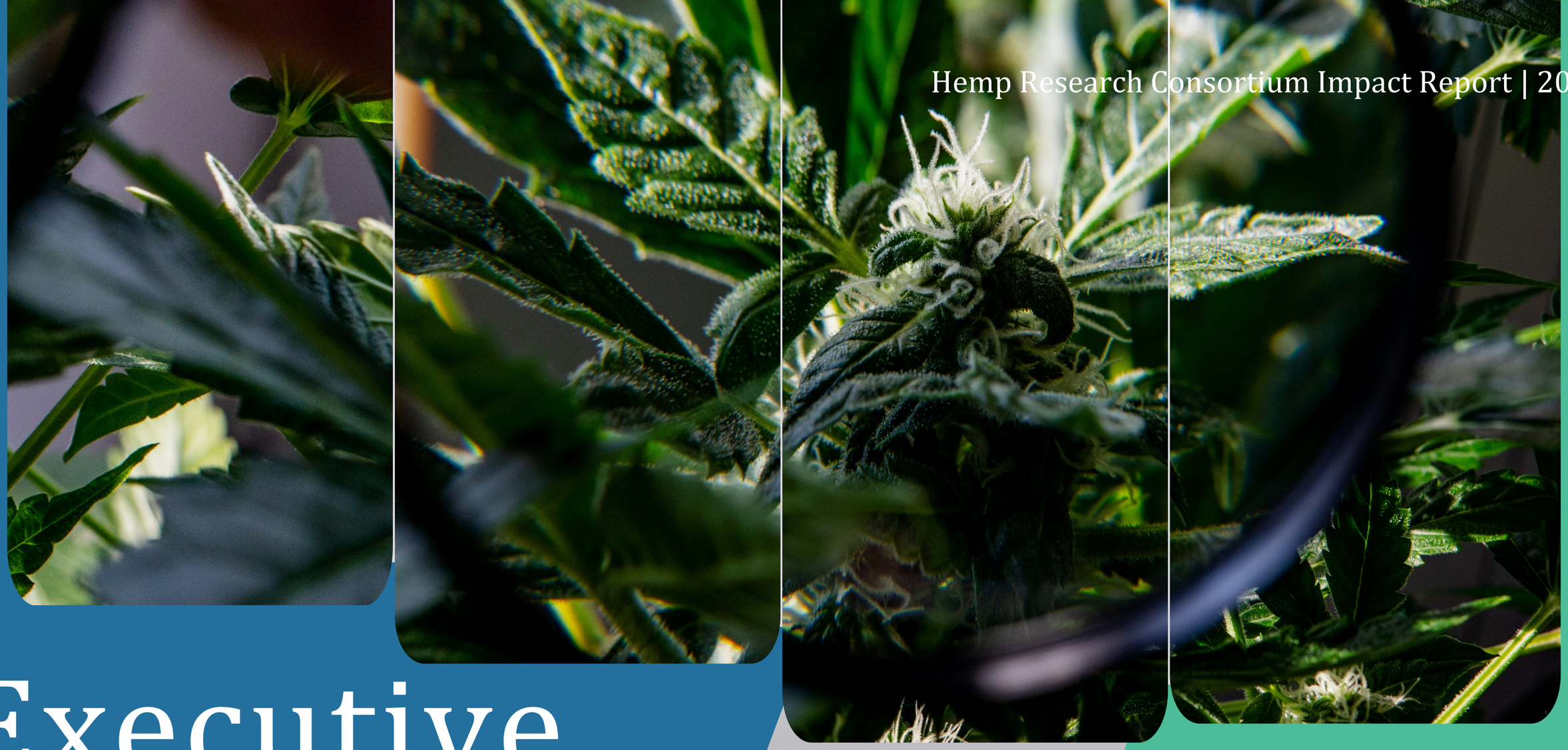
Dr. Trey Riddle
IND Hemp

Derek Montgomery
International Hemp

Dr. Larry Smart
Cornell University

Dr. Bob Pearce
University of Kentucky

Dr. Kathy Munkvold
Foundation for Food & Agriculture Research



Executive Summary

The Hemp Research Consortium is a public-private partnership established by the Foundation for Food & Agriculture Research (FFAR) to foster a deeper understanding of the relationship between hemp genetics, physiology and the environment to optimize industrial hemp production. FFAR contributed $2.5 million to establish the Consortium, and industry members provided another $2.5 million in matching funds.

The Executive Committee met twice this year to discuss new membership and make changes to Consortium operations. These changes include the following updates: a) new members have one calendar year to initiate research projects, and b) new proposals must be submitted annually on either May 1 or November 1. These changes were made to improve Consortium organization, accelerate Consortium-led research and aid in the proposal review process.

> The Consortium welcomed a new member in 2023: The Global Hemp Innovation Center

The Consortium did not initiate any new projects in 2023. All seven projects funded by the Consortium were continuations from year one efforts. Total funds allocated to these projects was $3,459,198. FFAR intends to fund Dr. Christine Smart's proposal, Evaluation of the Efficacy, Agronomic Fit, and Environmental Fate of Biopesticides for Management of Economically Important Diseases and Arthropod Pests of Hemp, leaving $1,120,802 in available funds from the initial $5 million investment ($2.5 million industry member support and $2.5 million FFAR matching funds). FFAR has indicated a willingness for additional matching funds for highly collaborative, cross-cutting research as the Consortium adds new members. We want to continue pushing for increased membership, from both industry and academic fields, as the strength of this Consortium lies in the diversity of its members.

Project Reports

Elucidating the Genetic Basis for Sub-Tropical Flowering in Hemp

Principal Investigator: Larry Smart, Cornell University

Industry Partner: Consortium Partners

This research project aims to elucidate the genetic basis for flowering time variation. Specifically, researchers are identifying germplasm with a critical day length threshold that is compatible with production of CBD or Cannabigerol in U.S. southern latitudes, including Florida. The research team is conducting a genome-wide association study using a highly segregating, high-CBD hemp population that includes individual plants that display a wide range of flowering time sensitivity. This population, marketed as a cultivar called “Carolina Dream” by Ryes Creek, was evaluated by Cornell University in 2020 and has been grown in Florida by stakeholders, flowered very late in the season and accumulated reasonable levels of biomass. We expect that these selections will be a strong basis for future cultivar development for Florida and similar southern latitude environments.

Key Outcomes

- Preliminary data suggests a new flowering time locus on chr02.
- A comparison of mean flowering time suggests high heritability for flowering time and significant genetic gain from selected S1 progeny.

Project Reports

Breeding and Characterizing New Cultivars of Grain & Fiber Hemp

Principal Investigator: Larry Smart, Cornell University

Industry Partner: International Hemp

This research supports a long-term breeding program aimed at developing and characterizing new cultivars of hemp for grain and fiber production in U.S. growing regions. Germplasm obtained from China has a much shorter critical day length, allowing it to remain in vegetative production longer at high latitudes and to reach full growth potential at lower latitudes. The researchers are making crosses with promising, fast-growing lines and ensuring they are compliant while selecting for high grain and fiber yields. The project is evaluating pre-commercial lines in replicated small plot trials in New York, and also collaborating with colleagues at North Carolina State University, The University of Kentucky and other hemp growing regions appropriate for the cultivars being tested. Breeder seed is scaling up in pollen-isolated controlled environment facilities or in isolated field sites at a southern latitude. New cultivars will be licensed and further scaled to be certified seed by International Hemp and will be offered for license to other FFAR Hemp Research Consortium members according to the bylaws.

Key Outcome

- Field scale-up of a new fiber cultivar yielded approximately 8,000 pounds of seed with an acceptable germination rate.

Project Reports

Analysis of Terpenes & Neutral Cannabinoids Using Gas Chromatography/Mass Spectrometry & Genotyping of Hemp using the SureSelect System

Principal Investigator: Joss Rose, Cornell University

Industry Partner: Agilent Technologies

Using the SureSelect system, this project is coupling phenotypic analysis of cannabinoids and terpenes produced by hemp (Cannabis sativa <0.3% THC) with genotypic analyses. This paired analysis forms a basis for breeding for defense against herbivores and compounds with pharmacological and wellness value. Terpenes are very amenable to analysis by GC-MS and combining terpene and cannabinoid analysis into a single method is highly desirable for cultivar characterization and quantitation. In addition, the optimized protocols will be used to characterize the profiles of cannabinoids and terpenes in a diverse range of Cannabis cultivars.

Key Outcomes

- Validation of the latest version of the custom designed probe suggests the design will be useful across diverse hemp germplasm.
- Researchers have developed a complete design for trait mapping; data will soon be available to validate the design.

Project Reports

Breeding & Genetics of Disease Resistance, Flowering Time, & Cannabinoid Content in Hemp

Principal Investigator: Larry Smart, Cornell University

Industry Partner: ScottsMiracle-Gro

The breeding of distinct, uniform, and stable hybrid cultivars of hemp requires selecting highly inbred parents that can be crossed to produce a progeny population with consistent performance for all the desired traits. Key among these characteristics is flowering time, powdery mildew resistance and cannabinoid profile. Researchers have made progress toward identifying the gene responsible for the autoflower trait and are developing markers to introgress that trait into a wide range of hemp genetic backgrounds for cultivar development. The research team is also using genetic mapping populations to identify the locus or loci conferring resistance or susceptibility to powdery mildew. This research is producing molecular tools for marker-assisted breeding, development of inbred parental lines suitable for hybrid seed production and identification of parental combinations that produce promising hybrid populations which meet customer expectations.

Key Outcomes

- The research has identified the genetic basis for cannabinoid chemotype IV phenotype.
- Development of molecular markers applicable to breeding programs to introgress high CBGA/low THCA phenotype into elite grain cultivars.

Project Reports

Multistate Characteristics of Agronomic Performance of Hemp Cultivars, Including Sterility of New Triploid Cultivars

Principal Investigator: David Suchoff, North Carolina State University

Industry Partner: Oregon CBD

Pollination of floral hemp grown for cannabinoid extraction can result in drastic yield loss and unmarketable quality due to the presence of seeds. Consequently, farmers growing floral hemp require tools to minimize the threat of pollination. To address the challenge of wind-dispersed pollen in hemp production, particularly in floral hemp intended for cannabinoid extraction, triploid (3n) hemp cultivars were investigated as a potential solution to reduce the risk of pollination and subsequent seed production. The proposed project sought to characterize newly developed triploid hemp cultivars for sterility and agronomic traits over two growing seasons; field trials were conducted in North Carolina, New York and Kentucky. Each location contained a pollen-challenged and pollen-free site. Three triploid hemp cultivars and their corresponding diploid (2n) equivalent (n=6 cultivars) from Oregon CBD were used in these field trials.

Key Outcomes

- Researchers observed no measurable differences between diploids and triploids when grown in the absense of pollen. Triploids tended to initiate floral development later than diploids.

Project Reports

Assessment of the Available Literature & Gap Analysis on the Use of Industrial Hemp as an Animal Feed

Principal Investigator: David Harmon, University of Kentucky

Industry Partner: International Hemp

Researchers conducted a comprehensive review to aid future research aimed at expediting federal approval. The review focused on hemp grain and fiber's application in feed additives, identified relevant federal and state agencies, and aimed to clarify review criteria, particularly regarding companion animals versus livestock. Additionally, the review aimed to identify knowledge gaps to pinpoint future research opportunities.

Future research needs to demonstrate that feeding low levels of cannabinoids over prolonged periods does not result in appreciable amounts deposited in animal milk and tissues. Alternatively, hemp seed cannot produce cannabinoids, which mainly originate from cannabinoid-producing trichomes in the inflorescence. Due to its high protein and fat contents, particularly ruminal undegraded protein and unsaturated fatty acid compositions, hemp seed may represent the most viable and least controversial livestock feedstuff derived from industrial hemp.

Key Outcomes

- Of the three main components of the hemp plant (fiber, inflorescence and seed), hemp seed and inflorescence are the most promising as livestock feeds.

Project Reports

Impact of Spectra & Intensity of LED Supplemental Lighting on Morphology, Growth, Flower Yield, & Phytochemical Content of Cannabis Sativa

Principal Investigator: Ricardo Hernandez, North Carolina State University

Industry Partner: The Scotts Company

Optimizing the light environment for plant growth and profitability is important to reduce energy use and maximize productivity for hemp grown in controlled environments, such as greenhouses or warehouses. This project is focusing on the impact of UV, blue, green, red and far-red light and their interaction for nursery yield, flower yield, phytochemical concentration and profitability. This project also reveals Cannabis response to light intensity and provides information on yield/revenue per added light. The researchers plan to disseminate results to the hemp industry via publications, presentations and web-resources.

Key Outcomes

- Reductions of the supplemental light during the first 28 days of primarily vegetative growth reduced the flower yield.

Image by jcomp

Financials

Project Title	Principle Investigator	Total Budget	Total FFAR Contribution	Total Match
Breeding & Characterizing New Cultivars of Grain and Fiber Hemp	Larry Smart	$1,500,000	$750,000	$750,000
Elucidating the Genetic Basis for Sub-Tropical Flowering in Hemp	Larry Smart	$840,000	$420,000	$420,000
Multistate Characterization of Agronomic Performance of Hemp Cultivars, Including Sterility of New Triploid Cultivars	David Suchoff	$103,254	$51,627	$51,627
Analysis of Terpenes & Neutral Cannabinoids Using Gas Chromatograph/Mass Spectrometry & Genotyping of Hemp Using the SureSelect System	Joss Rose	$502,000	$251,000	$251,000
Breeding & Genetics of Disease Resistance, Flowering Time & Cannabinoid Content in Hemp	Larry Smart	$300,000	$150,000	$150,000
Impact of Spectra & Intensity of LED Supplemental Lighting on Morphology, Growth, Flower Yield & Phytochemical Content of Cannabis Sativa	Ricardo Hernandez	$200,000	$100,000	$100,000
Assessment of the Available Literature & Gap Analysis on the Use of Industrial Hemp as an Animal Feed	David Harmon	$13,944	$6,972	$6,972
Total	-	**$3,459,198**	**$1,729,599**	**$1,729,599**

Appendix A: Philosophy & Goals

The Hemp Research Consortium is a public-private consortium bringing together private companies with leading hemp research universities to mutually identify, execute and facilitate advances in sustainable hemp production and utilization toward fulfilling the Consortium's mission of supporting innovative science that addresses today's food and agriculture challenges. By providing a "safe harbor" for Hemp Research Consortium participants, FFAR is creating a space for collaboration on areas of mutual interest.

The knowledge generated by the Consortium will be publicly available through scientific publications, data-sharing and dissemination of research tools as appropriate, benefiting future public and private research efforts. Knowledge generated will also enable participants to accelerate development of their own proprietary knowledge, products and technologies, and will ultimately advance a sustainable global hemp enterprise.

Rather than each Participant duplicating the same costs and efforts, the initial risk associated with research and discovery can be shared among participants. Working together, participants decrease their individual risks and multiply their combined tools, knowledge and financial resources. This accelerates the discovery and development of knowledge, tools and training for more immediate impact and benefit to the public and private sectors.

Appendix B: Participating Organizations

Agilent Technologies

BAST FIBRE TECH

BioWorks®

Cornell University

IND HEMP
OILSEEDS & FIBER

INTERNATIONAL HEMP

NC STATE UNIVERSITY

The IR-4 Project

Scotts Miracle-Gro

FFAR®

University of Kentucky

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