



## **CLIMATE SMART FIBER HEMP: A VERSATILE THREAD CONNECTING THE NATION'S UNDERSERVED FARMERS, CLIMATE CHANGE MITIGATION AND NOVEL MARKET OPPORTUNITIES**

*USDA PARTNERSHIPS FOR CLIMATE SMART COMMODITIES PROPOSAL OVERVIEW*  
6/9/2022

The Climate-Smart Fiber Hemp Project (Project) is a collaborative initiative to expand the production of industrial hemp as a climate-smart commodity, evaluate its greenhouse gas benefits (GHG), and promote the value of market development to a cross-section of production agriculture, including small, medium, and/or historically underserved producers across the state of Tennessee. The Project is a partnership bringing together Tennessee State University (TSU), Hemp Alliance of Tennessee (HAT), University of Tennessee (UTK), and Tennessee Department of Agriculture (TDA) to address the global challenges posed by climate change.

The key initiative within this Project, is the plan to promote market development of industrial hemp supply as a climate-smart commodity through incentives to underserved Tennessee growers enrolled in our pilot production Program (Program). The Program will engender equity and empower producers through financial and technical assistance to embrace climate-smart practices in developing a resilient market for supply to end application markets.

In addition to the production Program, the Project focuses research on quantifying environmental, soil health and climatic impacts. Within this objective, supplemental research on suitable genetics and best management agronomic practices, processing, and supply-chain economics will help growers make the most informed decisions about industrial hemp production, reducing inequity. Additional research along the supply-chain, financial analysis and market studies will inform constituent intelligence in policy, regulations, and material specifications necessary to develop a more resilient and scalable market. Expected outcomes from the Project include the following:

- Delivering approximately 1,500 tons of hemp fiber on 500 acres, emphasizing small, medium and/or historically underserved producers, and processing it into raw material for secondary and end-user manufacturing in bioplastics, fabrics, and other industrial materials, creating a pathway to scale operations, improve efficiency, and access new end-user markets to redeem more benefits to producers in Tennessee and the Southeast
- Monitoring, measuring, recording and verifying on-farm soil carbon (C) storage and sequestration, soil health assessment, and GHG reductions
- Developing consensus-based technical standards and specifications for hemp fiber materials; with the development of a sustainability certification program that will be meaningful, truly address sustainability interests, and advance innovation
- Evaluating cost-effectiveness of product value chains based on plant varieties, processing methods, and variations in agronomy and infrastructure



- Consistent with the Justice40 Initiative our Project plan is focused on serving small and underserved producers both as incentivized program participants receiving direct subsidies, but also in the targeted dissemination of insights resultant from virtually all program research through technical assistance outreach
- Producer awareness of market opportunities for industrial hemp. Education regarding best practices for production and financial management to support economically sustainable and thriving small and minority farms
- Insights into the viability of and economic returns to producers moving up the supply chain capturing value through processing
- Manufacturer awareness of industrial hemp as a climate-smart commodity, the qualification of hemp as a viable input to their production, and the economic, social, and environmental value of building a sustainable end market for industrial hemp
- Market development of end applications for industrial hemp. Identification of optimal product market candidates on which to focus supply chain capacity growth, and data intelligence to economically scale consistent with constraints of a dynamic market environment

Project funds will be expended for hemp production, focused on underserved farmers, on technical assistance and outreach, assessment of best management climate-smart production strategies, carbon accounting, development of technical standards/specifications, value-chain analysis, and promotion of climate-smart hemp fiber product markets.

On-station and on-farm trials will also be established to evaluate best management climate-smart agronomic practices to sustainably grow fiber hemp, including evaluation of ideal genetics for Tennessee, inclusion of hemp in existing grower crop rotations, cover cropping and reduced tillage strategies, and assessment of varieties by nitrogen fertilizer requirements. Soil health assessment and soil C storage, C sequestration in the soil and crop biomass, and GHC analysis will all be quantified. Four on-station trials and four on-farm trials will be established at the research stations of TSU, UTK, and within the farms of selected hemp growers for this Project. Results from these trials, including a specific objective on economic analysis of this initiative, will provide a proxy for sustainable and climate-sensitive agricultural production strategies for the State of Tennessee in particular, and the rest of the country in general.

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## **Project Partners**

1. Tennessee State University (TSU), a public historically black land-grant university in Nashville, Tennessee. Role: Primary Awardee, Fiduciary, Project Director, Program Recruitment, Training and Technical Assistance
2. Hemp Alliance of Tennessee (HAT), a nonprofit trade association focused on developing a thriving hemp industry in the state of Tennessee. Role: Promotion and Market Development, Market and Financial Research, Program Recruitment and Outreach
3. University of Tennessee Institute of Agriculture (UTK), a public land-grant university in Knoxville, Tennessee that provides teaching, discovery, and service through the Herbert College of Agriculture, UT AgResearch, and UT Extension for Tennessee and beyond. Role: Agronomy, Soil Science, Agricultural Economics and Market Research
4. Tennessee Department of Agriculture (TDA), a Cabinet-level agency in the government of Tennessee, whose mission is to serve all the citizens of Tennessee through provision of options for responsible use of agricultural and forest resources, developing economic opportunities, safeguarding food and fiber, and ensuring equity in the marketplace. Role: Market Promotion and Development, Producer Program Oversight and Outreach
5. The Tennessee New Farmer Academy (TNFA), based at Tennessee State University. Role: Underserved Program Recruitment, Promotion, Training and Technical Assistance

## **Underserved/Minority-Focused Partners**

Tennessee State University (TSU), a historically black land grant institution, provides training, technical support and economic and environmentally sustainable assistance to marginalized and rural communities across the State of Tennessee.

The Tennessee New Farmer Academy (TNFA) at TSU is a seven-month certificate program designed for new and beginning farmers as well as those transitioning into agriculture from other fields such as military service. The program addresses daunting challenges faced by new and beginning farmers in general, and historically underserved producers, minorities, women and veterans in particular, through comprehensive education and training to build sustainable agriculture businesses.

The Project Director (PD) of this Project is also the PD of a recently funded USDA-NIFA BFRDP program (Award number 2020-70017-32737) that targets military veterans, beginning farmers/ranchers and socially disadvantaged farmers and ranchers with limited resources in the same way as the New Farmer Academy but with a sharper focus on industrial hemp production training and outreach. Among other objectives, the TSU BFRDP program aims to educate beginner farmers in best management practices for industrial hemp (and other selected crops) and livestock enterprises, crop certification, entrepreneurship development, business planning and financial management. The BRFDP project targets the same category of farmers including those who have operated a farm or ranch for less than 10 years, are new to agriculture, new hemp producers, and those who wish to transition into agriculture from other vocations. This



experience further strengthens our capacity to recruit growers, especially from the underserved members of the community, to participate in this Project.

### **Compelling Need for the Project**

Industrial hemp (*Cannabis sativa* L.) is considered a new crop for the United States after many years of Federal legislation outlawing the genus *Cannabis* L. The 2014 Agricultural Act (“farm bill”, P.L. 113-79, Sec. 7606) provided opportunities for university institutions, like 1890 Institutions such as TSU, to be at the forefront of hemp cultivation and marketing research and extension. These reforms caused resurgence in hemp production in the U.S. in general, with Tennessee being among the leading states in adoption of industrial hemp as a specialty crop. More than 36 states have passed legislation in support of hemp and the number continues to grow. However, there is evidence that this extraordinary support for the “new crop” may have resulted in predictably excessive initial enthusiasm and adoption by growers that is beginning to dissipate as the legislative, production, and market realities become better understood.

Consistent with the Director of the NEC’s comments on an Industrial Strategy (Deese, 2022), our Project examines the failure of the free market to meet national objectives regarding equality and the environment, proposes that development of the industrial hemp market could help meet those objectives, and produces insights into the science and economic impacts of further development. Our Project supports sustainability of a hemp market and its ability to meet national objectives on the environment. The Project supports the national objective on equality by promoting the climate, business and market insights within the small, minority and underserved farmer community through creation of resources, education and assistance complementing the existing state and local efforts of our partners, HAT, TSU, UTK, and TDA.

This Project addresses the growing global challenges posed by climate change, with increasing negative impacts being felt including increasing temperatures, weather variability, shifting agroecosystem boundaries, invasive crops and pests, and more frequent extreme weather events. On farms, these impacts are resulting in reduced crop yields, reduced nutritional quality of major cereals, and lowering livestock productivity. These effects are especially severe among underserved communities. There is therefore a compelling need for substantial investments in adaptation strategies to mitigate the most extreme effects of climate change, maintain current agricultural yields and to achieve production and quality increases to meet demand. Paradoxically, agriculture is a major part of the climate problem, currently generating 19–29% of total greenhouse gas (GHG) emissions (Bank, 2021), through food storage, agrochemical manufacturing and use, and farming techniques such as tillage. Agricultural practices that enhance yields while improving the health of the soil and increasing resilience to climate change are required. Industrial hemp, a versatile, productive and widely adapted crop has many potential applications in automotive, plastics, textiles, paper/pulp, and building materials industries. Because of its rapid growth rate (4–5 months crop cycle) and ability to capture 2–3 times the carbon dioxide per acre per year compared to a forest (Tripathi and Kumar, 2022), coupled with an estimated 25,000 different applications, hemp presents an excellent opportunity for



sustainable agriculture and climate change mitigation (Pervaiz and Sain, 2003; Tripathi and Kumar, 2022). There are substantial unexplored environmental (climate-smart) advantages of using hemp-based natural fiber mat thermoplastics (NMT) compared with commercially available glass fiber composites used in automobiles. While studies have shown that hemp-based NMT have comparable or better strength properties than conventional flax-based thermoplastics, the carbon capture potential of hemp is far more superior. Carbon (C) sequestration and storage by hemp crop through photosynthesis has been estimated as equivalent to 325 kg carbon per metric ton of hemp-based composite stored by the product during its useful life (Pervaiz and Sain, 2003). Net C sequestration by industrial hemp crop has been estimated to be about 0.67 ton/ha/year, which is comparable to all USA urban trees and close to natural forests (Pervaiz and Sain, 2003). It has been suggested that a net saving of 50,000 MJ (approximately 3 tons of carbon dioxide emissions) per ton of thermoplastics can be achieved by replacing 30% glass fiber reinforcements with 65% hemp fiber (Pervaiz and Sain, 2003).

Industrial hemp, as a new crop for Tennessee, offers the potential to provide an alternative to traditional commodities such as corn, cotton, soybean, and wheat while providing soil improvements as a rotational/cover crop (Malone and Gomez, 2019). Hemp is also beneficial to polluted soils as it pulls toxins and heavy metals out of the soil (Ahmad et al., 2016; Rheay et al., 2021). Previous studies have found positive correlations between hemp yield and nitrogen (N) fertility (Papastyliau et al., 2018, Black and Vessel, 1945). However, higher rates of N have promoted thinning due to rapid growth resulting in decreased fiber strength and a reduction in fiber yield (Black and Vessel, 1945). Thus, it is important to investigate the response of various cultivars of fiber hemp to varying rates of N fertilization to determine optimal yield while maintaining high quality fiber materials.

The overall goal of this Project is to create opportunities for underserved Tennessee growers to grow industrial hemp specifically targeting the automobile industry while monitoring and quantifying its environmental, soil health and climatic impacts compared to current popular commodities. The broad objective of the Project is to conduct supplemental research and communicate findings on suitable genetics, best management agronomic practices, processing, and markets to help growers avoid costly mistakes, make the most informed decisions about industrial hemp production, increase farm revenues and mitigate climate change. Specific objectives include the following:

- Develop a pilot program for industrial hemp for fiber to be produced, decorticated, and delivered to a market in TN.
- Understand the climate-smart potential (greenhouse gas emissions and carbon sequestration) of industrial hemp as grown in rotation with common commodities.
- Investigate the impact of nitrogen fertility and cultivar selection on yield and performance in TN.
- Determine economic feasibility of fiber hemp as related to profitability, viability of hemp-based products for the automotive, plastics, textiles, paper/pulp, and building



materials industries, and analyses of possible locations for decortication and final market facilities.

- Disseminate useful production information to fiber hemp producers through field days, Extension publications, farm visits, and other programmatic activities.

### **Minimizing Transaction Costs**

The proposed Project subsidizes costs at the production and processing levels to provide raw materials as an incentive to develop the market. Material specifications will be defined, which enhances the ability of the producer and supply chain to deliver raw materials. This will be an iterative process over the course of the study focused on refining production and processing to identify opportunities and eliminate barriers to viable markets across the spectrum of end-product applications.

Income from the Program is not expected at the termination of the Program and all grant funds will be expended exclusively for direct Program activities, including research and production of hemp raw materials. All raw materials are anticipated to be fully consumed in product application research and development with our corporate partners. Any excess product not consumed by corporate partners will be sold to the market with all resulting revenues reinvested exclusively into Project activities (additional acreage of production, additional processing, and additional market research and development).

Funding allocations are designed to fully remove risks to farmers producing fiber hemp, by covering 100% of production costs. This feature enables farmers to shift acreage from other crops or add acreage without speculation and incentivize their best effort to produce a successful crop in an efficient manner. An additional incentive payment to support positive returns to production is made to Program participants with delivery to processing. Program participants may lose eligibility for failure to perform in an adequate manner. The Project also provides technical assistance to farmers who are new to hemp production or to farming in general, thus reducing crop failure risk.

Funding also helps cover the cost of primary processing, by covering the expenses of centralized facilities, by providing local processing services, or by engaging the producer in alternative processing practices under research (ensilage) with a focus on minimizing costs given those options. The need for a geographical concentration of participating farmers and the value of producers retaining a greater sale of final market values by control of processing will be evaluated.

### **Reducing Producer Barriers to Climate-Smart Commodities**

Besides production risks which our Program addresses, a key barrier to producing hemp fiber as a CSAF practice is the lack of primary processing required to bring their crop to market. To



overcome this barrier, the Project allocates a significant portion of the award to cover the cost of primary processing of hemp as a fiber crop. This effort will be implemented through a multi-faceted approach, utilizing different methods appropriate to downstream product specifications, presence of existing infrastructure, and geographic concentration of participating farmers. The Project will also evaluate the cost-effectiveness of these different approaches and refine/adjust their application over the course of the Project. One such approach is the sharing of early-stage hemp processing such as specialized harvesting machines and decortication (generating high value separate hurd and bast fiber material streams), through farmer-owned cooperatives.

**Benefits of localized supply chain:** There are significant climate and economic benefits to an industrial hemp supply chain that is grown, processed, and manufactured all within the same area. Raw material shipping costs from farms growing hemp fiber to initial processing and then to final end manufacturing users are minimized. Overall profitability is improved, and timing issues are ameliorated. Greenhouse gas emissions are also reduced because of the close proximity of farms to immediate processing and end users.

### **Geographic Focus**

Located in the heart of the climate-transition zone, Tennessee offers flexible weather conditions for crop production. It is a leader in using farm soil conservation practices with 80% of the arable land in no-tillage (NT) cultivation, the highest percentage in the US (USDA-NASS, 2017). However, despite such conservation practices, the hot and humid climate limits soil C sequestration that is often restricted to shallow depths and vulnerable to losses (Jagadamma et al., 2019). Therefore, Tennessee row crop producers are now enthusiastic about innovative, more stable, ways of deep soil C sequestration based on fiber hemp's rapid growth and deep-rooting characteristics. Due to a relatively short growing season, hemp for fiber can be easily incorporated into existing rotations while its limited N requirement may also further reduce emissions of potent GHGs such as nitrous oxide (N<sub>2</sub>O), thus providing a net CO<sub>2</sub> equivalent emission benefit. Additionally, growing interest and new market opportunities for using hemp fiber products in the automotive and other regional industries means Tennessee is an optimal location for research that supports local sourcing of raw material and economic growth.

### **Project Management Capacity**

Our Land Grant partners (TSU and UTK) have a long-standing relationship working with a wide range of producers with a strong focus on underserved farmers. These institutions have institutional capacity in managing large grants involving multiple partners. The TSU and UTK partnership offers strength in agronomy (Drs. Omondi and Richmond) - a critical aspect when including a non-traditional crop in a traditional rotation, soil health and quantifying soil C and GHG dynamics (Drs. Saha and Omondi). Our Project presents a strong focus on evaluating economic feasibility and farm profitability (Dr. Hughes) and optimizing spatial concentration of hemp production and processing based on potential market development opportunities to minimize production costs (Dr. Yu and Harry Crissy).



HAT offers expertise in project management of market studies, economic and financial analysis, technological implementations to support data intelligence gathering and the marketing and promotion of information to support market development. Key individual contributors of HAT bring decades of experience leading private investments in innovative new markets, identifying and coordinating best in-class contributors to reach targeted outcomes.

The TDA is uniquely positioned to assist in this Project by managing the payments to Tennessee farmers to offset the cost of production. TDA has the infrastructure and expertise already in place to take on this role. As a state agency, TDA will serve as a neutral party, which is critical when handling payments of significant amounts of money directly to Tennessee farmers. TDA has participated in a similar fashion for other USDA grants in the past, and is committed to seeing this Project through completion.