

## II. Research Proposal

The regulations require the completion of a research proposal before your research license application can be considered. If you completed a Pre-Application and Pre-Application Research Proposal and want to certify your Pre-Application Research Proposal for use as your research proposal on this research license application, you must complete all provisions of the research license application and submit a copy of your Pre-Application Research Proposal. As the Primary Applicant, you will be given the opportunity to certify your request in the Acknowledgment Section below. **To be able to certify your Pre-Application Research Proposal, the Primary Applicant must be the same individual that completed the Pre-Application and Pre-Application Research Proposal.**

**Your research proposal must explain the research you plan to conduct on behalf of the Kansas Department of Agriculture. Your research proposal will play an important role in the evaluation of your research license application and approval to participate in the Program.**

**Below are possible research topics that may be useful areas of study. Once you have determined the area of your research, explain in detail, on the following pages, the specific subject your research will cover.**

- Agronomic research and analysis of soils, growing conditions or water usage required to successfully grow industrial hemp.
- Research on types of industrial hemp seed that are best suited to be grown in Kansas, including seed availability, creation of hybrid seed types, in-the-ground variety trials and seed production.
- Agronomic research and analysis of the most efficient types of equipment and techniques for seeding, tillage or harvest.
- Agronomic research and analysis of the most effective, economical and environmentally beneficial pest control or fertilization products or methods.
- Analysis of the management techniques and/or environmental factors that impact the delta-9 tetrahydrocannabinol (THC) concentration in industrial hemp.
- A study on the feasibility of attracting federal and private funding for industrial hemp research.
- Analysis of the economic feasibility of developing markets for the various types of industrial hemp that can be grown in Kansas.
- Research and analysis of the most efficient types of equipment and techniques for transporting industrial hemp plants, plant parts, grain or seeds.
- Analysis of the estimated value-added benefits, including environmental benefits, that Kansas businesses would reap by having an industrial hemp market of Kansas-grown industrial hemp varieties.
- Research and analysis of the most efficient types of equipment and techniques for processing industrial hemp plants, plant parts or grain.
- Analysis of the economic feasibility of developing markets for varieties of industrial hemp seed in and beyond Kansas.
- Research into the development of national and international markets for Kansas-grown industrial hemp and industrial hemp products.
- Analysis of the most efficient and economical methods for distributing and transporting Kansas-grown industrial hemp and industrial hemp products.
- Other types of research into the economic development, cultivation, market analysis, manufacturing, distribution and transportation of industrial hemp and industrial hemp products.

## Research Proposal Instructions:

- **Complete the following sections**, either by utilizing the fillable form or by providing your answers on a separate page(s). *Handwritten submissions are strongly discouraged.*
- **If answering on a separate document**, please label each section (A-F).
- **Be concise:** Your research proposal should be as concise as possible; **not to exceed 2 pages total.**
- **For more information on how to write a research proposal**, please see the Technical Bulletin on How to Conduct Research on Your Farm or Ranch by visiting <https://www.sare.org/Learning-Center/Bulletins/How-to-Conduct-Research-on-Your-Farm-or-Ranch>.

**SECTION A:** Identify your research question and objective, including a statement of the type of research to be conducted and its purpose.

The goal of this project is to determine grower best management practices to increase the potential profitability of cannabidiol (CBD) resin and reduce risk of plants with THC content that is higher than allowable in Kansas. The specific research goals are listed below:

- 1) To investigate water conservation practices such as plasticulture, rolled cover crop mulches, and caterpillar tunnels, and determine their effects on crop water-use efficiency and THC production
- 2) To identify how the implementation of high tunnel production systems impact plant growth characteristics, yield, THC, and CBD production
- 3) To determine which of the approved varieties are best-suited for CBD resin production in Kansas in high tunnel and open-field production systems
- 4) To identify successful sexual and asexual propagation systems for approved CBD varieties

**SECTION B:** Identify your experimental design.

All experiments will be conducted in a split-plot, randomized complete block design (RCBD) with a minimum of four replications per treatment. The main plots will consist of the four systems being tested (tunnels, plasticulture, cover crop mulch, bareground). The sub-plots will consist of the four varieties being tested. Variety trials will be planted in caterpillar tunnels (OHCIH2) and the open field (OHCIH1). Each plot will consist of at least 10 plants at 36" in-row spacing (2 rows per block) and rows will be 5' apart (center-to-center). Buffer plants will be planted between the experimental plots to reduce interplot interference and allow for preliminary sampling to support protocol development in the lab. Replicated trials will be conducted in OHCGH1 to identify methods for cloning, grafting, and pollen collection from female plants of approved CBD varieties. Similar protocols are currently in use for tomato and other vegetable crops at the Olathe Horticulture Center and are available upon request.

**SECTION C:** Explain what will be measured and what data will be collected.

Data will be collected to assess the growing environment (eg soil and air temperature, soil moisture, etc.) as well as plant growth. Plant growth parameters that will be measured include plant height, leaf area, biomass production, inflorescence number, flower dry weight, and compactness. CBD and THC will be monitored throughout the growing season and after postharvest drying/curing. Crop water use will be measured with flow meters to determine the relationship between water use, overall crop yield, and THC production. Plots will be monitored and maintained in regards to plant growth, weeds, and insect presence.

**SECTION D:** Explain how the project will be implemented, including location and size of your anticipated research areas (in acres or square feet), duration of your research operations and variety of industrial hemp that will be used in your research.

The primary research activities will be happening in fields OHCIH1 and OHCIH2. The combined production area is 0.45 acres, however much of this space allows for grassed driveways between high tunnels and field plots. Each replication in the four systems will be 120' long and include two rows of 40 plants. Therefore, we anticipate planting no more than 1500 plants in those areas combined. The "conservation practices" comparison of bareground, plasticulture, and cover crop mulch will occur in OHCIH1 and will contain 960 plants (18,720 sq ft) across all three treatments. The caterpillar tunnel trials will occur in OHCIH2 and each 1560 sq ft tunnel will contain 80 plants. Therefore, OHCIH2 will contain 6240 sq ft of growing space with approximately 320 plants in it. If there is plant material available, OHCIH3 will be utilized as an "isolation field" to minimize the effects of exogenous pollen contamination from nearby plantings. We will use this area to determine if sexual propagation can be accomplished with female plants using plant growth stimulants such as silver thiosulphate. The field consists of 3 acres and is ideal as it is completely isolated and inaccessible to the public. Finally, propagation of plant material as well as propagation studies will be conducted in a 24' x 72' greenhouse at OHCGH1. The greenhouse is 1728 sq ft, we anticipate having plant material in the outdoor adjacent areas during hardening and acclimation pre-planting. Propagation will begin in April and field planting will occur in mid-may. We expect to harvest our 2019 crop in late September or early October

**SECTION E:** Explain how research data will be collected, recorded and analyzed.

Data will be collected by students and staff at the Olathe Horticulture Center in a manner that is consistent with our procedures for collecting data from other projects. Data will be written on paper with pencil then transcribed to Excel spreadsheets. Handwritten data will then be filed and saved in case of computer failure. Data will be analyzed with a common statistical analysis software such as SAS. Data will be subjected to analysis of variance and means will be subjected to a common means separation tool when appropriate. Graduate students (Wyatt and Hoppenstedt) will be responsible for collecting and storing the data on shared computer servers throughout the project.

**SECTION F:** Explain how the data will be interpreted and how conclusions will be drawn, including anticipated results.

Data will be interpreted after all statistical analyses are completed. Conclusions will be based on that statistical analysis in a manner consistent with academic research ethics standards. We expect to draw our conclusions based on three overall goals that will help guide grower recommendations in Kansas:

- 1) to identify methods that increase production and reduce water inputs
- 2) to identify varieties and methods that reduce the likelihood of unallowable THC content
- 3) to increase the profitability of CBD resin production in Kansas.

2019 Industrial Hemp Research Program Research Report

Primary Licensee: Cary Rivard



License Number: KDA-0060040622

Date: 11/30/2019

**SECTION A:** Restate your research question and objective; please indicate if the research question or objective changed. Why did you choose to study this research question and objective?

The goal of this project was to determine grower best management practices to increase the potential profitability of cannabidiol (CBD) resin and reduce risk of plants with THC content that is higher than allowable in Kansas. The specific research goals are listed below:

- 1) To investigate water conservation practices such as plasticulture, rolled cover crop mulches, and caterpillar tunnels, and determine their effects on crop water-use efficiency and THC production
- 2) To identify how the implementation of high tunnel production systems impact plant growth characteristics, yield, THC, and CBD production
- 3) To determine which of the approved varieties are best-suited for CBD resin production in Kansas in high tunnel and open-field production systems
- 4) To identify successful sexual and asexual propagation systems for approved CBD varieties

We were able to address objectives 1, 2, and 4 with greenhouse, field, and high tunnel trials that were performed at the Olathe Horticulture Center. However, due to limitations with seed sourcing and regulations, we were only able to test the performance of two varieties. ‘Cherry Wine’ was utilized for the high tunnel and field trials (objectives 1, 2) and ‘Otto II’ and ‘Cherry Wine’ were used to address objective 4 in the greenhouse.

**SECTION B:** Restate your experimental design. Did it change over the course of your research?

We utilized a split-plot randomized complete block design with three replications to address objectives 1 and 2. A completely randomized design was utilized in experiments related to objective 4. Our experimental design was similar to proposed, although the variety factor was not included in high tunnel and open field trials.

**SECTION C:** Explain how the project was implemented, including location and size of your licensed research areas (in acres or square feet), duration and applicable activities (germplasm acquisition, handling, planting, distributing, planting, harvesting, drying, and processing) of your research operations and variety(s) of industrial hemp used in your research.

The primary research activities happened in fields OHCIH1 and OHCIH2. The combined production area was 0.45 acres, however much of this space allows for grassed driveways between high tunnels and field plots. Each replication included a comparison of black plastic, white plastic, and (no-till) cover crop mulch. We did not include the isolation area in OHCIH3 due to limited capacity and planting material. Finally, propagation of plant material as well as propagation studies were conducted in a 24' x 72' greenhouse at OHCGH1.

The crop was harvested and dried in the greenhouse and we are still working to prepare the plant material for further processing (oil extraction). Whole plants were hung and dried for approximately 10 days before flowers were removed and primary leaves were eliminated.

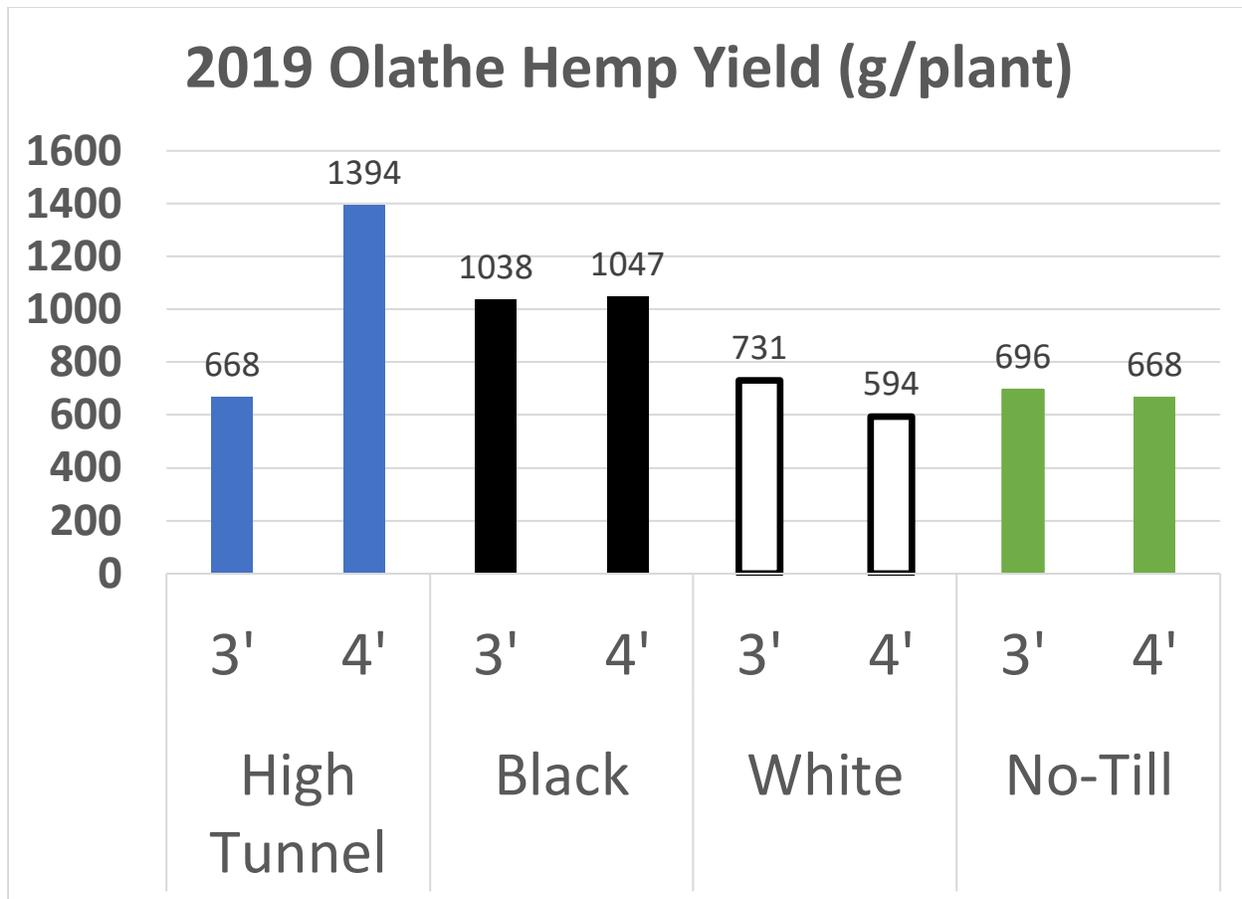
**SECTION D:** What data was collected? How was the data measured? Provide the collected data.

Data was collected to assess the growing environment (soil temperature) as well as plant biomass. CBD and THC were monitored throughout the growing season and after postharvest drying/curing. Data was collected by students and staff at the Olathe Horticulture Center in a manner that is consistent with our procedures for collecting data from other projects. We are still in the process of data organization and analysis. Data has been entered into spreadsheets, but has yet to be statistically analyzed.

**SECTION E:** What were the results of the research? Were the results what you anticipated? Explain.

The yield results of the study are shown below. CBD and THC concentrations are still being determined in the lab and can be reported at a later date. Reports from colleagues in other states indicate that a “good” crop is 1 lb per plant. All of the treatments we tested exceeded this yield. In particular, the plants grown in the high tunnels at 4’ in-row spacing produced over 3 lbs per plant.

Propagation studies were successful and we identified methods for asexual propagation of CBD hemp. We found that it was difficult to propagate plants that had begun to flower.



**SECTION F:** Interpret the results as it relates to the research question and objective. Draw conclusions upon your analysis.

After we determine the final CBD and THC content of our trial plants, we will be able to provide a more comprehensive interpretation of the data. However, our plants were tested by the Kansas Department of Agriculture and were passed for harvest. Therefore, we can presume that all four systems resulted in a flower harvest that was legal under Kansas law. Based on the yield data, the high tunnel system clearly resulted in the highest yields. Our preliminary (non-replicated) findings also indicated that the CBD content in the high tunnels was as high or higher than in the open field treatments. Based on these data, it appears that the high tunnel system would be an excellent one for production of industrial hemp for CBD oil. Within the open field treatments, the black plastic mulch had the highest flower yield and the white plastic mulch and no-till system were similar.

Interestingly, there were very few differences amongst the open field treatments (black, white, no-till) in regards to plant spacing whereas a dramatic treatment effect occurred in the high tunnel plots. In the high tunnel, the plants grown at 4' spacing had just over double the per plant yield compared to the ones that were growing at 3' spacing. It is important to note that both male and female plants were initially planted and the males were rogued out once flowering initiated.

During harvest, areas where there were missing plants were avoided for the purpose of data collection, but a more thorough examination of planting density will require the use of asexual propagation methods in order to ensure the quality of the data. Based upon anecdotal observations of the growth of the plants in the trial, utilizing the 3' spacing was problematic as many of the plants encroached onto each other resulting in unwanted shading in the lower portions of the plant.

Overall, the results of our study were favorable for growers that wish to grow industrial hemp for CBD production in Kansas. All of the treatments produced more than one pound per plant and the highest yielding treatment (4' – HT) produced just over three pounds per plant. Although there is very little in the literature regarding hemp yield, colleagues and others working with hemp indicated that this is an excellent yield. It is likely that the high tunnel system will be recommended for CBD production in Kansas. Many of the specialty crop growers that produce vegetables around the state already utilize these structures and hemp would be an ideal crop rotation option if available.