



# HEMP MANUAL



**NORTH CAROLINA AGRICULTURAL  
AND TECHNICAL STATE UNIVERSITY**

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*AGRICULTURE AND ENVIRONMENTAL  
SCIENCES*

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# 1. INFORMATION ON HEMP, COMPARISON WITH OTHER PLANTS, NARCOTIC PROPERTIES

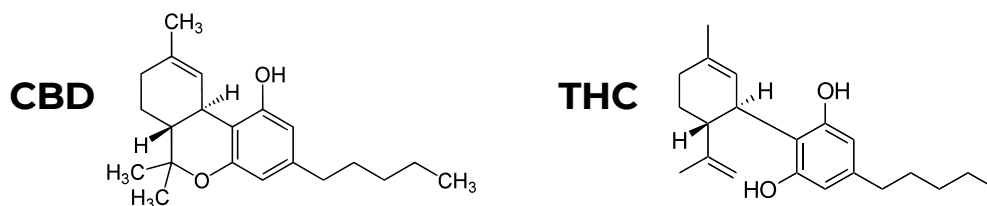
Originating in Central Asia, hemp is a warm season, annual herbaceous species of the Cannabaceae family. It is a short day dicot and begins to flower as days shorten after the summer solstice, June 21. It is naturally dioecious (there are male plants and female plants).

The scientific name of hemp is *Cannabis sativa* L. Cannabis is one of the most ancient domesticated crops. Hemp and marijuana are different cultivars of cannabis. Hemp has been an important source of fiber and oilseed while marijuana has been known for its inebriant and psychoactive effect.

Hemp and marijuana cannot be distinguished by their appearance. The difference is in the content of the psychoactive chemical Tetrahydrocannabinol (THC) and the non-psychoactive Cannabidiol (CBD). Industrial hemp has more CBD and a mandated THC content of less than or equal to 0.3%, while marijuana has less CBD and more THC (>0.3%, with an average of about 10%).

## THC and CBD

- Both are cannabinoids, which are rich in trichome of the bracts of female flowers.
- THC refers to a psychotropic cannabinoid and is the principal psychoactive constituent of cannabis.
- CBD is one of at least 113 active cannabinoids identified in cannabis. It is a major phyto-cannabinoid, accounting for up to 40% of the plant's extract. It does not have any intoxicating effects but may have effects on anxiety, anti-psychotic effects, or other health benefits.
- Different molecular structure:



It has been claimed that there are more than 25,000 products made from hemp. Three major product categories with market potential for hemp are fiber (bast and hurd), seeds (grain and oil), and cannabinoids (female floral parts).

Hemp has a wide range of environmental adaptation, but varieties perform better in their areas of development. Hemp does best on a loose, well-aerated loam soil with high fertility and abundant organic matter. Well-drained clay soils can be used, but poorly drained clay soils are inappropriate. Industrial hemp requires a near-neutral pH for optimal growth. A pH of 7.0-7.5 is preferable, with a lower limit of 6.0. The optimal growth temperature for hemp is 66-77°F. Hemp is sensitive to photoperiod (day length). As a short-day plant, its critical photoperiod,

under which the crop is induced to flower, is about 14 hours once the juvenile phase has been satisfied. About 20-28 inches of water is necessary over the growing season for hemp, with 10-14 inches of water needed during the vegetative period.

Direct seeding is typical for fiber and grain hemp production. Clones and/or feminized seeds are used for CBD hemp production. When using feminized seeds, it is recommended that seedlings be raised in a greenhouse, and transplanted into the field later. Currently, 100% female cultivars do not exist. Extra efforts are necessary to remove male plants for CBD production.

## **2. THE STATE'S HEMP POLICY, IMPLICATIONS FOR N.C. A&T AND NCSU**

For decades, federal law did not differentiate hemp from other Cannabis plants. Cannabis of any kind was made illegal and hemp was classified as a Schedule I controlled substance according to the Controlled Substances Act of 1970. There was no large-scale industrial production in the United States, and the U.S. market was mainly dependent on imports for both finished hemp products and for ingredients to be used in further processing.

In 2014, the United States Congress granted permission through the Farm Bill to run test programs for growing hemp in a number of states. In 2016, the North Carolina General Assembly passed SB 313, legalizing the production of industrial hemp in the state (NC Department of Agriculture, 2015). This bill was followed by HB 992, passed in 2015, that established an Industrial Hemp Commission to develop the rules and licensing structure necessary to stay within federal laws. As a result of this legislation, GS 106-568.55 was written to allow the development of industrial hemp research programs to be directly managed by the state's land grant universities, North Carolina Agricultural and Technical State University and North Carolina State University, allowing them to be licensed growers for the purposes of conducting research on the commercial uses of industrial hemp.

Under state and federal laws, individuals must be issued a license to participate in the industrial hemp pilot program. Growers in North Carolina who wish to cultivate industrial hemp shall submit an application for a license to the Industrial Hemp Commission, which must be approved by commission members. The Industrial Hemp Commission is responsible for developing rules and applications for participating in the program.

N.C. A&T and NCSU, both being land grant universities, continue to conduct research on industrial hemp as a part of the state's pilot program, as allowed under federal law. These two universities work with farmers to collect data from the private sector while conducting research on the university farms as well. This data is being used to better represent the production and success of the industrial hemp program in North Carolina.

### **3. LICENSING REQUIREMENTS FOR PIS**

To conduct industrial hemp research at N.C. A&T, the principal investigator (PI) must submit a plan of work to the associate dean for agricultural research. This plan should include what will be researched, where the research will be conducted, how the research will be conducted without disrupting ongoing projects, and how and where the material will be handled and stored. The PI must consider labor, storage and space. Since space on the N.C. A&T University Farm is limited, it is recommended that new researchers consider working with existing projects or find local farmers to assist by providing land and data for the PI. In order to participate in the Hemp Research Program, each PI must receive a research license from the North Carolina Hemp Commission. The application can be found at <https://www.ncagr.gov/hemp/application.htm>.

### **4. ENGAGING IN HEMP RESEARCH**

Faculty who have secured external funding to support hemp research must submit a Hemp Activity Form to the associate dean for research. Also, faculty planning to use the University Farm for their research must submit an Access to Farm, Greenhouse, and Lab Request Form and receive approval prior to submitting proposals to funding agencies. Once engaged in hemp research and upon relocating hemp products or derivatives from the initial research location to another location on or off campus, a Chain of Custody Form must be completed and approved. The Chain of Custody Form enables the CAES to comply with state regulations.

Students interested in participating in the industrial hemp program must first obtain permission from the project PI. Once the PI agrees, they will pass the students' information to the staff (or designated personnel) to contact the students and arrange a meeting. At this meeting, the students will be instructed on responsibilities, expectation of duties, field dress requirements, and anything else that the designated personnel deems necessary. At this meeting, the students must complete liability and Code of Conduct (COC) waivers. The liability waiver is the standard liability waiver for anyone working on the farm. This COC will explain the dos and don'ts to the student worker. This COC should include, but may not be limited to, the fact that students are not allowed to (i) work at the field plot without supervision; (ii) handle samples without direct supervision; (iii) remove plants, plant matter or any derivative from the field under penalty of law (if caught they could face criminal charges). The students' signed copies should be kept on file by the designated personnel.

## 5. CAES INDUSTRIAL HEMP TASK FORCE

In 2015, the N.C. House and Senate passed Senate Bill 313, legalizing industrial hemp production in the state. The purpose of the bill was to establish a pilot program in the state in order to enhance agricultural production by providing small farmers an opportunity to generate profits through hemp production. The original legislation, which included the formation of the N.C. Industrial Hemp Commission, was modified (House Bill 992) in 2016 to establish a research program and to expand the original five-member commission to nine members, including N.C. A&T. The governor recently completed his work in forming the commission which will establish the rules and regulations related to testing hemp for THC levels, supervising the growth and harvesting of industrial hemp, and verifying the type of seeds that can be used by licensees. Guochen Yang, Ph.D. represents A&T as a member of the commission.

The purpose of the task force is to provide leadership in coordinating research programs related to cultivating or growing hemp in the state; vet relationships with selected growers who will be licensed to plant and cultivate demonstration plots; and develop guidelines and procedures consistent with those of the Industrial Hemp Commission and applicable to A&T. Currently, there are 11 active members, consisting of CAES hemp researchers, a member of the NC Industrial Hemp Commission, university law enforcement members and Agricultural Communications staff (Table 1).

The task force meets quarterly on an hourly basis; however, there are occasions when it may meet more or less often, depending on the nature of the matters to be discussed. There may also be follow-up meeting discussions and questions amongst the group by email.

## 6. HEMP INVENTORY CONTROL

- A. Planting material** – When seeds or clones are procured, they should be kept by the PI or the research staff designated by the PI until the time of planting. For example, seeds and clones for the 2019 planting season were housed in the Soils Lab on the N.C. A&T Farm and were only accessible through the research staff member with the key to the lab. A Chain of Custody form should be filled out by the PI/research staff and kept with the planting material along with a copy of the PI's hemp permit, the seller's hemp permit and the bill of sale of the seeds or clones.
- B. Planting** – The planting time will be determined by the PI and research staff. Once the planting time has been determined, the research staff will be in charge of seed propagation, clone propagation, or receiving and caring for plants that are to be used in the research study. Permanent greenhouse space, with locks, would ensure limited access to the plants unless granted by the PI. Any time plants are introduced or removed from the

**TABLE 1. LIST OF N.C. A&T INDUSTRIAL HEMP TASK FORCE MEMBERS**

<b>NAME</b>	<b>POSITION</b>	<b>DEPARTMENT</b>	<b>EMAIL</b>
Shirley Hymon-Parker, Ph.D.	Associate Dean for Research	Office of Agricultural Research	sjhymonp@ncat.edu
Guochen Yang, Ph.D.	Commissioner, N.C. Industrial Hemp Commission; Professor	Natural Resources and Environmental Design	yangg@ncat.edu
Abolghasem Shahbazi, Ph.D.	Director of Biological Engineering Program, Director of CREST Center	Natural Resources and Environmental Design	ash@ncat.edu
Daniel Nonte	Interim Director, Agricultural Communications	Agricultural Communications	dmnonte@ncat.edu
Charles Wilson	Chief of Police	University Police Department	cewilson@ncat.edu
Alphanie McCall	Administrative Support Specialist	Office of Agricultural Research	aymccall@ncat.edu
Leon Moses	Farm Superintendent	University Farm	ljmoses@ncat.edu
Sanjun Gu, Ph.D.	Horticulture Specialist	Cooperative Extension	sgu@ncat.edu
Arnab Bhowmik, Ph.D.	Assistant Professor, Soil Science	Natural Resources and Environmental Design	abhowmik@ncat.edu
Osei Yeboah, Ph.D.	Professor, Agribusiness	Agribusiness, Applied Economics and Agriscience Education	oyeboah@ncat.edu
Melissa Holloway, J.D.	General Counsel	Office of Legal Affairs	mjholloway@ncat.edu

greenhouse, a Chain of Custody form should be signed with the PI's permission.

- C. Harvesting** – Harvest time will be decided by the PI and the research team. Harvest will be conducted by the entire Hemp Project Team and any registered N.C. A&T student volunteers. All student volunteers must fill out a waiver and be approved by the PI to work in the project. Once harvest has begun, no one is allowed to harvest without supervision by the PI or the designated research staff. Harvested material will be transported by the designated research staff to the drying/curing chamber, where the plants will be weighed and data will be recorded. The floral material (bud) will be bucked from the stalks and the bud will be weighed and recorded, and then placed into the drying chamber with a secure lock. Once dried, the weight of the dried buds will be recorded and the buds placed into containers and transported to the designated lab in the department by the research staff. The harvest will be secured until transfer to the analytical staff for extraction/distillation. Every time, upon transfer, a Chain of Custody form must be signed by both the designated research and analytical staff.
- D. Transporting** – Transportation of any material will only be done by the PI or designated research staff. When transporting any material – seeds, plants or harvested material – a copy of the PI's Industrial Hemp Permit must be included during transport. A copy of the Chain of Custody should also be with the material at all times.
- E. Storage** – Any time seeds, plants or plant material is being held, there must be limited access to the material. Keeping materials in a locked cabinet, behind locked doors and in a space that is not accessible to non-designated personnel is mandatory.
- F. Sampling** – Sampling of any part of the plant – tissue, flowers or soil – should be done under the supervision of the PI. Once samples have been taken in the field they are to be immediately dropped off for analytical evaluation and a Chain of Custody form must be signed.
- G. Disposal** – All biomass collected from the industrial hemp field should be dried, weighed and processed so that a shelf-stable product can be saved for future testing. All remaining biomass, including but not limited to stalks, leaves, trimmed waste and any leftover biomass, needs to be destroyed in the incinerator at the N.C. A&T Swine Unit. When this occurs, there must be a COC form filled out by the research specialist and a member of the Swine Unit to ensure that all waste was properly destroyed. The research specialist should also take pictures or a video to keep with the COC for records. This is the same process that we would use for any industrial hemp crop that is not compliant with state or federal law, i.e., if the crop tests above the allowable THC limit or “hot.” If this occurs, the crop must be destroyed by using the incinerator at the Swine Unit. Again, the research specialist must have a COC filled out with a signature from a representative at the Swine Unit.



## HEMP CHAIN OF CUSTODY TRACKING FORM

Project Title:

Investigator(s):

Varieties: \_\_\_\_\_

Date/Time of Transfer: \_\_\_\_\_ Location of Transfer: \_\_\_\_\_

DESCRIPTION OF PRODUCT			
Item #	Item type	Quantity	Description of Item (e.g., flower, seed, fiber, tissue)

CHAIN OF CUSTODY					
Item #	Item type	Date/Time	Released by (Signature & ID#)	Received by (Signature & ID#)	Comments/Location



# HEMP CHAIN OF CUSTODY TRACKING FORM

CHAIN OF CUSTODY					
Item #	Item type	Date/Time	Released by (Signature & ID#)	Received by (Signature & ID#)	Comments/Location

CHAIN OF CUSTODY
<p><b>AUTHORIZATION FOR DISPOSAL</b></p> <p>Item(s) #: _____ on this document pertaining to (suspect): _____  is/are no longer needed as evidence and is/are authorized for disposal by (check appropriate disposal method)</p> <p><input type="checkbox"/> Return to Owner      <input type="checkbox"/> Destroy</p> <p>Name &amp; ID# of Authorizing Person: _____ Signature: _____  Date: _____ Telephone Number: _____</p>
<p><b>WITNESS TO DESTRUCTION OF PRODUCT</b></p> <p>Item(s) #: _____ on this document were destroyed by Product Custodian  _____ ID#: _____ in my presence on (date) _____.</p> <p>Name &amp; ID# of Witness to destruction: _____ Signature: _____  Date: _____</p>
<p><b>RELEASE TO LAWFUL OWNER</b></p> <p>Item(s) #: _____ on this document was/were released by Product Custodian  _____ ID#: _____ to</p> <p>Name _____  Address: _____ City: _____ State: _____  Zip Code: _____  Telephone Number: (____) _____</p> <p>Under penalty of law, I certify that I am the lawful owner of the above item(s).</p> <p>Signature: _____ Date: _____</p> <p>Copy of Government-issued photo identification is attached. <input type="checkbox"/> Yes <input type="checkbox"/> No</p>
<p><b>THIS HEMP FLOWER CHAIN-OF-CUSTODY FORM IS TO BE RETAINED AS A PERMANENT RECORD BY THE INVESTIGATORS OF THE PROJECT</b></p>

## 7. TESTING THC LEVELS

External testing is done by sending representative samples to AVAZYME for THC and CBD analysis <https://www.avazyme.com/industrialhemptestinglelaboratory/>.

Conditions used by N.C. A&T Department of Natural Resources and Environmental Design internal testing lab are listed below:

### **DRY**

Dry material to w/w moisture content of between .5%-1.25%

65o C until  $\Delta$ mg/min is 1.

### **HOMOGENIZE**

Remove seeds and stems; grind until uniform.

### **WEIGH**

Place approximately .2000 g of dry homogenous industrial hemp within a 50 ml centrifuge tube.

Record weight of sample within .0001g.

### **EXTRACT**

Decant 40 ml of ACS Grade Methanol into centrifuge tube with industrial hemp.

Place on Wrist Action Shaker for 15 min, shake at highest setting.

### **VIAL PREP**

Use 1 ml syringe, pull sample of methanol from middle of 50 ml centrifuge tube.

Place .22 $\mu$ m, Hydrophobic PTFE filter tip on syringe.

Use syringe to filter sample into 2ml amber vial. Cap.

### **ANALYSIS EQUIPMENT**

Agilent 7890A GC, with FID detector, with Auto Sampler.

Rxi-5ms, 15 m, .25mm ID, .25 $\mu$ m df Column

## ANALYSIS CONDITIONS

### Front Inlet

Mode: Split  
Initial temp: 250 °C  
Pressure: 9.52 psi  
Split ratio: 20:1  
Split flow: 15.6 mL/min  
Total flow: 19.1 mL/min  
Gas Saver: On  
Saver flow: 20.0 mL/min  
Saver time: 2.00 min  
Gas type: Helium

### Oven

Initial Temp: 200 °C at 0 min  
Ramp: 15 °C/min at 300 °C, hold 0 min

## CALIBRATION, ERROR VERIFICATION

Known concentrations of analyte are prepared within methanol across expected concentrations that are identified for retention times associated with a specific signal produced by the detector.

Levels are prepared to match expected responses at corresponding percentages of THC in the 200 mg sample. Example: 0.30% at a 0.200 g hemp sample is 0.60 mg or 600 µg. Extraction in 40 mL of methanol would result in a concentration of THC at 600 µg/40 mL which equals 15 µg/mL.

LEVEL	CONCENTRATION (µg/ml)	THC CONCENTRATION (w/w%)	FID SIGNAL (pa/s)
1	100	2	
2	50	1	
3	25	.5	
4	15	.3	
5	5	.2	
6	2.5	.1	

Plotted on a line; Cannabinoid Concentration Vs FID Signal must achieve  $r^2 \geq .995$  or calibration is rejected.

Each series of analytic samples are running with a blank, a duplicate and a standard.

Blank Vial: Amber vial with only methanol (no THC). If any signal is seen besides solvent peak entire series is rejected.

Duplicate vial: Amber vial with a replicate of a randomly selected sample within the series. If a variance of over 5% is seen between the sample and its duplicate, the series is rejected.

Standard vial: a vial is prepared with a known concentration spike. If a variance is seen of 5% between the known spike and its corresponding calibration point, the series is rejected.

## **REFERENCES**

Sample Prep: Colorado Department of Agriculture Biochemistry Laboratory SOP No.: PT-LBOP-014

Analysis: Colorado Department of Ag SOP No.: PT-METH-031

For more information: <https://www.ams.usda.gov/rules-regulations/hemp/information-laboratories>

## **8. BIOSAFETY PROCEDURES**

### **CROSS POLLINATION**

In order to avoid cross contamination due to pollen transfer to CBD hemp from fiber and seed hemp, considerations must be made. According to research conducted in 1998, cross pollination reduces the plants' essential oils, which are where THC and CBD compounds are contained, by 56%. Male hemp plants flower for 2-3 weeks and each male plant can produce up to 350,000 pollen grains. In order to minimize cross pollination, it is recommended that possible pollination plantings should be located at least 5 miles apart or a dense wind break must be planted. It is important to note that this cannot eliminate the possibility of cross pollination; however, it will drastically reduce the possibility. The PIs of both research projects and the farm manager need to come to an agreement with the CAES Industrial Hemp Task Force on the planting areas before project initiation.

Cross pollination can also occur from within the field. If using seed stock for propagation, it is important to remove all males from the research study, either before or after planting. When using seeds, plants should be sexed before planting to reduce the possibility of males being transplanted into the field of research. Forced flowering can allow researchers to sex the plants before planting in the field. This can be done in either a greenhouse that can be deprived of light or an indoor facility where light can be manipulated. Hemp plants are photosensitive and begin to flower when they receive 12 hours of light and 12 hours of uninterrupted dark. This can be achieved during the winter, if you are in a greenhouse, by manipulating the lighting period inside, or by allowing the plants to get 12 hours of light outside and then moving them inside a light-deprived area for 12 hours. It takes roughly 2 weeks for flowers to begin to form once this change in light has occurred. One would then begin to remove the males over the next 3-5 days, and then return light to the levels of vegetative periods. This will allow the plant to re-

enter vegetative growth until time for field planting.

Caution should also be taken if researchers visit other hemp plantings around the state. If visiting a field where male plants are identified, researchers must change or wash the clothing they were wearing before entering a research field. However, it is a good idea to change clothes before entering any hemp research fields after a visit.

## **SOIL CONTAMINATION**

It is important to understand that bacteria, viruses and other pests can be introduced to hemp research fields by physical means. Contaminated soil can be introduced to a research field by shoe, truck tire, equipment or other carrier. When visiting other hemp plantings around the state, researchers should wear booties or another form of shoe protection to ensure no contaminated soil is brought into their vehicle or back to another researcher's field. Tires of any truck visiting another hemp field planting throughout the state should be washed to avoid cross contamination.

Precautions should be taken during field days or other events when the public will be visiting any hemp research site on the farm. Shoe protection needs to be provided to the public to ensure that no soil contamination be introduced to those research sites. It is also suggested that hand sanitizer be provided to anyone who will be touching hemp plants during the events. Caution should also be taken when prepping the research area for planting. Any equipment used should be washed prior to and after use in the area. For example, when using a rototill attachment for field prep, the tires of the tractor and the rototill should both be washed prior to and after use. This will ensure that no contaminated soil is introduced into the research area or into another researcher's area.

## **PEST INTRODUCTION**

Pests can be introduced to a field as easily as pollen. Aphids, thrips and spider-mites can all be introduced by visitors to multiple fields. Therefore, if a researcher visits another field, it is always recommended that the researcher wear shoe protection and change clothes before entering a research site.

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I hereby confirm that I have read the instructions in the manual.

Name: \_\_\_\_\_

Signature: \_\_\_\_\_