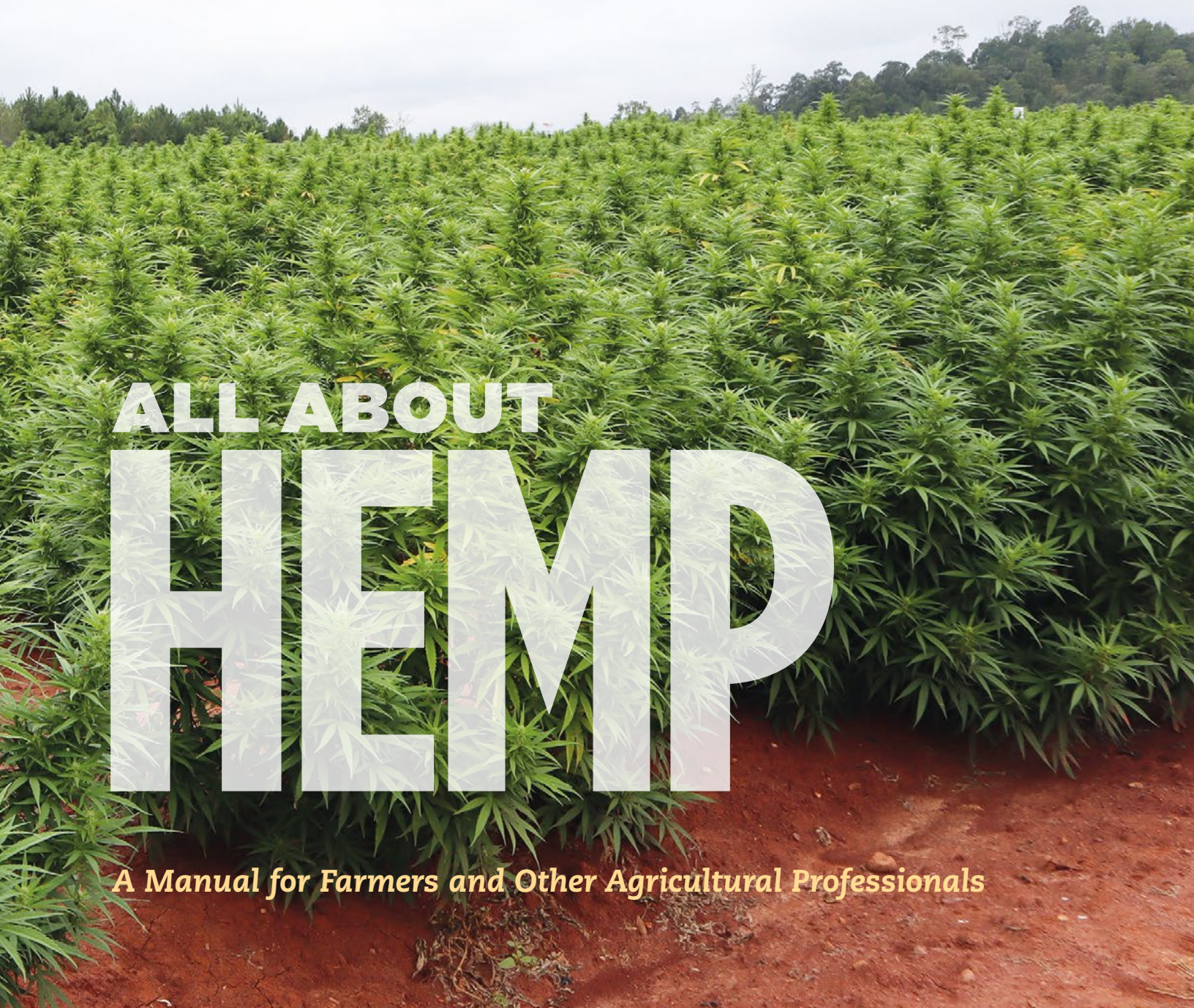




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# ALL ABOUT HEMP

*A Manual for Farmers and Other Agricultural Professionals*

# ALL ABOUT HEMP

## *A Manual for Farmers and Other Agricultural Professionals*



### **PREFACE**

This manual, designed for small-scale hemp growers, extension agents, and other agricultural professionals, is a guide to hemp regulations and research-based production recommendations, using the 2018 Farm Bill's definition of hemp. Hemp plants for CBD (cannabidiol) production are not visually different from marijuana plants, but the two have distinct amounts of the psychoactive compound THC (tetrahydrocannabinol). Hemp has less than 0.3% of THC. Any hemp plant exceeding that amount is illegal and must be destroyed.

In this manual, we cover hemp biology, market and uses, regulations, small farmers and hemp, floral production for CBD, and fiber and seeds/grains production. Each chapter stands alone, although reading the chapters in order will provide an overall picture of hemp and hemp production.

Chapters one through four provide information and chapters five and six are instructional guides for fiber, seeds/grains, and CBD hemp production. At the end of chapters one through four, a list of references has been provided for those wanting to learn more.

The hemp markets and regulations are still very dynamic, and those interested should frequently visit government, university, and industry sites for the latest updates.

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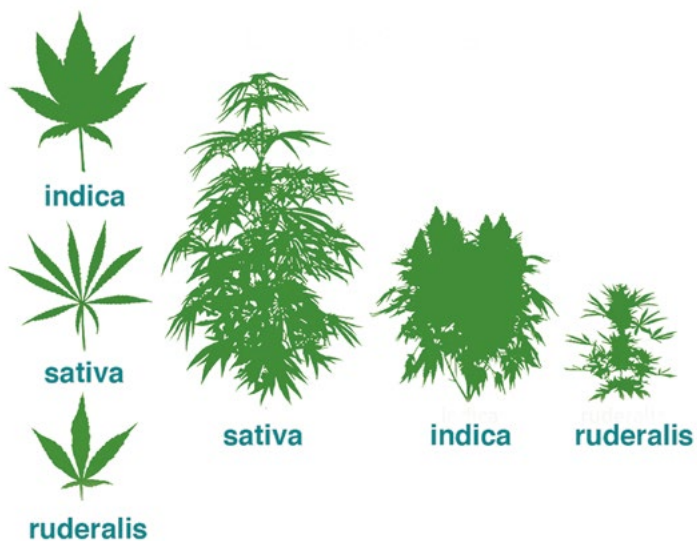
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# THE BIOLOGY OF HEMP

Hemp is a plant of the species *Cannabis sativa*. Hemp originated in Central Asia and was one of the most ancient, domesticated plant species; it has been part of human culture for thousands of years. Today, it is associated with people in almost all parts of the world<sup>1</sup>.

### Cannabis Classification <sup>2,3</sup>



<https://www.alchimiaweb.com/blogen/anatomy-cannabis/> (accessed June 18, 2020).

Cannabis is from the family *Cannabaceae*. Cannabis (hemp) and *Hunulus* (hop) are two important genera in this family.

Genera Cannabis has two species, *C. sativa* and *C. indica*.

*C. sativa* L. includes tall, poorly-branched plants with large leaves and large grey-brown colored grain. It corresponds to fiber hemp.

*C. sativa* was further divided into two subspecies:

*C. sativa* ssp. *spontanea* or *ruderalis*, wild form grown spontaneously outside the cultivated plots.

*C. sativa* ssp. *culta*, cultivated forms grown for fiber and grain.

*C. indica* LAM includes short, abundantly branched plants with small leaves and small, shiny, dark-colored grain. It is characterized by a high content of tetrahydrocannabinol (THC).

## Hemp Plant

Hemp is a warm-season, annual herbaceous species. It is a short-day dicot and begins to flower as the days shorten after the June 21 summer solstice. Naturally, it is dioecious (male and female flowers on separate plants, i.e., there are male plants and female plants). Still, some commercial cultivars are monoecious (a single

plant will have both male and female flowers). Hemp's morphology (the general aspects of biological form and arrangement of the parts of a plant) varies according to the growing conditions. Plants tend to increase branching at low plant-density rates but form long, straight unbranched stems at high plant density<sup>4</sup>.



*Hemp male (left in the left and middle pictures) and female (right in the left and middle pictures) dioecious plants, and a monoecious plant with male and female flowers (right).*

## Roots

Direct-seeded hemp has primary roots that can grow down to 6.5 feet, and secondary roots can extend as much as 2.5 feet, although the highest root density occurs in the top four inches of soil. About 50% of hemp's root biomass is located within 40 inches of the topsoil. The ratio between the below-ground and above-ground biomass of a hemp plant is about 0.18<sup>5</sup>. Male plants often have a weaker root system than

female plants. Hemp plants grown for the female floral buds (ultimately for cannabinoids) that started with clones or seedling transplants will lose their taproots; therefore, their roots are not as deep as those of the direct-seeded plants.

# CHAPTER 1

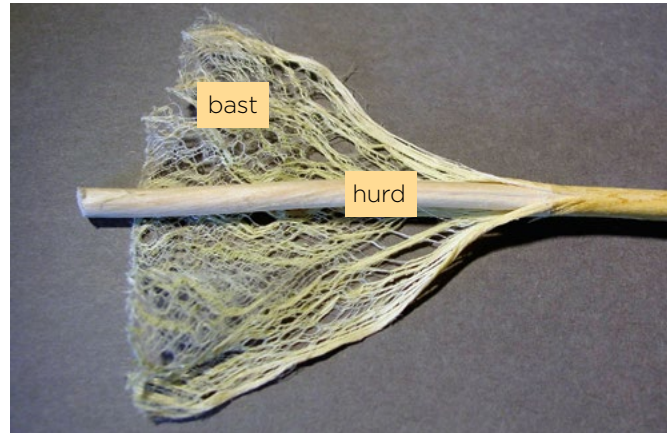
## THE BIOLOGY OF HEMP

### Stem

Hemp, especially fiber and grain cultivars, has a long stem and few branches when planted at a high density. As a plant matures, a rigid, woody stem develops, ranging in height from three to 19 feet and 1/4 -3/4 inch in diameter, and does not have much foliage besides near the top of the plant. Uncrowded plants, such as transplanted clones or seedlings for cannabinoid production, have many spreading branches, and the central stalk can grow one to two inches in diameter. They may need a trellis to prevent falling due to their

heavy above-ground biomass and shallow roots.

Male hemp plants tend to be 10%-15% taller but are slimmer than female plants. The stems of most varieties are hollow. The outer portion of the hemp stem contains strong and long *bast fiber*, which provides the strength and quality attributed to the crop. The inner portion of the stem contains the *hurd fiber*, which is considered a by-product and is used for paper, animal bedding, and building materials.



Hemp stem showing bast and hurd fibers. Left: <https://hemp.cals.cornell.edu/media/> retrieved Sep. 9, 2021. Right: <https://upload.wikimedia.org/wikipedia/commons/2/2d/Hanfstengel.jpg> retrieved Sep. 9, 2021.

### Leaf

A direct-seeded hemp plant will have two cotyledons (the first set of leaves from a seed) above the ground after germination, and then true leaves will develop. True leaves come in pairs on the stem with an opposite arrangement at the vegetative stage but become an alternate arrangement as the plant flowers. A true leaf has a petiole and a hand-shaped leaf blade (palmate compound, a leaf with several lobes), which typically consists of an odd number (up to 13) of folioles (leaflets) with serrated edges, depending on the species and the

position of a leaf on the stem. The first pair of true leaves have one leaflet, the second pair have three, the third pair have five, and so on, although there are exceptions. A *C. sativa* (fiber and grains) leaf can have five to 13 leaflets (usually seven or nine), while a *C. indica* leaf typically has less than seven leaflets. At the top of a flowering hemp plant, the leaflet number diminishes to a single leaflet per leaf. *C. indica* tends to have darker leaf color than *C. sativa*<sup>6</sup>.

# CHAPTER 1

## THE BIOLOGY OF HEMP



*Hemp leaves of different growth stages and with a different number of leaflets on a leaf. The last two photos show developing female and male flowers, after this stage, number of leaflets on a leaf start to decrease.*

# CHAPTER 1

## THE BIOLOGY OF HEMP

### Flowers

Hemp plants have imperfect flowers. Naturally, hemp is dioecious, so there are male and female plants. Some commercial cultivars may be monoecious, meaning a single plant will have both male and female flowers.

Male plants are essential for grain/seed production as pollination is needed to produce seeds. The male inflorescence forms a loose cluster of flowers on the end of a central stem called a rachis. Male flowers have five greenish-yellow sepals enclosing five tightly packed stamens that will open to reveal anthers, which will release pollen. Hemp is primarily wind-pollinated, but bees can also pollinate the plant. For pure-bred seed or cannabinoids production, an isolation distance of one to three miles or more is recommended, depending on site topography. Male plants die soon after shedding their pollen.

Female flowers appear at the apex of a stem and are borne on racemes. A female flower has two pistils and a single seed pod. The pistils are enclosed by a small sheath called a bract. The bracts bear the highest density of trichrome glands that produce cannabinoids including CBD and THC. The (female) floral buds are the center of CBD hemp production. In this regard, female flowers should not be pollinated because fertilized female flowers will develop seeds, losing the capacity of producing a high level of cannabinoids.

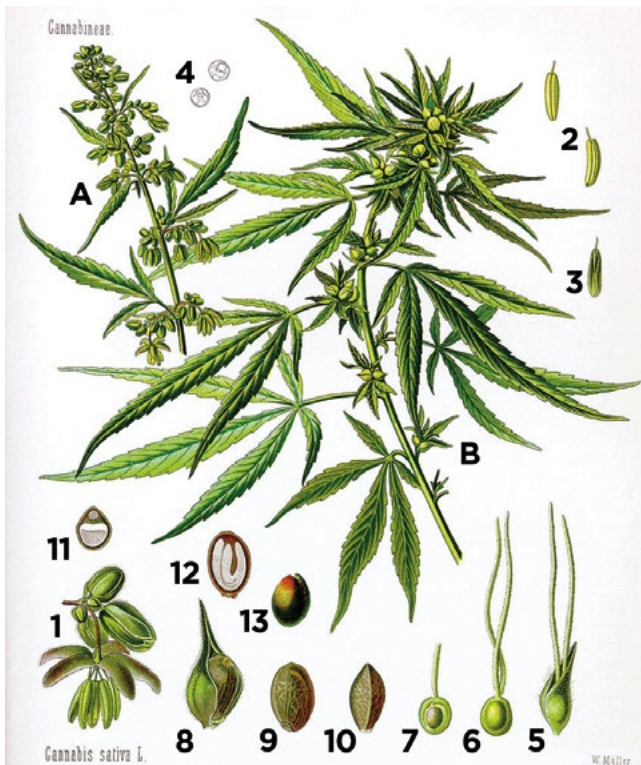
### Types of Flowers and Plants

**A perfect flower:** a flower with both male and female parts.

**An imperfect flower:** a flower that is missing male or female parts.

**Dioecious plants:** plants such as asparagus and kiwi that have male and female flowers on separate plants. Flowers are imperfect.

**Monoecious plants:** plants such as sweet corn, tomato, cucumber, and okra that have male and female flowers on one plant. Flowers can be perfect (tomato) or imperfect (cucumber).



A: Male plant, B: Female plant.

1. male flower, enlarged detail; 2 & 3. pollen sac;
4. pollen grain, enlarged; 5. female flower with bract; 6. female flower, bract removed;
7. female seed with bract, longitudinal section;
8. seed with bract partially removed; 9 & 10. seed without bract; 11. seed cross section; 12. seed longitudinal section; 13. seed without hull

(Franz Eugen Köhler 1887. <https://www.alchimiaweb.com/blogen/anatomy-cannabis/> with revisions).



# CHAPTER 1

## THE BIOLOGY OF HEMP



*Top: male flowers and pollen (right)*

*Bottom: female flowers*



*Non-pollinated female floral buds are the center of cannabonoids production.*

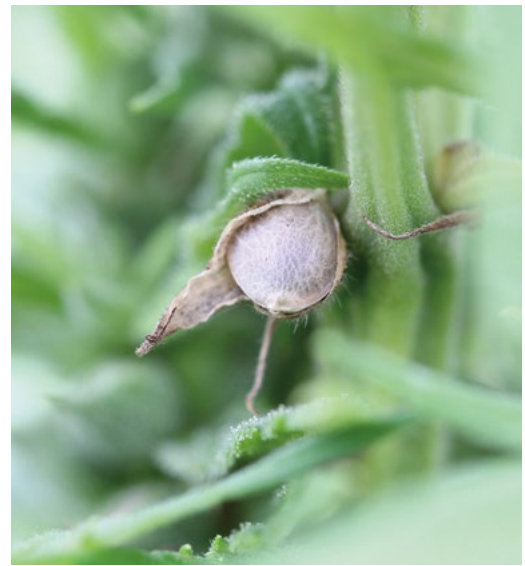
# CHAPTER 1

## THE BIOLOGY OF HEMP

### Fruit and Seed

The hemp fruits are commonly referred to as seeds (small dry nuts). The ovule produces an indehiscent fruit, botanically termed an achene, in which the embryo (seed) takes up all the volume. Fruit contains a single seed surrounded by a thin pericarp, the “wall” surrounds the seed. The seed is smooth, elliptical (1/8 to 1/4 inch long), and the large part of its mass is the

two cotyledons, which are rich in oil and protein<sup>2</sup>. The weight of the achenes ranges from 0.1 to 2.5 ounces although 0.5 to 0.75 ounces is more common. Monoecious cultivars have smaller seeds than dioecious cultivars. Hemp seeds do not ripen evenly, and they shatter when mature, resulting in seed loss and future volunteer plants.



*Hemp seed(s) on a plant (top) and harvested (bottom).*

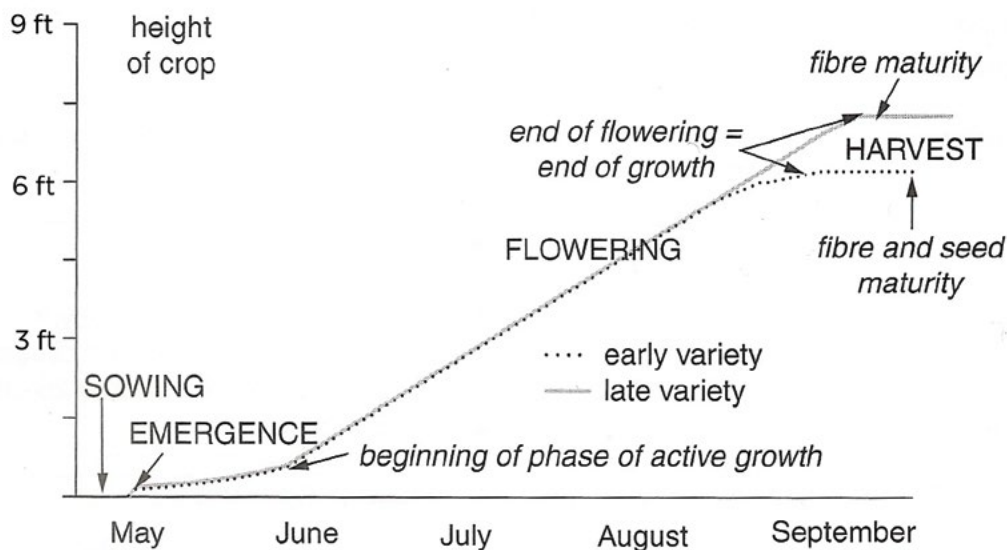
*Hemp nuts without or with seed coats (hulls), and hulls (bottom left); Seeds just harvested showing uneven ripening as indicated by the varied patterns and colors of seed surface (bottom right).*

## The Hemp Life Cycle and Growth Stages

The hemp life cycle (four to six months) has four growth stages: germination and emergence, vegetative stage, flowering and seed formation, and senescence. The vegetative phase was further divided into juvenile, photo-sensitive, and flower development phases.

More specifically, starting from sowing, the growth stage of *fiber hemp* includes emergence, implantation, active growth, flowering, full flowering, and end of

flowering<sup>2</sup>. *Seed hemp* will have an additional seed development and mature stage before seed shattering. *Floral hemp* (for cannabinoids) can start with clones or seeds. If starting with seeds, plants will have similar growth stages as *seed hemp* plants do. However, the female flowers of floral hemp will bloom but should not be pollinized. *Floral hemp* started with clones do not have the seed germination and implantation stages.



### *The growth stages of fiber and seed hemp<sup>2</sup>.*

- **Emergence:** from sowing to the emergence of cotyledons, which takes about four to 10 days, depending on soil moisture status.
- **Implantation:** developing more roots than stem/leaves. It is about three weeks from emerging. Plants will have grown to one to two-feet high and three pairs of leaves.
- **Active growth:** from implantation to the start of flowering. The yield of hurd and bast fiber is generated during this stage.
- **Flowering:** the appearance of the first flowers.
- **Full flowering:** from the appearance of the first flowers to the opening of the last female flowers. This stage is relatively fixed regardless of the sowing dates for a cultivar.
- **End of flowering:** the fertilization of the last female flowers.
- **Seed development and mature:** from the end of flowering to physiological maturity of the seeds. It takes about 40 days.
- **Senescence:** from maturity to germination of the next season.

# CHAPTER 1

## THE BIOLOGY OF HEMP

### Environmental Requirement, Physiology and Resource Use Efficiency

Hemp has a wide range of environmental adaptations, but cultivars will perform better in their own areas of development. Light, air and soil temperatures, soil and its mineral nutrients, and water availability in soil are the main influences of hemp growth and development. The following information applies mostly to fiber and seed hemp<sup>7</sup>, although floral hemp would respond similarly to environmental factors.

**Light:** 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. The radiation use efficiency of 2.0-2.2 grams/MJ of PAR (*photosynthetically active radiation*) during the development stage and 1.1-1.2 grams/MJ after flowering were observed in Northern Europe. Declining in the radiation use efficiency post-flowering is associated with losses of shed leaves, increase in growth respiration due to the synthesis of fat and protein in the seeds, reduction of gross crop photosynthesis due to senescence of the canopy, and synthesis of lignin in the stems. Hemp's radiation use efficiency values are at a lower range compared to other crops such as rice, wheat, and potato.

**Temperature:** The base temperature for the emergence and vegetative growth is 34 degrees F, and the optimal growth temperature for hemp is 66-77 degrees F. Hemp seeds will germinate in eight to 10 days at soil temperatures of 46-50 degrees F. The young plants can survive frost as low as 23 degrees F until they have four to five pairs of leaves. About 3,400-3,600 degrees F Growing Degree Days (GDD) are needed for fiber hemp production, and 4,800-5,400 degrees F for seed hemp to mature, using 34 degrees F as the base temperature<sup>4,9</sup>.

#### Resource Use Efficiency (RUE)



Resource use efficiency is defined as the amount of biomass produced per unit of supplied resource<sup>7</sup>.

RUE is commonly applied to explain and understand the link between potential and realized productivity or biodiversity effects on ecosystem biomass production.

#### Growing Degree Day (GDD)



Plant growth and development only occurs when the temperature reaches to a threshold, which is called the base temperature. Growing Degree Days estimate the heat accumulation of a species and predict the growth and development of the species using the daily mean temperature and the base temperature.

$$GDD = T_{\text{mean}} - T_{\text{base}}$$

Where  $T_{\text{mean}}$  = daily mean temperature, which is calculated as  $(\text{high temperature} + \text{low temperature})/2$ .

If the mean temperature is at or less than the base temperature for the day, the GDD for that day will be zero.

The base temperatures vary among plant species and are determined experimentally. Although not perfect, GDD are more reliable than calendar days in predicting crop growth and development including maturity.

**Water:** About 20 to 28 inches of water is necessary over the growing season for industrial hemp, with 10 to 14 inches of water needed during the vegetative period. The water use efficiency (WUE) of industrial hemp is 0.02 pounds biomass per gallon of water at early harvest (beginning of flowering) and 0.03 pounds biomass per gallon of water at the end of flowering.

**Soil and mineral nutrients:** Hemp does best on 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. Hemp requires a near-neutral pH for optimal growth. A pH of 6.0-7.5 is suitable. Hemp grows fast and requires substantial available nutrients to produce high biomass yields. It requires approximately the

same fertility as wheat. The recommended fertilization rate for fiber hemp is N 70-100 pounds/acre, P 0-45 pounds/acre, and K 45-178 pounds/acre. The effect of nitrogen (N) on stem yield was positive up to 215 pounds/acre, but above 85 pounds/acre, the best fiber yield and quality decreased. The nitrogen use efficiency (NUE) of industrial hemp has not been quantified well. Reports indicated that NUE differed greatly among cultivars, with a wide range of 7.5-61.7 pounds biomass yield for each pound of nitrogen. In June 2020, North Carolina released soil fertility management for hemp production (Soil Test Crop Code 310), with the target soil pH of 6.2 for mineral soils (Table 1)<sup>10</sup>.

*Table 1. North Carolina soil fertility guidelines for floral, fiber, and seed/grain hemp.*

Hemp types	Production system	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	S	B	Target soil pH		
							Mineral	Mineral Organic	Organic
Floral	Open beds Plasticulture	80-120	0-150	0-150	0-25	0-1	6.2	5.5	5.0
Fiber	Field	50-100	0-150	0-150	0-25	0-1	6.2	5.5	5.0
Seed/Grain	Field	100-150	0-150	0-150	0-25	0-1	6.2	5.5	5.0

Note: Application rate in pounds/acre, based on recent soil test results, soil type, and crop history.

# CHAPTER 1

## THE BIOLOGY OF HEMP

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# HEMP USES AND MARKETING

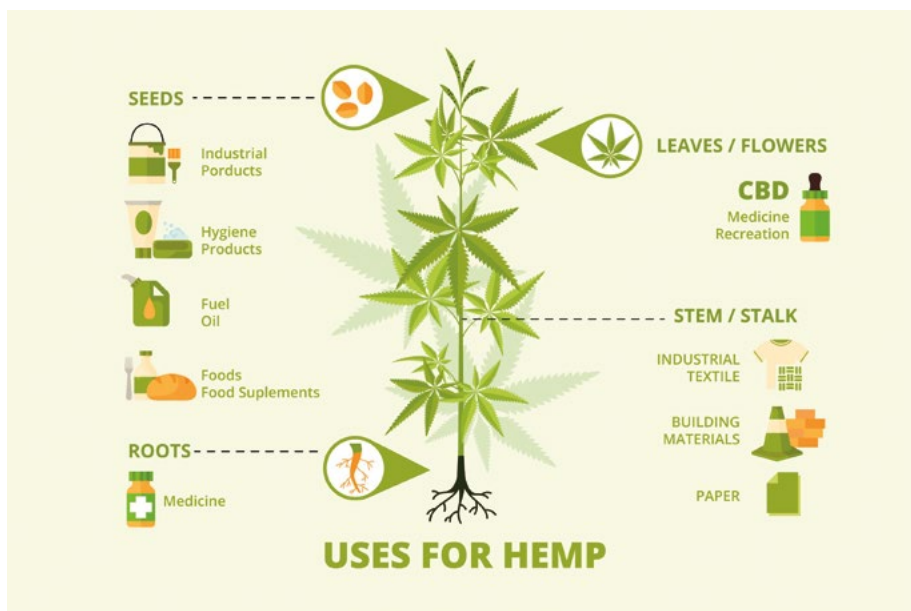
Human beings have used hemp for thousands of years. Traces of hemp have been found in China dated to 8000 BCE. The first plant-based writing materials, invented by the Egyptians in the form of papyrus around 2900 BCE gave way to Chinese hemp paper around 700 BCE, with Arabs adopting the practice in 900 AD. Hemp made its way to North America in the early 1600s, where the Jamestown colony grew the plant to make rope, sails for ships, and clothing. In the 1700s, the British Crown required American colonies to grow hemp to supply warships with cordage and sails<sup>1</sup>. Indeed, the Declaration of Independence was written on hemp paper. When the first Americans headed west, their Conestoga wagon covers were made from hemp<sup>2</sup>.

Hemp was widely grown in the U.S. until the mid-1930s when a combination of a rising temperance movement, an active campaign against hemp by those with competing business interests, and public sentiment decrying the psychoactive effects of hemp's cousin marijuana spelled the end of legal, widespread production in the form of the Marijuana Tax Act of 1938<sup>3</sup>. Except for a brief period during WWII, when the War Department encouraged hemp production to offset the loss of sources of hemp controlled by

opposition forces, hemp in America was virtually a forgotten crop. Renewed interest in hemp as an agricultural commodity increased in the late 20th century. When restrictions were finally eased by way of the Farm Bills of 2014 and 2018, many farmers stood ready to exploit this versatile crop once again. It has been claimed there are over 25,000 products made from hemp<sup>4</sup>. All parts of the hemp plant can be used. Stalks and stems for fiber, seeds for grain and oil, and flowers for cannabinoids.

All types of clothing can be made from hemp - even shoes. Hemp's use for rope making is well known. Hemp rope is of impressive strength and has been used as cordage for ship's anchors. Hemp is also used for construction and insulation. Hemp concrete or hempcrete, a hemp-infused concrete, is fire resistant, holds heat well, and is an effective sound-proofing material<sup>5</sup>.

Hemp can be used for personal care in the form of soaps, beauty products, and moisturizers. Hemp oil can be used in paints, ink, and varnish. While advocates continue to push for hemp to be used in human food and animal feed, the U.S. Food and Drug Administration (FDA), which has regulatory authority through the Federal Food, Drug, and Cosmetic Act, has to date generally banned the use of hemp in these products. Exceptions are hulled hemp seed, hemp seed protein, and hemp seed oil, which have received Generally Regarded as Safe (GRAS) exemptions and can be legally marketed in human foods without food additive approval, provided they comply with all other requirements and do not make disease claims.



*Uses of hemp illustrated (image from freepik.com).*

## CHAPTER 2

# HEMP USES AND MARKETING

### Fiber

Hemp is highly productive as a fiber plant, surpassing most commercial tree species in terms of fiber produced per acre. Hemp fiber has many qualities, such as strength and durability, making it useful in a wide range of products. Hemp plants contain two main types of fibers. Bast fibers or long fibers are found in the skin or bark of the stem, while hurd fibers, or short fibers, are found in the stem's inner, woody core (see photo in Chapter 1). Bast fibers are characterized by their long length, high cellulose, and

low lignin content. Hurd fibers are short and have a higher lignin content<sup>6</sup>. Hurd fibers were at one time considered a waste by-product of bast production; however, hurd has been found useful for insulation, construction materials, and other applications such as medium-density fiberboard, building blocks, and hemp concrete. Textiles, clothing, ropes, nets, and paper are long-standing uses for bast fibers. Bast fibers can also be used in caulking materials and in brake and clutch linings<sup>7</sup>.

### Seeds

Hemp seeds have potential as a human and animal food source. However, food products for human consumption must be approved by FDA and by the Association of American Feed Control Officials (AAFCO) for feed products<sup>8</sup>. Hemp seed contains 20%-30% edible oil, 25%-30% protein; 20%-25% fiber; 20%-30% carbohydrates; and other essential nutrients and vitamins<sup>9</sup>. The protein component includes eight daily essential amino acids

recommended for the human diet. These proteins can be used to create tofu, veggie burgers, butter, cheese, milk, and ice cream.

Seed meal, seed powder, and protein-rich flour can be made from hemp seeds, which could lower cholesterol and blood pressure. Iron, magnesium, and zinc are other important mineral nutrients found in hemp seeds<sup>10</sup>.

### Seed Oil

Trends toward health-consciousness may drive increased market share for this aspect of hemp production. Body and skin-care products — shampoo, soap, creams, and hair conditioner, can be manufactured from hemp seed oils<sup>5</sup>. Hemp seed oils may have value as nutritional supplements as they are rich in linoleic acid, antioxidants, Omega-6, Omega-3, essential fatty

acids, and unsaturated fatty acids. Linoleic acid has value as an anti-inflammatory. The hemp seed oil has a pleasant flavor and can be used like olive oil and for salad dressing. Lighting oil, soaps, paints, varnishes, solvents, putty, and industrial oils are additional uses for hemp seed oils.

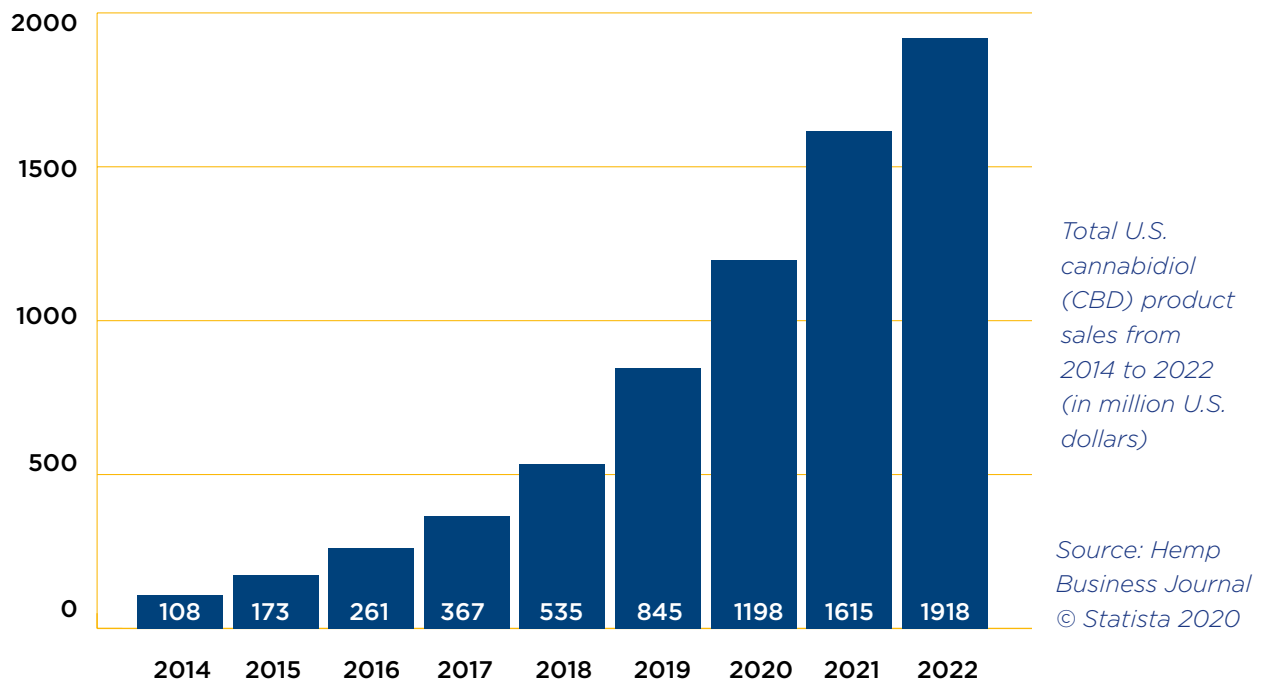


### CBD and Other Cannabinoids

The cannabis plant contains more than 120 cannabinoids. CBD, a non-psychoactive component extracted from hemp plants, is one such compound. CBD oil is different from hemp seed oil. CBD can be extracted from many parts of the hemp plant, but the highest concentrations are found in the floral buds or unpollinated female flowers. CBD was first known to be extracted from cannabis plants in the 1930s and has since been found to have the potential to treat inflammation and anxiety. It may well be a neuroprotective agent and an antioxidant<sup>5</sup>. Through

the years, CBD has been tested to treat arthritis, cancer, diabetes, neurodegenerative diseases, and pain.

Wild claims about CBD abound, with some claiming CBD will transform agriculture and human health. These claims cover the spectrum and should be regarded cautiously<sup>11</sup>. Still, hemp for CBD may be the fastest-growing emerging market segment for hemp products.



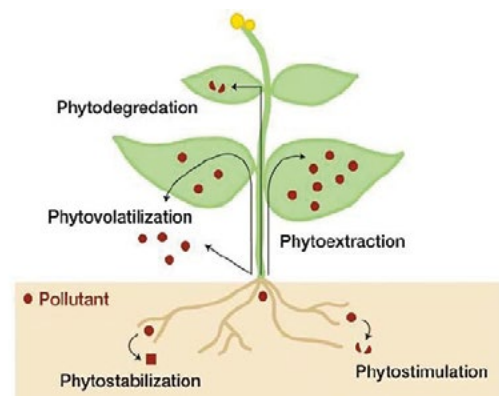
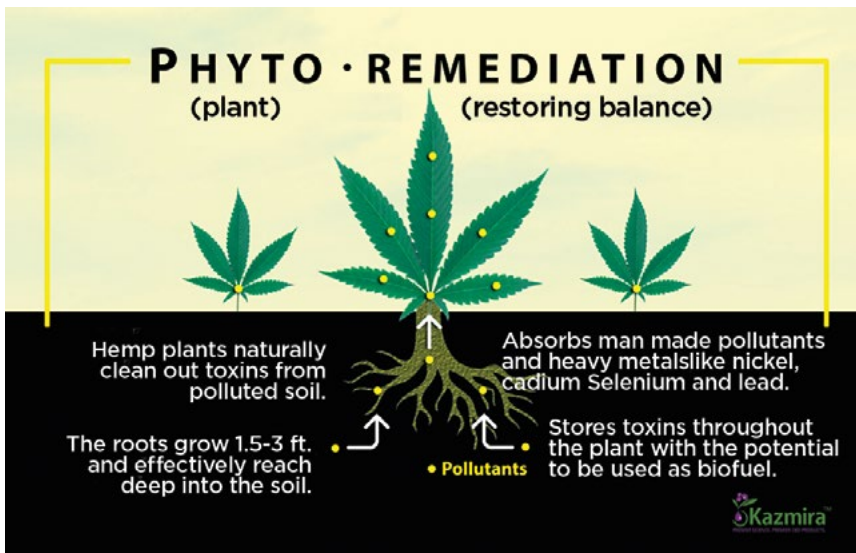
To reiterate, as is the case with any part of the hemp plant to be used as a food source, the FDA tightly regulates all uses of hemp for food and medicine. All potential food and medicinal products will be subjected to rigorous FDA testing before finding their way to the marketplace. To date, only one CBD-based medication, Epidiolex, to treat seizures in two rare forms of epilepsy, has gained FDA approval<sup>12</sup>. Still, the FDA recognizes the potential of CBD in such products and remains committed to improving

the regulatory pathways to legal marketing with consumer health and safety at the forefront.

Another cannabinoid – cannabigerol (CBG) – has drawn interest in recent years. Preliminary studies suggest CBG holds considerable therapeutic promises. CBG is in low concentrations in most cannabis plants but breeding efforts have been attempted for CBG-rich cannabis cultivars.

## CHAPTER 2 HEMP USES AND MARKETING

### Environmental Benefits of Hemp



*Hemp and phytoremediation (Infographic [revised for legibility] from Kazmira, Inc. and National Hemp Association).*

**Phytoremediation.** Hemp plants are suited for phytoremediation, an aspect of bioremediation that uses living organisms – in this case, plants – to break down hazardous substances into less toxic or even non-toxic substances<sup>13</sup>. Phytoremediation includes the ability of plants to take up heavy metals such as cadmium, lead, copper, and nickel.

Fiber hemp varieties with their deep root systems are particularly adept at this form of scavenging. Hemp was planted at the Chernobyl nuclear disaster site to help remediate the contaminated soil<sup>14</sup>. Although heavy metal concentrations appear throughout the plant, the highest concentrations are found in the leaves.

**Carbon sequestration.** The rapid growth of hemp plants allows hemp to convert CO<sub>2</sub> to biomass quickly. Hemp can absorb 8.9 tons of CO<sub>2</sub> per acre. As most of the accumulated CO<sub>2</sub> is stored in the stems rather than roots and leaves, hemp stalks can be a suitable feedstock in the production of bio-char. The 5.3 tons of biochar per acre annually produced by hemp waste (stalks) could improve carbon sequestration in soils,

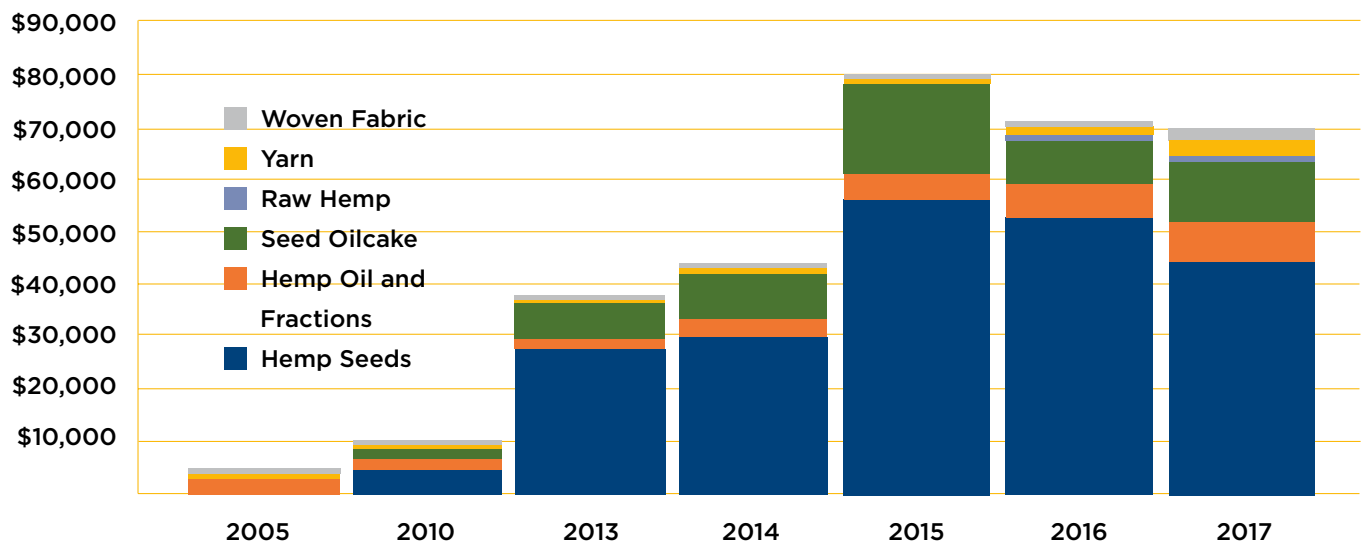
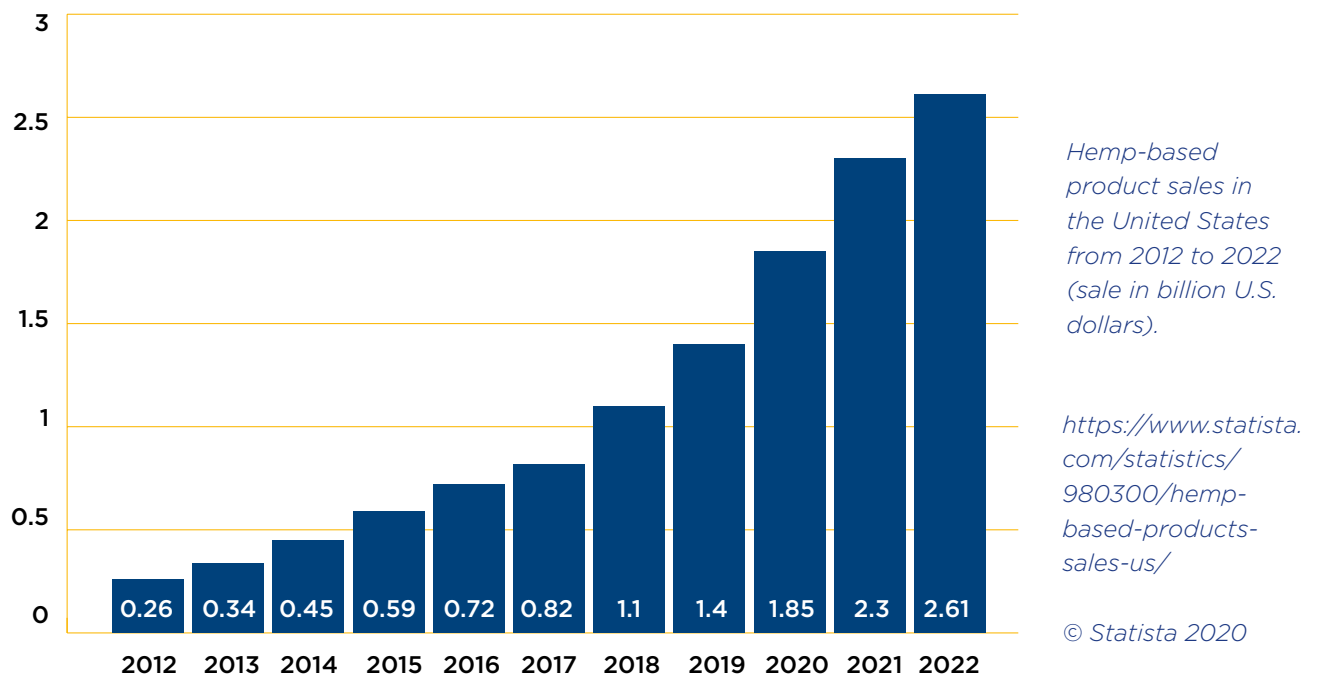
potentially mitigating the effects of global warming<sup>13</sup>. Water bottles and other polymer-based plastic fiber products could substitute up to 50% of those materials with hemp fibers. Using a natural fiber composite could save up to 3.07 million tons of CO<sub>2</sub> emissions<sup>13</sup>.

**Biomass and bioenergy.** Due to its high biomass and energy concentration per acre, hemp is recognized as an energy source plant. Hemp's ability to control weeds and improve soils coupled with low pesticide requirements increases hemp's energy efficiency. Renewable energy could be made from hemp because of its low sulfur emissions and low ash content when burned in biomass boilers using gasification and combustion. Hemp biomass can be converted into biogas and ethanol<sup>15</sup>. A 2017 study by researchers at the University of Kentucky and the Idaho National Laboratory evaluated a production system that would convert hemp grain and stems into ethanol. For every dry ton of hemp stems, approximately 82 gallons of ethanol would be produced<sup>16</sup>. Hemp biomass can be pelletized to use as heating fuel. This presents a marketing opportunity, particularly in regions with long winters already accustomed to using pellet stoves<sup>17</sup>.

## Marketing

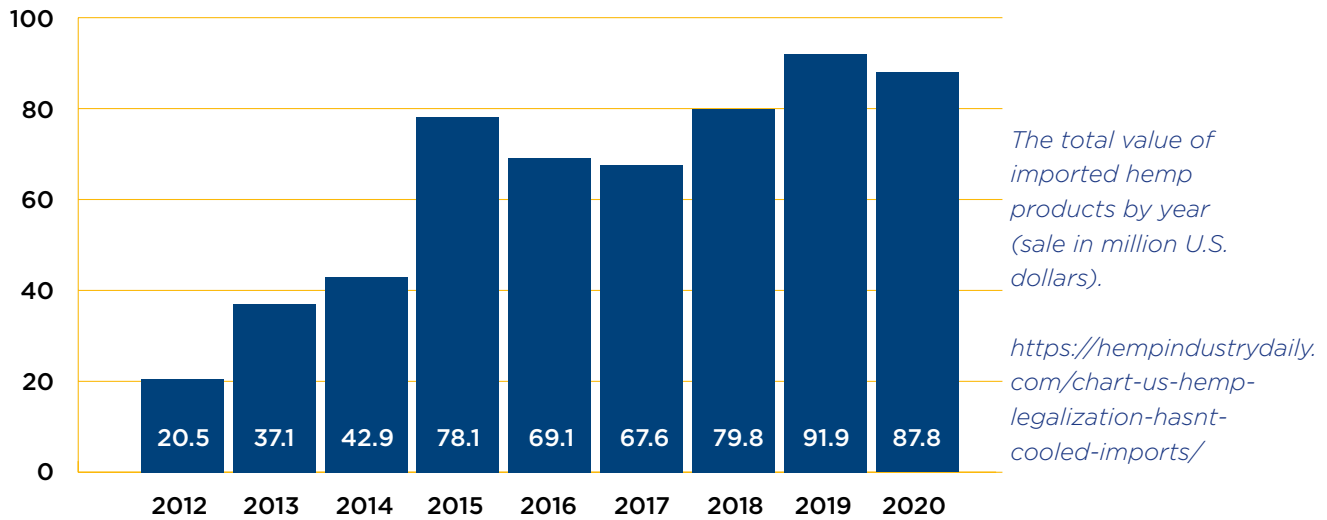
Despite the enthusiasm for the return of hemp products to the marketplace, the market potential for hemp remains unclear, although U.S. hemp-based products sales will continue to grow. However, one

could be optimistic given the dollar value of hemp products imported into the U.S.- \$67.3 million in 2017 and \$ 87.8 million in 2020<sup>18,22</sup>.



*U.S. hemp product imports by categories (2018, Farm Bureau).*

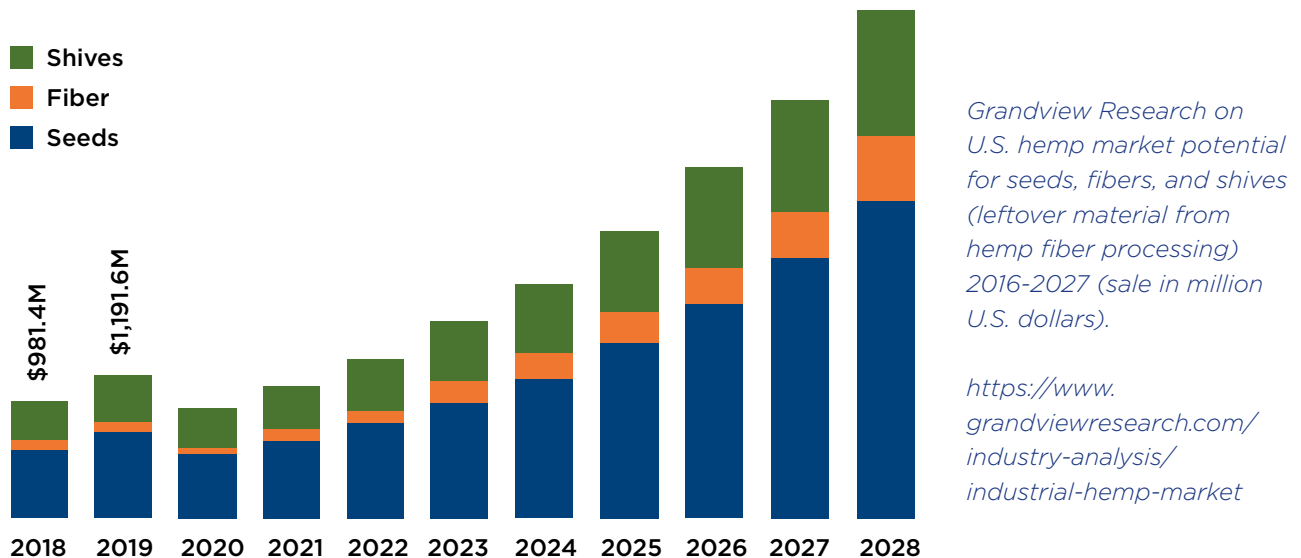
## CHAPTER 2 HEMP USES AND MARKETING



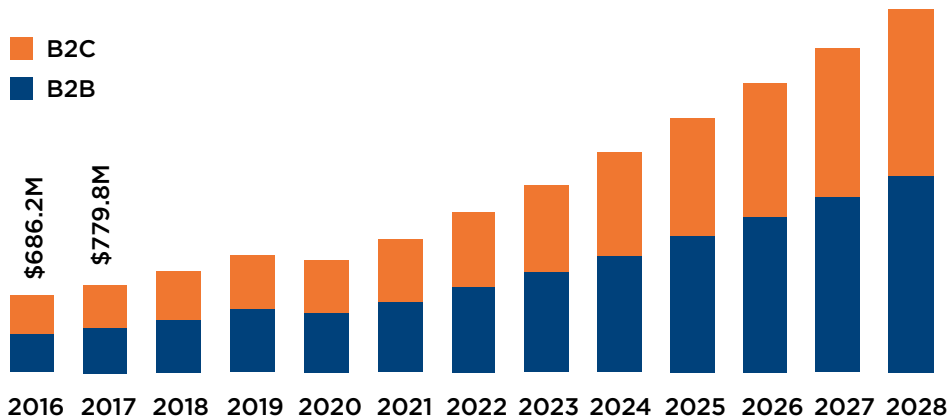
U.S. hemp producers face additional challenges in the form of intense competition from the world's major hemp-producing countries, most of which have hundreds of years of experience cultivating the crop. U.S. producers will face a steep learning curve in attempting to penetrate these well-established markets. Still, given the tens of thousands of goods manufactured from hemp, niche markets may afford a way forward for new farmers. Solid working relationships between federal and state governments, growers, buyers, processors, and consumers will be critical to any potential for developing U.S. markets for hemp.

As the hemp market evolves, supply is currently outpacing demand. This is typical of a new industry, with failures and bankruptcies being common. As the industry transitions into a maturity phase, market demand and supply will become more aligned, resulting in an equilibrium of growers, acreage, processors, and buyers<sup>19</sup>.

Despite hemp's early struggles and growing pains, market projections remain optimistic. According to a report published by Grandview Research, a marketing research company, all segments of the hemp market are projected to continue to grow in the coming years. There is a significant uptick for hemp fiber and seeds and hemp CBD.



## CHAPTER 2 HEMP USES AND MARKETING



*U.S. hemp CBD market potential 2016-2028, showing business-to-business (B2B) and business-to-consumer (B2C) channels. Source: Grandview Research*

The projections are echoed by data from New Frontier Data/Hemp Benchmarks

- **Fiber:** Wholesale market for processed hemp fiber reached \$47.1 million in 2020 and is estimated to reach \$82.2 million by 2025.
- **Seeds:** The U.S. is the largest user of hempseed for human consumption; retail sales for hemp food products are estimated to have reached \$67.1 million in 2020 and are projected to reach \$144.1 million by 2025.
- **CBD:** U.S. consumer spending on CBD is estimated at \$3.83 billion in 2020, projected to reach \$6.26 billion by 2025<sup>20</sup>. Though hemp fibers lead the global market, in the U.S., hemp CBD continues to grow rapidly. It is expected to drive the U.S. market with an annual projected growth rate of 12.3% from 2021-2026, due primarily to the perceived, although as yet unproven, health benefits<sup>21</sup>.

## CHAPTER 2

# HEMP USES AND MARKETING

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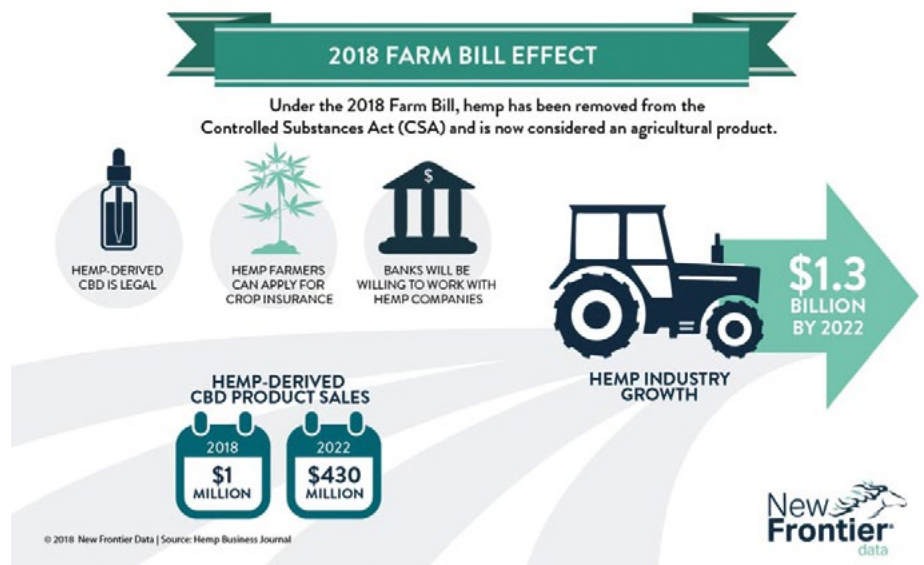
# FEDERAL AND NORTH CAROLINA REGULATIONS ON HEMP PRODUCTION

Regulation of domestic hemp production has a long history entwined with legal concerns, business interests, and farmer livelihood. A comprehensive dive into the long, complex timeline from a virtual ban on hemp in the 1930s to descheduling and, in some states, decriminalization of hemp is beyond the scope of this manual. Instead, we will provide a brief history of, as well as the current federal and state regulations on hemp production and testing.

## Federal Hemp Regulations

The current law related to the production of hemp for fiber, grains, and CBD begins with provisions enacted in the 2014 and 2018 Farm Bills. **The 2014 Farm Bill** allowed colleges and universities and state departments of agriculture to grow hemp under the control of state pilot programs if so permitted by state law<sup>1</sup>. The 2014 Farm Bill also defined “*Industrial Hemp*” and set a threshold for THC at 0.3% dry weight. All cannabis varieties remained Schedule 1 Controlled Substances and subject to the oversight of the Drug Enforcement Agency (DEA).

**The 2018 Farm Bill** legalized (*industrial*) hemp as an agricultural commodity, removing hemp from the Schedule 1 Controlled Substances list. This bill, which has a tremendous effect on the hemp industry, also cleared the way for hemp to become eligible for Federal Crop Insurance and streamlined the process for the Federal Crop Insurance board to develop hemp policies. For more information on this issue, see *chapter 4* entitled “Hemp and Small Farmers.”



*The impact of the 2018 Farm Bill on hemp (Hemp Business Journal, 2018. New Frontier Data. Accessed July 14, 2020).*

The Bill also highlighted what was illegal, including producing plants with more than 0.3% THC content and cultivating hemp without a license. In addition, the 2018 bill also charged the United States Department of Agriculture (USDA) with drafting rules to establish and administer a U.S. hemp production program. Under this rule, states that wanted to pursue hemp regulatory authority could submit

plans to the USDA secretary for approval. USDA issued its Interim Final Rule (IFR) in October 2019. The issuance of the IFR started a two-year clock requiring the USDA to have a Final Rule in place by Nov. 1, 2021. Under the terms of the IFR, all state pilot programs were to expire at the end of October 2020<sup>2</sup>.

## CHAPTER 3 REGULATIONS ON HEMP PRODUCTION



### The Difference Between USDA's Interim Final Rule and the Final Rule

	INTERIM FINAL RULE	FINAL RULE
DATE ISSUED	10/31/2019	01/15/2021
STATE PILOT PROGRAMS	Expire Oct. 31, 2020	Expire Jan. 1, 2022
SAMPLING BEFORE HARVEST	15 days	30 days
THC SAMPLING	Total THC (delta-9, THCA)	Total THC (delta-9, THCA)
THC TESTING THRESHOLD FOR NEGLIGENCE VIOLATION	0.5%. If grower incurs three violations within five years, grower license revoked.	1.0%. Grower cannot incur more than one violation per calendar year. Three violations in five years will <b>still</b> result in a revoked grower license.
LABS THAT TEST HEMP	Must be registered with DEA.	Due to a shortage of DEA registered labs, DEA agreed (February 2020) to allow non-DEA registered labs to continue testing hemp until Jan. 1, 2022. DEA subsequently agreed to delay enforcement until Dec. 31, 2022.
DISPOSAL OF NON-COMPLIANT PLANTS	Disposal must be carried out under the Controlled Substances Act and DEA policies. Requires an authorized federal or state law enforcement officer to be present.	Disposal may be conducted on-farm (farmer) or at the research site (researcher) by plowing under, mulching /composting, disking, bush mowing, deep burial, and burning. Law enforcement presence is not required.
NON-COMPLIANT PLANT REMEDIATION	No provision.	Remediation permitted. It can be achieved by separating and destroying non-compliant flowers while retaining stalks, leaves, and seeds; or by shredding the entire hemp plant to create a homogenous "biomass" that can be retested for THC compliance.
PART(S) OF PLANTS SAMPLES ARE TAKEN FROM	Top third of the plant.	Five to eight inches from the main stem, terminal bud, or central cola of the flowering top of the plant.

## The History of Hemp Regulations in North Carolina



In 2015, the N.C. General Assembly passed SB313, creating the state's hemp pilot program. N.C. SB313 also provided for the creation of the N.C. Industrial Hemp Commission, charged with developing rules and licensing structures to comply with federal laws. The law was modified in 2016 via House Bill 313 to include definitions of certified seed, commercial use, grower, and hemp products. The N.C. Industrial Hemp Commission adopted temporary rules in 2017 that were approved by the N.C. Office of Administrative Hearings Rules Review Commission. Potential growers submitted applications to the N.C. Industrial Hemp Commission which reviews and approves or rejects the application. The NCDA carried out testing of hemp for THC content. N.C. has operated under the rules of the state pilot program, which was developed based on the 2014 Farm Bill since 2015<sup>4</sup>. The state's rules will be replaced by the final rules developed by USDA on Jan. 1, 2022.

### THE N.C. FARM ACT OF 2019

- SB315, the N.C. Farm Act of 2019 was ratified in June 2020. Proposed provisions in the Bill had critical implications for N.C. hemp producers and processors, among them – a ban on smokable hemp, regulations for hemp retailers, and language that would have given NCDA the authority to submit a state plan for hemp to the USDA<sup>9</sup>.
- Unable to agree on these provisions – particularly the ban on smokable hemp – legislators removed ALL language concerning hemp from the final version of the Bill.
- When it became apparent the legislature was not interested in introducing stand-alone legislation for hemp, the N.C. Hemp Commission sent a letter to the USDA in August, 2021 stating N.C. will not submit a plan for hemp and N.C. growers will come under the USDA rules effective Jan. 1, 2022.
- The Commission also sent letters to the governor and legislature informing them the Commission will dissolve effective Jan. 1, 2022, concurrent with the expiration of the N.C. Pilot Program. Instructions for applying to USDA for a hemp license were sent to all licensed growers in N.C. Current N.C. hemp licenses will expire Jan. 1, 2022. (For detailed instructions on applying to USDA for a hemp license, see the Hemp and Small Farmers chapter)

## CHAPTER 3

# REGULATIONS ON HEMP PRODUCTION

### Federal Hemp Regulations and N.C. Growers

From 2017-2021, all N.C. hemp producers were required to hold licenses issued by the state hemp program. Those licenses will expire on Jan. 1, 2022. Due to the changing licensing requirements, it is imperative to know the key differences between the federal and state regulations of hemp, which are highlighted below. Future growers should check with Cooperative Extension and reputable sources for the latest on hemp production and regulations.

#### ***Sampling Requirements***

Until the expiration of North Carolina's Pilot Program (Jan. 1, 2022), the NCDA&CS's Plant Industry Division or law enforcement agencies could sample hemp for THC content at any time. License holders were responsible for notifying the division at the initiation of floral buds. Sampling was required to take place 15 days before harvest or randomly based on the availability of sampling personnel. The division or law enforcement agency collecting the sample notified the license holder when the sample was collected. Any lab performing the analysis was required to have the legal authorization to possess hemp.

***Implications for North Carolina:*** The USDA Hemp Final Rule extended the sampling window to 30 days before harvest<sup>5</sup>. Even with this extension, North Carolina lacked both the personnel and facilities to meet this requirement. The N.C. Hemp Commission proactively began developing guidelines for field screening by private entities. The guidelines were never implemented as North Carolina elected to come under the terms of the USDA Final Rule rather than submit a State Plan for hemp to the USDA. Beginning Jan. 1, 2022, all hemp producers will follow the USDA rules that require growers to contact sampling agents from an approved USDA list.

#### ***Testing for Total THC vs. Testing for Delta-9 THC***

Language in the 2018 Farm Bill defined hemp as any Cannabis plant or derivative thereof that contains not more than 0.3% delta-9 THC on a dry weight basis<sup>7</sup>. The Final Rule mandates testing also for THCA, the acid form of THC, to render a total THC concentration in the sample. During Gas Chromatograph-Flame Ionization Detector (GC-FID) analysis, which is one of two common methods of testing for THC, the heat applied to the sample converts THCA into delta-9 THC. Another common, reliable testing method for THC is High-performance Liquid Chromatography (HPLC). Cannabinoids remain unchanged using this method. Therefore, THCA and delta-9 THC are rendered as separate measurements and must be added to obtain total THC, which combined cannot exceed the 0.3% legal threshold.

***Implications for North Carolina:*** The USDA initial requirements for state pilot programs required states to establish protocols for THC testing. No particular testing methodology was specified or required. Since the inception of the state's pilot program, N.C. has tested using the GC-FID method. Consequently, North Carolina already tests for total THC, which aligns with the Final Rule requirement. Beginning January 1, 2022, NC growers will comply with the USDA rules for testing, which is to test for total THC.

### ***Certification and Registering of Labs Testing for THC***

Under the 2014 Farm Bill, labs testing for THC only had to obtain the legal authority to possess hemp samples. However, the language in the 2018 Farm Bill also requires labs to be registered with the DEA. This ruling has the potential to severely limit access to testing facilities as there are currently only 70 such labs in the U.S.<sup>8</sup>. As a compromise, DEA agreed to allow non-DEA registered labs to continue testing hemp until Dec. 31, 2022.

***Implications for North Carolina:*** As of August 2021, there are 1,500 licensed hemp growers in North Carolina, representing 14,016 licensed acres and 6,874,413 square feet of licensed greenhouse production. There are 1,295 registered processors. With only five DEA-registered labs in the state, coupled with the 30-day pre-harvest sampling requirement, North Carolina growers will be challenged on both fronts. As of fall, 2021 the five DEA registered labs in North Carolina are:

- Avazyme Inc. in Durham  
<https://www.avazyme.com/industrialhemptestinglaboratory/>.
- Delta 9 Analytical in Raleigh  
<http://delta9analytical.com/wp/>.
- Global Laboratory Services in Wilson  
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- NMS Labs, Inc. in Winston-Salem  
<https://www.nmslabs.com/>.
- Research Triangle Park Laboratories, Inc. in Raleigh  
<http://www.rtp-labs.com/>.

The list of DEA-registered labs continues to grow. Growers can visit this link for updates:  
[https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories?field\\_lab\\_location\\_administrative\\_area=NC](https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories?field_lab_location_administrative_area=NC).

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### Resources and Further Reading

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# HEMP AND SMALL FARMERS

As stated in the Uses and Marketing chapter, there is limited information on market opportunities for potential North Carolina growers. Growers are strongly advised to proceed with caution and thoroughly examine any potential marketing opportunities<sup>1</sup>. Also, some growers were either unable to sell or be paid for their 2019 and 2020 crops.

Even though optimistic market projections abound, there remains a wide variance among forecasters, as illustrated below.

- Global industrial hemp market projected to grow from \$4.6 billion in 2019 to \$26.6 billion by 2025<sup>2</sup>.
- CBD market will hit \$22 billion by 2022<sup>3</sup>.
- Industrial hemp market to reach \$13.03 billion by 2026<sup>4</sup>.

Textiles, personal care products, and food and beverages represent the largest market segments by application<sup>5</sup>. Keep in mind these are global statistics. In the U.S., the FDA regulates any potential food and beverage products and, to date, it has been slow to consider such products for entry into the marketplace.

## Potential Hemp Markets and Challenges

The market for hemp remains volatile, with 2020 bringing a steep drop in prices paid to growers. Hemp Benchmarks, a subscription service offering monthly hemp spot-pricing indexing, reports that the price of CBD biomass was \$38 a pound in April 2019. By April 2020, the price had dropped to \$8.10 a pound, reflecting a reduction of 79%<sup>6</sup>. PanXchange, a commodity marketing firm, reported a significant drop in the price for CBD hemp for the period beginning in January 2019

through November 2020. The price per percent CBD fell from \$3.50 to \$0.50, stabilizing at \$0.50 for the entire year between November 2019 and November 2020<sup>7</sup>. Ongoing uncertainty regarding the long-term outlook for hemp requires due diligence, including monitoring of crop commodity sites and industry groups such as those mentioned above. Hemp farmers are strongly urged to refrain from investing more than they can afford to lose<sup>8</sup>.



### Market Challenges for Different Types of Hemp

**Fiber:** Intense competition globally, especially from China; the U.S. environmental stance on retting, a semi-controlled rotting process to assist in fiber separation.

**Seeds and grains:** Current yields are not on par with traditional grains such as flax and rapeseed.

**CBD and other cannabinoids:** Market segment largely untested; lack of research into proper health or medicinal benefits of CBD

Currently, there are more unknowns than knowns regarding hemp markets<sup>9</sup>. Among the many influencers to consider:

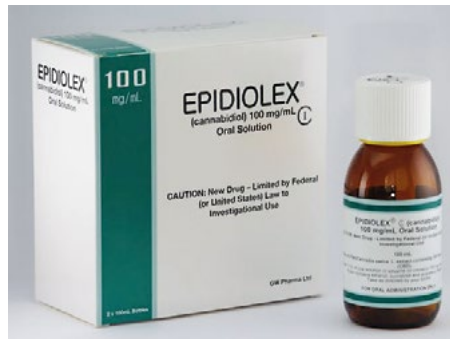
- Uncertainty regarding state and federal regulations.
- Interaction between hemp and marijuana.
- A high number of hemp producers with little to no farming background.
- Varying regional production costs and practices.
- Intense international competition.
- Contracted acres: supply currently exceeding demand.
- Standardization within sampling, THC testing, fees, etc.
- Bankruptcies, reorganizations, consolidations among hemp companies.



*Hemp Retting (Iowa State Extension photo)*



*Hemp seeds and grains (Rutgers Extension photo)*



*Epidiolex, an FDA approved drug from hemp (GW Pharmaceuticals photo)*

# CHAPTER 4

## HEMP AND SMALL FARMERS

### Hemp Licensing

Hemp licenses issued by the NC Industrial Hemp Pilot Program expire on Jan. 1, 2022. Farmers wanting to grow hemp for the 2022 crop season and beyond must apply directly to USDA for a license and are encouraged to apply before Jan. 1, 2022.

### Applying for a USDA License to Grow Hemp in North Carolina

All information on the USDA Hemp Program is available at <https://www.ams.usda.gov/rules-regulations/hemp/>.

Questions may be submitted to [farmbill.hemp@usda.gov](mailto:farmbill.hemp@usda.gov); or call at (202) 720-2491 for additional information.

***Here are the steps current North Carolina licensees can take to ensure they are licensed for the 2022 and future crop seasons:***

**1. Create an eAuthorization Account:**

***<https://www.eauth.usda.gov/eauth/b/usda/home>***

Creating a USDA eAuthentication (eAuth) account is the first step in applying for a USDA license. Once your E-Auth account is established, you will be able to access the Hemp eManagement Platform (HeMP).

HeMP is the secure online tool where you will apply for a USDA hemp production license and manage hemp reporting information for USDA.

**2. Obtain a copy of your FBI criminal history report. (<https://www.fbi.gov/services/cjis/identity-history-summary-checks>)**

You will need to provide a copy of the criminal history report for yourself and each “key participant” under your license. If you or any key participant involved in the operation (someone with a financial interest) have had a felony conviction related to a controlled substance during the last 10 years, your license application will be denied.

**3. Register to use the Hemp eManagement Platform (HeMP) at [www.hemp.ams.usda.gov](http://www.hemp.ams.usda.gov).**

Detailed instructions on how to use and register for this system are available at the USDA website <https://www.ams.usda.gov/rules-regulations/hemp>.

**4. Apply for a license**

Follow the instructions on the HeMP online tool to apply for a USDA hemp production license. You will need to provide certain required information and upload a copy of your FBI criminal history report.

**5. Designate your lots**

A “Lot” is defined as a **contiguous** area in a field, greenhouse, or indoor growing structure planted **with the same variety or strain** of hemp. You may establish as many separate lots as you wish, but each lot must be sampled and tested separately. If you plant different varieties or strains, or plant across non-contiguous land areas, you must designate separate lots. You are responsible for all sampling and testing fees for each of your designated lots. There is no restriction on the size of a hemp lot or the number of lots designated.

**This step is critical for indoor growers who will not have harvested prior to Jan. 1, 2022. All hemp harvested after Jan. 1, 2022, is subject to USDA sampling and testing requirements. If planting in the Fall of 2021 with an anticipated 2022 harvest, you must designate your lot(s) per USDA requirements and have an approved USDA hemp license by Dec. 31, 2021.**

## 6. Report Hemp Acreage to FSA

All USDA licensees must report the land area where hemp is planted. Immediately after planting hemp, contact your local USDA Farm Service Agency (FSA) Service Center and make an appointment to establish your Farm record (if not already established) and report your hemp crop acreage.

You must provide a copy of your hemp license and documents showing ownership or lease on the land under hemp production. You will need to provide planting date, GPS coordinates, crop type, intended use, size of each growing location, and irrigation practice. FSA will assign an FSA Lot ID for each of your planted hemp lots. The FSA Lot ID is a combination of the following assigned numbers: Farm-Tract-Field-Subfield (if applicable). Each FSA Lot ID must be sampled and tested separately. FSA Lot ID is NOT your hemp lot ID.

## Contracts

When evaluating hemp contracts, proceed cautiously and remember hemp contracts are similar to contracts for other products. Parties should:

- Deal only with other reputable parties.
- All parties should perform their **due diligence**.
- Parties should consult with a N.C. licensed attorney before signing.

While not hemp-specific, a good guide to evaluating farm contracts is the USDA publication "Contracting in Agriculture: Making the Right Decision," available at [https://www.gipsa.usda.gov/psp/publication/AMS\\_contracting/contracting.pdf](https://www.gipsa.usda.gov/psp/publication/AMS_contracting/contracting.pdf).


## 7. Sampling and Testing

You are responsible for finding your own sampling agent and laboratory testing facility. USDA does not sample and does not test hemp. First, identify a certified hemp sampling agent (A listing will be available on the USDA website). Licensees may not act as a sampling agent. Next, identify a laboratory to test your sample for Total THC. You may use any laboratory that meets the DEA minimum performance requirements. Laboratories must test for Total THC concentration and report all test results to you and the USDA.

## 8. Reporting Requirements

As a USDA licensed hemp producer, you are required to submit certain information to USDA throughout the year. For detailed information about North Carolina's transition to the USDA rules and applying for a USDA hemp license, review the recorded webinar, U.S. Domestic Hemp Production Overview: North Carolina Transition at <https://hemp.ces.ncsu.edu/2021/10/nc-usda-transition-webinar-online/?src=rss>.

## Due Diligence



Reasonable steps taken by a person in order to satisfy a legal requirement, especially in buying or selling something.

## CHAPTER 4

# HEMP AND SMALL FARMERS

### A Checklist for Evaluating Hemp Contracts<sup>10</sup>



#### GOOD TO GO

- ✓ Delivery point and price are clear and timely.
- ✓ Verification of funds: Buyer places a portion of funds in escrow to cover the purchase.
- ✓ Purchase price for flowers is based on delivered weight and percent CBD.
- ✓ Required testing, sampling protocol, and acceptable limitations are clearly described.
- ✓ A third-party testing facility is mutually agreed upon between producer and buyer.
- ✓ Buyer is providing plant material in the form of seeds or transplants.
- ✓ Buyer is registered with the secretary of state.

#### PROCEED WITH CAUTION

- ▼ Post-delivery location of product is unclear.
- ▼ Payment will be made all or in part with product instead of cash.
- ▼ Purchase price for CBD is based on delivered weight only.
- ▼ Non-compete clause preventing selling to another buyer after the contract has been filled.
- ▼ Exclusivity: Restriction for contracting with any other buyer for the current year or multiple years.
- ▼ Buyer completely dictates the variety to be grown.
- ▼ Purchase price for floral bud is based on acreage only.

#### STEER CLEAR

- ✗ Company contact information is not disclosed in the contract.
- ✗ No specific purchase information is included.
- ✗ Payment will be delayed until final product is marketed.
- ✗ Assigning grower license to buyer.
- ✗ Non-disclosure provision about disputes or contract terms.

## Hemp Economics and Budget

The economics of producing hemp vary based on the product made (fiber, seeds, both fiber and seeds, CBD) and the growing environment (field, greenhouse, bare soil, plasticulture). The local variations in hemp agronomy may further impact regional production costs.

Table 1 below is a short form of a sample hemp budget for fiber, grains, and CBD.

For a more detailed look at the economics of hemp production, potential growers should consult the following enterprise budgets. Keep in mind, however, these budgets change frequently and are greatly influenced by marketing price and the development and application of new practices.

- The most detailed and current budgets are those developed by the University of Kentucky Extension Agriculture Economics department. They are available at <http://agecon.ca.uky.edu/budgets>.
- N.C. State University has a hemp for floral CBD budget template available at [https://hemp.ces.ncsu.edu/wp-content/uploads/2018/11/Sample\\_Farm\\_Budget\\_Hemp.pdf? fwd=no](https://hemp.ces.ncsu.edu/wp-content/uploads/2018/11/Sample_Farm_Budget_Hemp.pdf? fwd=no).
- The Alabama Cooperative Extension Service (Alabama A&M & Auburn Universities) offers a hemp budgeting template available at <https://www.aces.edu/blog/topics/farm-management/industrial-hemp-enterprise-budgets/>.

*continued on the next page*

	<b>Fiber</b>	<b>Grains</b>	<b>CBD</b>
<b>Variable Costs*</b>	\$886.76	\$795.06	\$1,396.15
<b>Labor**</b>	56 hours	56-70 hours	\$5,025 - \$6,476 / acre
<b>Gross income</b>	\$700	\$840	\$5,250
<b>Net income***</b>	(-\$187)	\$45	\$3,854
<b>High-low</b>	\$0.10 - 0.05 / lb.	\$1.00 - 0.50 / lb.	\$6 - \$1 for per percent CBD
<b>Midpoint</b>	\$0.07 /lb.	\$0.70 / lb.	>\$1 per percent CBD with 1,200 lb/acre bud yield

*Table 1. Estimated hemp production budgets (per acre) for fiber, grains and CBD*

\* Including but not limited to site prep, soil test, fertilizer, seed, crop insurance, testing, and transportation. Note that fixed costs are not included. Fixed costs are items such as tractors and other machinery, irrigation system, and land purchase. Be aware, these can add significantly to your cost of production.

\*\* Insufficient data available for labor costs for hemp fiber and grains.

\*\*\* Income projections are estimates. Income will vary based on current market prices.

CAUTION! The hemp market remains volatile.

## CHAPTER 4

# HEMP AND SMALL FARMERS

- The Institute of Agriculture at the University of Tennessee has produced a CBD hemp enterprise budget available at <https://ag.tennessee.edu/arec/Lists/Budgets/DispForm.aspx?ID=7>.

Through its Hemp Benchmarks division, New Leaf Data Services, LLC, a paid subscription service, offers monthly hemp market information. The free but incomplete snapshot of the hemp price can be accessed at <https://www.hempbenchmarks.com/hemp-market-insider/>.

Keep in mind that hemp is an evolving industry and market dynamics will change quickly as new producers enter the business and production increases<sup>11</sup>. Since hemp restrictions have been further eased via the 2018 Farm Bill, licensed hemp acreage has increased by 455% between 2018 and 2019<sup>12</sup>. Such a dramatic increase could result in market saturation causing hemp prices to drop, as we have observed the price of \$0.5 per percent of CBD towards to the end of 2020. The University of Kentucky enterprise budgets illustrate how even a moderate reduction in price could negatively affect return per acre.

## Decision-Making Tools for Small Farmers

Managing risk is a key component of any agricultural enterprise. One of the greatest risks farmers take is deciding to produce a new crop<sup>13</sup>. As the hemp industry is new and evolving, growers are well-served to closely follow emerging trends and information. Broadly, risks can be grouped into three main categories<sup>14</sup>.

An additional risk category may be referred to as human risk, the uncertainty about the character or behavior of people involved in the business. The “wild west” or “gold rush” mentality surrounding hemp has seen many jumping on the bandwagon who may or may not represent reputable business operators.

### TYPES OF RISK FOR HEMP PRODUCTION

#### BUSINESS RISK

**Production** - Information about varieties, production methods, limited pesticides

**Crop Insurance** - Programs / limited availability

**Contracts** - Only as good as the issuer of the contract. Defaulting may be common especially in the early stages of hemp industry development

#### FINANCIAL RISK

**Working Capital** - Is the growers' cash flow able to mitigate short term risks? What happens if the crop fails, or yield is less than projected?

**Budgets** - Growers should have business plans, use available enterprise budgets to calculate cost outlays and potential returns

#### STRATEGIC RISK

**Logistics** - How close are processing facilities? Need to be relatively close to minimize transportation costs

**Labor** - Hemp is very labor intensive to produce. Make sure labor needs are addressed in your business plan

**Processors** - If acres planted increases, processing capacity may become strained

**Pricing** - Hemp is an emerging commodity. Lack of market pricing availability makes it difficult to determine if the price offered to a grower is appropriate.

*Adapted from Oklahoma State University Extension*

## Available Crop Insurance for Hemp

In 2020, the USDA took major steps toward providing coverage opportunities for hemp producers via a new pilot program, Multi-Peril Crop Insurance (MPCI) and through additional provisions added to the long-running Noninsured Crop Disaster Assistance Program (NAP)<sup>15</sup>. MPCI provides coverage against yield loss because of insurable causes of loss for hemp grown for fiber, grain, or CBD oil. Insurable causes of loss under this pilot program include adverse weather conditions, such as drought and excess precipitation, earthquake, failure of the irrigation water supply (if caused by an insured peril during the insurance period), fire, insects, and plant disease (except for insufficient or improper application of pest or disease control measures), wildlife, or volcanic eruption<sup>15</sup>.

Coverage under the MPCI pilot program became available for the crop year 2020 in certain counties in the following states – Alabama, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Maine, Michigan, Minnesota, Montana, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, Pennsylvania, Tennessee, Virginia, and Wisconsin. North Carolina ranked second, behind Kentucky, in the number of MPCI policies written<sup>15</sup>.

Not all counties in all states were initially eligible for hemp coverage under MPCI. The program was expanded in 2021 to include Arizona, Arkansas, Texas, and Nevada counties.

Information on counties eligible for MPCI can be found at the USDA Risk Management Actuarial Information Browser at <https://webapp.rma.usda.gov/apps/actuarialinformationbrowser2020/CropCriteria.aspx>.

Also, beginning in 2020, hemp producers located in states and counties not covered by the MPCI pilot program can apply for coverage under NAP, which provides coverage against loss for hemp grown for fiber, grains/seeds, or CBD. Coverage is available at 55% of the average market price for crop losses that exceed 50% of anticipated production. The 2018 Farm Bill included a provision to buy up – at a premium – from 50 to 65%

of the expected output at 100% of the average market price. This extra buy-up protection can be purchased in 5% increments. Again, this buy-up coverage comes at a premium cost to the producer<sup>15</sup>.

For all coverage levels, the NAP service fee is the lesser of \$325 per crop or \$825 per producer. For farmers farming in multiple counties, the combined fees, regardless of the number of counties farmed, are capped at \$1,950 per farmer.

### ***Example 1- Small farmer operating in only one county wishes to insure three crops***

The NAP service fee is \$325 for each insured crop. Farmer may insure multiple crops. The total farmer cost, regardless of the number of crops insured, is capped at \$825. If a farmer farming in a single county wants to insure his hemp, cotton, and corn. Based on a fee of \$325 per crop, the total would come to \$975. However, the farmer pays only \$825 to insure these three crops.

### ***Example 2- Small farmer farming in two counties wishes to insure three crops in county A and four crops in county B***

A small farmer in county A wishes to insure his hemp, cotton, and corn. The same small farmer also wishes to insure his hemp, cotton, corn, and soybeans in county B.

<b>County A NAP costs</b>		<b>County B NAP costs</b>	
Hemp	\$325	Hemp	\$325
Cotton	\$325	Cotton	\$325
Corn	\$325	Corn	\$325
		Soybeans	\$325
<hr/>		<hr/>	
<b>Total</b>	\$975	<b>Total</b>	\$1,300
<b>County A</b>		<b>County B</b>	

**Total county A and B** \$2,175

However, the total cost to this small farmer (based on cap) is \$1,950, not \$2,175.

## CHAPTER 4

# HEMP AND SMALL FARMERS

### *Eligibility requirements*

- Producers must have a license to grow hemp and must comply with applicable state, tribal, and federal regulations or operate under a university research pilot (All Federal Crop Insurance plans).
- MPCI plan
  - + Producers must have at least one year of history producing hemp.
  - + Producers must have a contract for the sale of the insured hemp.
  - + Minimum acreage required is five acres for CBD and 20 acres for grain and fiber.
  - + Hemp will not qualify for replant payments or prevented plant payments.
- NAP plan
  - + Producers must report hemp acreage to the FSA after planting to comply with federal and state law enforcement.
  - + Hemp having THC above the federal statutory compliance level of 0.3% is an uninsurable or ineligible cause of loss and will result in the hemp production being ineligible for production history purposes.

Two additional insurance programs offer producers more options and flexibility for hemp grown in containers.

- Revenue protection for hemp is offered under the Whole-Farm Revenue Protection plan of insurance.
- Beginning with the 2021 crop year, hemp is insurable under the Nursery Crop Insurance Program and the Nursery Value Select Crop Insurance Pilot Program.

Under both programs, hemp will be insurable if grown in containers and following federal regulations, the applicable state or tribal laws, and terms of the crop insurance policy.

Small farmers are advised that the eligibility requirements for the available crop insurance programs vary. Remember to check with each program for details. Regardless of the crop insurance plan, anyone who wants to insure their hemp crop must hold a valid hemp license and comply with applicable state, tribal, and federal regulations.



## CHAPTER 4 HEMP AND SMALL FARMERS

<i>Program</i>	<i>Administering Agency</i>	<i>Crop Year</i>	<i>Eligibility Requirements*</i>	<i>Types of Hemp Covered</i>	<i>Covers</i>
<b><i>MPCI Pilot Program</i></b>	RMA	2020 (Continued for crop year 2022)	Five acres CBD, 20 acres grains and fiber	CBD, grains, fiber	Losses due to natural events such as hail, frost, wind, drought
<b><i>NAP</i></b>	FSA	Ongoing	Report acreage planted to FSA. Producer must hold a hemp contract.	CBD, grains, fiber	Losses due to damaging weather, such as drought, freeze, floods
<b><i>WFRP</i></b>	RMA	Ongoing	Algorithm based on current prices, anticipated revenue, Sch. F	CBD, grains, fiber	Loss of farm revenue due to unavoidable natural causes
<b><i>Nursery Crop Insurance</i></b>	RMA	Ongoing	Nursery must be inspected and approved prior to coverage.	Hemp grown in containers	Losses due to adverse weather, failure of irrigation system (in some cases). Does not cover structures or diseases
<b><i>Nursery Value Select Pilot Program</i></b>	RMA	2022	Nursery must be inspected and approved prior to coverage.	Hemp grown in containers	Container-grown plants. Allows producers to select the amount of coverage based on production practices.

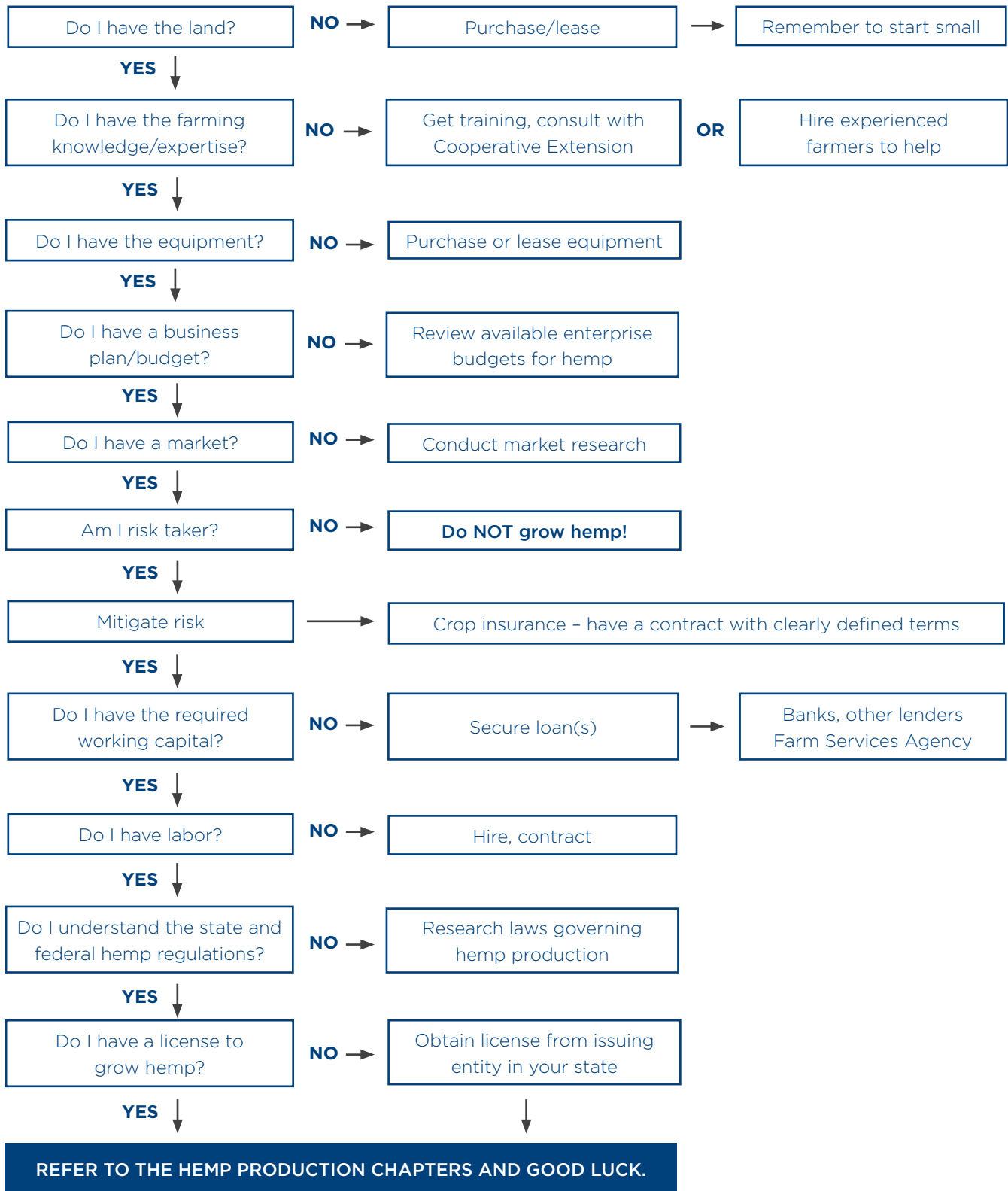
*Table 2. Comparison of crop insurance plans available for hemp.*

# CHAPTER 4

## HEMP AND SMALL FARMERS

### A Decision Tree for Potential Small Hemp Producers

The following decision tree guides potential growers in deciding whether to grow hemp. The bottom line, start small and never invest money that you cannot afford to lose.



## Resources

### SEEDS, CLONES, AND TRANSPLANTS

Davis, J. (2020). Planting Sources (Seeds, Clones, Transplants). NC State Extension Hemp Portal. <https://hemp.ces.ncsu.edu/seed-sources-for-planting/>.

### REGISTERED PROCESSORS

Within North Carolina <https://www.ncagr.gov/hemp/documents/ProcessorListForWeb.pdf>.

### DEA APPROVED LABS NATIONAL LIST

<https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories>.

### DEA APPROVED LABS IN NORTH CAROLINA

[https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories?field\\_lab\\_location\\_administrative\\_area=NC](https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories?field_lab_location_administrative_area=NC).

Avazyme Inc. in Durham <https://www.avazyme.com/industrialhemptestinglaboratory/>.

Delta 9 Analytical in Raleigh <http://delta9analytical.com/wp/>.

Global Laboratory Services in Wilson <http://www.globallaboratoryservices.com/>.

NMS Labs- WIN in Winston-Salem <https://www.nmslabs.com/>.

Research Triangle Park Laboratories, Inc. in Raleigh <http://www.rtp-labs.com/>.

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Gu, S. (2020). Hemp Contracts and Tips for Floral Hemp. NC A&T Hemp Conference. <https://www.ncat.edu/caes/agricultural-research/industrial-hemp-program/hemp-conference/files/gu.pdf>.

Yankee Farm Credit (N.D.) Hemp Contracts - Things to be Aware of. <https://www.yankeefarmcredit.com/getattachment/58c3ef43-6911-4909-b96e-3ab3f7f90eaa/HEMP-CONTRACTS-%E2%80%93-THINGS-TO-BE-AWARE-OF.aspx>.

## CHAPTER 4

# HEMP AND SMALL FARMERS

### Further Reading

#### **HEMP WEBSITES FROM THE DEPARTMENT OF AGRICULTURE AND LAND GRANT UNIVERSITIES IN NORTH CAROLINA**

Industrial Hemp Pilot Program in North Carolina. <https://www.ncagr.gov/hemp/>.

Industrial Hemp Program at N.C. A&T State University. <https://www.ncat.edu/caes/agricultural-research/industrial-hemp-program/index.php>.

Hemp Program from North Carolina State University. <https://hemp.ces.ncsu.edu/>.

USDA Hemp Production Program. <https://www.ams.usda.gov/rules-regulations/hemp>.

#### **BUSINESS PLANNING / ECONOMICS**

Alabama Cooperative Extension- Farm Management (2020). Industrial Hemp Enterprise Budgets. <https://www.aces.edu/blog/topics/farm-management/industrial-hemp-enterprise-budgets/>.

Building a Sustainable Business (SARE). <https://www.sare.org/resources/building-a-sustainable-business/>.

Enterprise budget template for crop production (Penn State). <https://extension.psu.edu/budgeting-for-agricultural-decision-making>.

NC Industrial Hemp Commission (2020). Industrial Hemp Pilot Program in North Carolina Frequently Asked Questions. <https://www.ncagr.gov/hemp/FAQs.htm>.

University of Kentucky industrial hemp agronomic research resource list (includes links to budgets and video series). <https://hemp.ca.uky.edu/node/9#GTV>.

University of Tennessee Institute of Agriculture- Department of Agricultural and Resource Economics. Industrial Hemp Budgets. <https://arec.tennessee.edu/extension/budgets/>.

USDA. Hemp and Farm Programs. <https://www.farmers.gov/manage/hemp>.

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# HEMP FLORAL BUDS PRODUCTION FOR CANNABIDIOL (CBD)

Hemp cannabinoids, including cannabidiol (CBD), are abundant in the trichomes of female floral buds. Production techniques for hemp CBD are distinctly different from those for hemp fiber or grains. Generally speaking, you can grow CBD hemp as a horticultural crop and grow oilseed and fiber hemp as a field agronomic crop.

North Carolina CBD hemp research did not start until 2019. Because the research is recent, there is still much to be known. As such, hemp growers need to check for updated research results from both N.C. State and N.C. A&T.

CBD Hemp is not for everyone and is not a guaranteed money-maker. If you have decided to try hemp production for CBD and other cannabinoids, start small to mitigate risk and consider the following practices. Since this publication only covers the field hemp production for CBD, check out the “Pour-thru Guide for Greenhouse Cannabis Production” by Dr. Brian Whipker from North Carolina State University for greenhouse production information.

**1. Acquire a hemp license.** Anyone growing hemp in North Carolina must have a valid license issued by the NCDA Industrial Hemp Pilot Program through 2021 or a valid license issued by USDA starting in 2022.

- If you want to grow hemp before December 31, 2021 but do not have a valid NC hemp license, click the following link for information on applying for a North Carolina hemp license: <https://www.ncagr.gov/hemp/application.htm>. It may take a month or longer to have your license approved and this license will expire by December 31, 2021.

- + If you have a valid NC hemp license, it will remain valid until Dec. 31, 2021.
- + If your current NC hemp license expires before Sept. 30, 2021, contact the NCDA Industrial Hemp Program to renew your license at no cost.

- + To avoid the potential gap between your NC hemp license and USDA hemp license, apply for a USDA hemp license as early as possible. Application is free. For more up-to-date information on USDA hemp rules and licensing, visit <https://www.ams.usda.gov/rules-regulations/hemp/information-producers>.

**2. Secure your market(s).** It is unlikely that you can sell hemp at farmers' markets\*, as you would do with vegetables, value-added products or processed items. Secure a buyer before the growing season because the current hemp market is unstable.

- Have a lawyer review your contract if you are required to sign one. To learn more about hemp contracts, see chapter four or visit <https://content.ces.ncsu.edu/industrial-hemp-in-north-carolina-guide-to-understanding-and-evaluating-contracts>.

\* *Some farmers markets may allow sale of hemp buds or other hemp products, you should always check and confirm with the farmers market manager before taking your hemp products to the market.*

**3. Consider buying an insurance policy.** Risk Management Agency (RMA) and Farm Service Agency (FSA) have insurance options (more details in chapter four).

- RMA: Multi-Peril Crop Insurance (MPCI) and Actual Production History (APH) coverage.
- FSA: The Noninsured Crop Disaster Assistance Program (NAP).

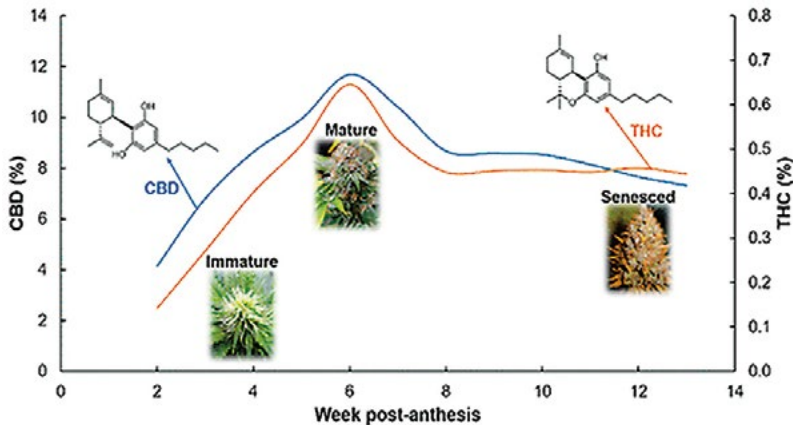
**4. Choose the best cultivars/strains for your situation.**

- Use cultivars/strains of different maturities, high bud/CBD yield, and low risk of elevated Tetrahydrocannabinol (THC).





### The Expectations of CBD Yield in Floral Buds



Total THC, CBD, and Cannabigerol (CBG) significantly increase as flowers mature, reaching the greatest concentration during six to seven weeks postanthesis (see figure above by Yang et al., 2020. Journal of Agricultural and Food Chemistry). The

CBD/THC ratio gradually decreases throughout the entire reproductive growing stage, from 28 to 15. The CBD/THC ratio is a genetic trait (chemotype) in industrial hemp. It remains constant and is not affected by external factors (Stack et al., 2020. GCB Bioenergy). This ratio ranges from 20-30 and usually is about 21 CBD to 1 THC. Given the legal limit of 0.3% THC, the expected maximum CBD content of an industrial hemp

cultivar/strain will be between 6% to 9% and unlikely to be higher than 9%. The current price is around \$0.5 for every percent of CBD per pound, meaning \$4.5 gross potential per plant, assuming one pound of dry buds from a plant.

- + If you have a contract, grow the cultivars listed in the contract.
- + Late maturing cultivar/strains usually have a high yield of floral buds.
- + Be aware that different names may be the same strain because hemp cultivars are not currently well-regulated.
- + Harvesting is time-intensive, and drying the harvested hemp flowers uses a lot of facility space. Cultivars with varied maturities will ease the challenges.
- The following cultivars/strains yielded about one pound or higher of dry bud per plant per the 2019 and 2020 state-wide tests in North Carolina.
  - + Early-maturity: Elektra, Matterhorn, TJ's, Suver Haze, Wulf
  - + Mid-maturity: BaOx, Berry Blossom, Cherry Blossom
  - + Late-maturity: Cherrywine, Citrus Cherry, Spectrum, Sweetened, Endurance
- A 2020 nationwide survey showed the top 10 CBD hemp cultivars as Cherry Wine, Sweetened, BaOX, T1, Lifter, Cherry, Cherry Blossom, Suver Haze, The Wife, and Berry Blossom.
- The report of the 2021 state-wide variety trials for floral hemp is available at <https://hemp.ces.ncsu.edu/wp-content/uploads/2021/11/2021-NC-State-Variety-Trial-Report.pdf?fwd=no>.
- Try triploid (seedless) cultivars if they are available to you. Triploid hemp will not produce seeds when male plants are in proximity. For more information about triploid or seedless hemp, visit <https://hemp.ces.ncsu.edu/2021/05/whats-up-with-new-seedless-hemp-varieties/>.

## CHAPTER 5

# HEMP FLORAL BUDS PRODUCTION FOR CBD



*Hemp CBD cultivars Elektra, BaOx, Cherry Blossom, and Cherrywine.*

**5. Use only female hemp plants.** Hemp for CBD production harvests only female flower buds. Male plants are detrimental, as they will pollinate female flowers resulting in seed development on the female plants that greatly reduces trichome development, thus significantly lowering the CBD yield.

- Using hemp clones is encouraged, although it might be expensive (\$1-\$3 per clone).
  - Feminized seeds can also be used (\$0.4-0.8 per seed) but not strongly recommended. Ideally, you shall identify and remove male seedlings before transplanting but in reality, it is difficult to do.
- + All feminized cultivars will have some seeds that develop into male plants.

+ Do not direct seed feminized cultivars, such as drilling the seeds into the soil. Feminized seeds are currently expensive so use transplants instead. Raising hemp seedlings for transplanting is similar to how you would raise tomato transplants.

**6. Time of transplanting is critical.** As a short-day and warm-season species, field hemp starts to initiate flowers after June 21, the summer solstice when the day-length begins to shorten. The transplanting time will depend on cultivars but generally should be between late May to mid-June. If transplanted in July, plants will have a low yield because they will flower regardless of the canopy size.

- Hemp clones become root-bound quickly. Clones staying in seedling cell inserts for a prolonged period will remain root-bound after transplanting, which could kill a grown plant later.

## CHAPTER 5 HEMP FLORAL BUDS PRODUCTION FOR CBD



*Hemp plants start to flower when days get shorter, regardless of the plant's size.*

*Left: a very small plant that will have very low floral yield.*

*Right: a full size plant that has a high bud yield potential.*

**7. "Isolation" considerations.** Make sure your CBD hemp field is away from fiber and seed hemp fields to avoid pollination.

- At least one mile if there are physical barriers such as trees and buildings, or at least three miles if not.
- Check and coordinate with farmers next to you for CBD hemp production. There should be no seed and fiber hemp plants within a three-mile radius.

**8. Soil preparation and fertility.** Conduct a soil test before hemp production. Soil with a pH of 6.0-7.5, well-aerated loams of high fertility, and organic matter is ideal for CBD hemp production. Fertilization rates for CBD hemp should be based on the soil-test results (NCDA Soil Test Crop Code 310). Work the fertilizers into the field when preparing the soil.

- N 100-150 pounds/acre
- P2O5, 0-150 pounds/acre (0 pound, P-index of 70; 150 pound, P-index of 0)
- K2O, 0-150 pounds/acre (0 pound, K-index of 80; 150 pound, K-index of 0)

**9. Use raised beds with or without plastic mulch.**

- Plastic mulch can be used if your soil is well-drained, otherwise use bare-soil raised beds.
- Plastic mulch helps control weeds. If using bare-soil beds, you will need field cultivation equipment for weed control.
- White-on-black mulch is recommended if using plastic mulch.
- More research is needed to draw conclusions on the benefit of plastic mulch on bud yield and quality.

**10. Spacing.** Spacing depends on the cultivar canopy profiles and the transplanting time. Typically, it is four feet in-row by five to six feet between rows. More specifically, in-row spacing can be six feet for late-May or early June transplanting, five feet for mid-June transplanting, and four feet for July or later transplanting.

**11. Irrigation.** Generally, 1 to 1.5 inches of water each week is needed. One or two lines of drip tapes can be used for irrigation.

- Keep in mind that industrial hemp plants do not like wet feet so do not over water and make sure your field drains well.

## CHAPTER 5

# HEMP FLORAL BUDS PRODUCTION FOR CBD

**12. Staking, tipping, and pruning.** Some practices of CBD hemp plant management are similar to what you do with indeterminate tomato plants.

- Depending on cultivars and planting time, your plants may need staking as they will grow tall quickly. Without staking, plants may fall and/or split.
- Tipping will result in more flower buds from lateral branches thus increasing yield.
- Pruning off some lateral branches may be needed if plants become overly crowded. This will help air circulation that mitigates disease problems and results in large floral buds.

**13. Identify and uproot male plants.** If using feminized cultivars, make sure to remove male plants before they flower. Uproot and move them out of the field. Bury or burn or compost them if you can. Ideally, they will be one to three miles away from your hemp field as plants pulled may still develop and release viable pollen before they die.

- Hemp male and female flowers are visually different before blooming. Remove male plants as early as possible.
- This needs to be a daily effort for a few weeks in July and August.



*Hemp branches can split if not staked.*



*Hemp male and female plants (left), and pollen sacks about to release pollen (right).*

## CHAPTER 5

# HEMP FLORAL BUDS PRODUCTION FOR CBD



*Caterpillars damaging hemp plants.*



*Middle row: Infestation symptoms of Russet mites in a high tunnel.*



*Southern blight disease in hemp.*

### 14. Pest management.

- CBD hemp has numerous pest problems, but pesticides for hemp production are still limited. Visit <https://www.epa.gov/pesticide-registration/pesticide-products-registered-use-hemp> for a growing list of approved pesticides. Also, as an option, you can use minimum risk pesticides (25b pesticides) in hemp production.
- + Contact your county extension office for help in identifying pest problems or sending samples to the Plant Disease and Insect Clinic at NC State for pest identification and control options.
- Early cultivation while plants are small, is the key to controlling weeds. Once plants take off, weeds should not be a major concern.
- Use listed bio-pesticides to control insect pests such as armyworms and fruit worms.
- Watch for symptoms of russet mite infestations. Dry conditions promote their spread. Russet mites are small, twice the width of a human hair, so they cannot be seen with the naked eye (<https://content.ces.ncsu.edu/hemp-russet-mite-in-industrial-hemp>). Using sprinklers can lessen this problem as well as the two-spotted spider mites infestation (<https://content.ces.ncsu.edu/twospotted-spider-mite-in-industrial-hemp>), if your field is equipped to do so.
- There is no cure for soil-borne diseases, such as Southern blight and Fusarium wilt, in hemp production. Uproot infected plants immediately and move them out of the field once spotted.
- Check with your contractor before spraying pesticides. Your contract may have language specifying allowable pesticide residues in your dried floral mass, which could be zero.

## CHAPTER 5

# HEMP FLORAL BUDS PRODUCTION FOR CBD

**15. Testing for THC.** The THC content will elevate as flowers get more mature.

- Beginning October 1, 2021, USDA's THC testing rules should be followed (see chapter 3).
- + All hemp is required to be sampled 30 days before harvest.
- + The growing list of DEA-registered labs can be found at [https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories?field\\_lab\\_location\\_administrative\\_area=NC](https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories?field_lab_location_administrative_area=NC). Any lab on the list can be used for testing hemp grown in NC.
- + DEA allows labs that are non-DEA registered but in compliance for THC testing until Dec. 31, 2022.

**16. Harvest.** Harvesting time is critical for high-level CBD in flower buds. The higher the CBD content (percentage), the higher the price.

- Most cultivars are ready for harvest between 55 to 70 days after flowering (September to October). Your clone provider or contractor can provide that guidance. If not, harvest when most trichomes have become milky to slightly amber from crystal clear or the stigma has turned orange. A hand-held magnifying glass will help in examining the trichomes.
- Presently, harvesting is primarily done manually, so get your farmhands ready.

- + For small-scale operations, harvest the buds only; for large-scale productions, harvest the whole plants. Over 200 man-hours might be needed to harvest one acre of hemp.
- + Have a copy of your hemp license with you when transporting the plants. It will be even better if your local law enforcement is aware of your hemp harvesting and transporting.

**17. Drying.** To dry, hang whole plants or snip buds and place them on a drying rack. Dry indoors at 60-70°F, 45-55% humidity for seven to 15 days until the moisture content is less than 10%.

- A tobacco barn is a good drying option. A typical bulk barn can hold about three-quarters of an acre of hemp.
- A sweet potato curing facility can also be used.
- Consider using air-circulation aids in your drying facility to speed up the process.
- CBD hemp is paid by the percentage of CBD content. Buyers may reject dry mass of low CBD content, so only keep dried buds, not the leaves and stems from the whole plant.

**18. Storage.** After drying, store the dry buds in airtight bags and place them in a cool and dry place, away from direct sunlight. Deliver the dried buds (whole buds or ground) to your contractor as early as possible.



*Hemp flower buds not ready to harvest (left) and about ready to harvest when stigmata have turned orange (right).*

# FIBER AND SEED HEMP PRODUCTION

Hemp is a great crop for fiber or grains (seeds or oilseeds), but because state-specific research has been limited, you may want to consider these general practices.

**1. Know what you are dealing with.** Hemp is a warm season, annual herbaceous species of Cannabaceae. It is a short-day dicot meaning it is a kind of flowering plant that begins to initiate flowering as the days shorten after the June 21 solstice. Naturally, it is dioecious, i.e., there are male plants and female plants. Male plants are not ideal for fiber production, but they are essential for grain/seed production.

- Do not grow seed/fiber hemp and CBD hemp in the same field. At least a 3-mile separation is needed between the two types of hemp. Make sure your neighboring farmers are aware of your seed/fiber hemp if they grow hemp for CBD.

**2. Acquire a hemp license.** Anyone growing hemp must have a valid license issued by NCDA Industrial Hemp Pilot Program before Jan. 1, 2022 or issued by USDA after Dec. 31, 2021.

**3. Secure a market for hemp fiber/grains or have a way to process oilseeds.**

- **Fiber:** It is unlikely you will grow hemp and process them yourself. Therefore, it is essential to contract with a hemp fiber processor close to your farm that will purchase your hemp plants. There are not many licensed processors in North Carolina or the neighboring states. Check <https://www.ncagr.gov/hemp/ProcessorsInfo.htm> for a list of registered processors and verify if they will accept and process your hemp.
- **Grains:** Hemp seeds are a nutritional food source and can make hemp oil and other forms of food. You can contact a buyer or process yourself if you intend to purchase the equipment needed, for example, a dehuller, for processing.

**4. Consider insurance options:** refer to “available crop insurance for hemp” in chapter 4.

**5. Choose and secure cultivars/seeds.** Use the cultivars your contractor suggests, or cultivars that have a low chance of getting ‘hot’ while providing a good yield. The legal limit for THC is less than or equal to 0.3% (dry weight).

- The price will vary among cultivars, but the average price was about \$4 per pound in late 2020, according to the HEMP BENCHMARKS®.
- For fiber: Cultivars bred in northern environments (high latitude) have lower biomass yield when grown in the South (low latitude). The harvest height for fiber is 10-15 feet, with a yield of 1.0-5.5 tons/acre of dry matter.
- For grains: In a 2017 North Carolina trial, Futura 75, CRS1, Felina 17, and Felina 32 had a higher yield than the other 10 cultivars. In a 2018 trial, Tisa, Monica, Carmagnola, and CFX2 had a higher grain yield (>500 lb/acre) than the other eight cultivars. The harvest height for grains is six to nine feet, with an average yield of 800-1,000 pounds per acre.
- There are dual-purpose (for both grains and fiber) cultivars available, which may complicate the harvest schedule. Felina 32 is such a cultivar.
- As a reference, check the list of approved cultivars by the Canadian government at <https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/producing-selling-hemp/commercial-licence/list-approved-cultivars-cannabis-sativa.html>.

## CHAPTER 6

# FIBER AND SEED HEMP PRODUCTION

### Hemp Fibers and Retting

THERE ARE TWO TYPES OF FIBERS IN HEMP, BASTS AND HURDS.

- Bast fibers are long vascular fibers from the exterior of the hemp stalk. They are used for textiles, fabrics, yarns, rope/twine, clothing/shoes, brake/cutch linings, etc.
- Hurd fibers are short, woody fibers from the interior of the hemp stalk. They are used for animal bedding, mulch, building materials, insulation, fiberboard, papermaking, etc.

HEMP FIBER PROCESSING IS DONE BY MECHANICAL SEPARATIONS OR RETTING.

- Mechanical Separation: hemp stalks pass between fluted rollers to crush and separate the woody inner core (hurds) from the exterior bark (basts).
- Retting and Fiber Separation: inner core fiber is separated from the exterior bark using water or spread in moist fields to break down. Fibers are further processed through a mechanical separation after retting, drying, and being baled.

### Hemp Essential Oil, Seed Oil, and CBD Oil

HEMP SEED OIL (HEMP OIL), ESSENTIAL OIL, AND CBD OIL ARE DIFFERENT.

- Hemp oils are cold-pressed hemp seed oils and can be obtained in large quantities because hemp seeds contain 30-35% fatty acids. Unrefined hemp oil is dark to clear light green, with a nutty flavor.
- Hemp essential oils are steam-distilled from hemp flowers and are in very little quantity because hemp flowers have trace amounts of volatile oils. It may take 50 pounds of flowers to make one ounce of hemp essential oil. Hemp essential oils are a pale yellow liquid containing aromatic terpenes.
- CBD oil is one type of cannabinoids abundant in the trichomes of hemp female floral buds. Cannabinoids cannot be obtained from cold-press or steam distillation. It has to be extracted. CBD content is less than 10% in dried hemp buds.



*Extracted hemp CBD oil (left, credit: [www.openaccessgovernment.org](http://www.openaccessgovernment.org)) and hemp seed oil (right, credit: Jason HS).*



## CHAPTER 6 FIBER AND SEED HEMP PRODUCTION

**6. Soil preparation and fertility.** A suitable soil for hemp growth is similar to the soil for growing corn. It should have a pH of 6.0–7.5 and have well-aerated loams of high fertility and organic matter. Fertilization rates for fiber/grain hemp should be N 70–100 pounds per acre, P 0–45 pounds per acre, and K 45–178 pounds per acre. Make sure you work the fertilizers into the field when preparing the soil in the spring.

- Some farmers have tried no-till and had some success.

**7. Seeding rate and time.** The seed rate is 40–60 pounds per acre (three to eight inches spacing) for fiber production and 10–40 pounds per acre (6-inch spacing) for grain/seed production. Drill seeds into the soil at a depth of 1/4 to 1 inch a couple of weeks after the last spring frost. If sowing too late, your plants will flower without reaching their full growth.

- Currently, there are no EPA-approved pre-emergent herbicides for hemp. Cleaning up the field is essential before drilling the hemp seeds.

**8. Irrigation.** Industrial hemp is prone to a poor establishment if there is a lack of water during germination. In general, 1.0 to 1.5 inches of water each week is needed.

**9. Pest management.** Fiber and seed hemp plants have less insect and disease problems than CBD hemp plants. Sprays may not be necessary. If needed, check the EPA site for pesticide options (<https://www.epa.gov/pesticide-registration/pesticide-products-registered-use-hemp>). Minimum risk pesticides (25b pesticides) can be used in hemp production.

- Make sure to have a good standing to control weeds. Hemp seedlings grow fast and usually can compete with weeds if there is good germination.
- Birds can be a big challenge to hemp grain production, as they will feed on the maturing seeds.



*A hemp field of good standing with little or no weed pressure (left) or of poor standing with high weed pressure (right).*

## CHAPTER 6

# FIBER AND SEED HEMP PRODUCTION

**10. Testing for THC.** When plants start to show female flowers, send samples for THC testing (see chapter 3 for details).

- Beginning Oct. 1, 2021, all hemp is required to be sampled 30 days before harvest.
- The growing list of DEA-registered labs can be found at [https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories?field\\_lab\\_location\\_administrative\\_area=NC](https://www.ams.usda.gov/rules-regulations/hemp/dea-laboratories?field_lab_location_administrative_area=NC).



*Female (left) and male (right) flowers of hemp. Fiber hemp harvest occurs before the full development of male flowers (no pollination).*



*A female hemp plant shows uneven ripening of seeds (left). Mature seeds will drop to the ground if not harvested in time (right).*

**11. Harvest, delivery, and storage.**

- **For Fiber:** Harvest hemp fiber by following your contractor's instructions or before the full flowering of the male plants. Equipment does not yet exist in the U.S. for optimal cutting and management of hemp during retting. You can use the skills in producing high-quality hay for successful field retting of fiber hemp.
  - + After harvesting, deliver the bales to the processors per their instructions. Storing acres of hemp fiber is not practical for most small farmers.
- **For grains/seeds:** Industrial hemp seeds do not mature at the same time. When seeds are fully mature, shattering takes place. Harvest when 70% of seeds have ripened.
  - + Harvested grains should be dried to below 12% moisture for short-term storage and 8-10% for long-term storage.
- **For dual-purpose cultivars:** Harvest the grains first, then harvest the fiber. Ideal practices are yet to be developed in North Carolina for these cultivars.



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