KENTUCKY STATE UNIVERSITY
COOPERATIVE EXTENSION | FACT SHEET

Information about the Kentucky State University Cooperative Extension Program 2021

Organic Hemp for Cannabinoid Extraction: Production, Opportunities, and Risks

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Introduction

The 2014 Farm Bill enabled the U.S. to establish pilot research programs to investigate production of industrial hemp (*Cannabis sativa* L.). The 2018 Farm Bill provided a framework for USDA oversight of state hemp programs and removed hemp from Schedule I status of the Controlled Substance Act (CSA), facilitating transport and sales of hemp products nationwide. To legally differentiate hemp from marijuana, the Farm Bills established that hemp can have a maximum level of 0.3% delta-9-tetrahydrocannabinol (THC). The Kentucky Department of Agriculture (KDA) oversees hemp permitting and regulatory compliance for Kentucky producers, handlers, and processors. The legislative changes have generated a significant interest in this crop from consumers, producers, processors, researchers, Extension personnel, and trade groups.

Hemp is generally grown for fiber, grain, or cannabinoid extraction. Many producers opt to grow hemp for cannabinoid production. In Kentucky, 92% and 95% of the acres approved by KDA for hemp production were for cannabinoid production in 2019 and 2020, respectively. Producers have noted the growth in consumer interest in non-intoxicating Cannabis products like Cannabidiol (CBD). Consumers are interested in CBD because non-clinical studies have suggested it may help with chronic pain, anxiety, sleep disorders, and multiple sclerosis. These potential uses are based on anecdotal evidence and non-clinical studies. As of this writing, the FDA has only approved one CBD product (Epidiolex®, GW Pharmaceuticals) for use as a therapy for seizures and consumers should use appropriate caution with other non-approved products. Cannabinoid crops require fewer production acres (median acreage in 2019 was 10 acres) and processing options are available, with some caveats. Barriers for fiber and grain production include larger acreages needed to achieve profits and a lack of processing infrastructure in Kentucky and the U.S. in general.

Some consumers interested in hemp products will be interested in USDA Organic products having minimal agrichemical residues. Producers have interest in organic hemp because organic products typically sell for higher prices than comparable nonorganic products. The USDA National Organic Program (NOP) clarified in Instruction 2040 that hemp grown in accordance with state run hemp programs could be certified organic. This fact sheet will concentrate on outdoor production of organic hemp for cannabinoid extraction. Producers interested in organic production must be certified by a USDA accredited organic certifier.

Soil and Fertility Considerations for Hemp Production

Hemp is a warm season annual crop that prefers well drained soils with a pH range between 6.0 and 7.0. Soils that are wet, have high clay content, or are prone to crusting should be avoided. General fertility recommendations are given in Table 1. Nitrogen is often the most limiting nutrient for hemp and other Extension publications recommend a nitrogen rate of 100 - 120 lbs / acre for cannabinoid crops. Hemp needs nitrogen throughout its lifecycle but has greatest demand in the vegetative stage as plants devote their resources to getting bigger. Phosphorus and potassium are also important during early vegetative growth. Phosphorus demand is also high during flowering. Most farmable soils in Kentucky will provide adequate calcium, magnesium, sulfur, and micronutrients. Organic producers generally provide nutrients via animal manures, cover crops, and green manures in a multi-year crop rotation. Commercial products are available but these can be costly and producers should verify product NOP compliance with their certifier before use. Application rates should be based on soil test recommendations.

Starting a Hemp Crop for Cannabinoid Cultivars

Cannabinoid crops are usually started from transplants or vegetative cuttings (clones). Kentucky producers should refer to the KDA *Summary of Varieties* (see references) to help make decisions on choosing cultivars that are compliant with the 0.3% THC threshold. In Kentucky, seeds should be started in a greenhouse in April or May. While certified organic hemp seeds must be used in organic production when available, organic seed availability is currently sparse in the U.S. Producers who cannot obtain organic seed may use untreated seed. Organic producers should start seeds in approved potting media and expect germination in 2 – 4 days at temperatures around 75°F. Producing clones is beyond the scope of this fact sheet but clones are a viable alternative to seed. Clones produce more uniform crops and eliminate the labor involved in culling male plants (see below). They are more expensive and growers should be aware that clones purchased from off-farm can be infested with greenhouse pests like aphids or spider mites. Anecdotal evidence suggests that plants started from seed develop more robust root systems than clones.

Young hemp plants need regular watering but overwatering is a very common mistake among new growers. While avoiding wilting, media should be allowed to dry out after watering. Care should also be taken to avoid plants becoming root-bound. Plants can safely be moved to the field when the second set of true leaves has developed (Figure 1). In Kentucky,

Table 1. Recommended fertility rates for selected macronutrients in cannabinoid hemp crops.

	Nutrient			
	Nitrogen	Phosphorus	Potassium	Sulfur
	lbs/ac			
Recommendation	50-150*	0-150†	0-150†	0-25†

* Recommended N supply for a season. Organic growers should account for N being supplied by manure, cover crops or green manures before applying additional N.

† Additions of P, K, and S should be based on results of soil tests and soil type as well as previous field history. Additional information on soil testing and nutrient recommendations for Kentucky Growers can be found in University of Kentucky Extension's AGR-1 Lime and Nutrient Recommendations (See references).

May and June are optimal planting months but some cultivars can be set in the field as late as early- to mid-July and still be expected to produce smaller, but reasonable, flower yields.

Figure 1. Hemp seedlings started in a greenhouse showing two sets of true leaves. These plants could be transplanted into the field if environmental conditions are appropriate. (Photo by Jonathan Palmer)

Planting and Weed Management

Most organic producers will create a tilled seedbed for their crop. Hemp cultivars grown for cannabinoids are bushy and branched. Field spacing varies depending on cultivar, planting stock or individual grower needs. Typical in-row spacing between plants ranges from 3.5 feet to 6 feet. Smaller spacing is used when male plants will be culled from the field (see below). Spacing between rows depends on planting methods, weed control strategies, and equipment but generally ranges from 5 to 7 feet. Growers often set plants by hand or use a waterwheel or other horticultural transplanter with or without a plastic layer. To prevent stem disease, the rootball should not be set deeper than 0.25 inch below field surface. Some growers use raised or mounded beds to enhance drainage and aeration. Drip irrigation systems help to provide water while transplants become established in the field. After root systems are well developed, many Kentucky growers find the need to supplement water during prolonged dry periods.

A major concern in organic systems is weed control. Some growers control weeds by planting in plastic mulch which is acceptable in organic production as long as the materials are petroleum based (no PVC) and are removed from the field after the season. Other growers dislike plastic because it can fragment over the course of a season, is laborious to remove, and the waste ends up in landfills. Organic growers should manage weeds through a systems approach involving weed suppressive cover crops prior to hemp, tillage, stale seed-bed techniques, and mechanical or hand cultivation within and between rows during the season. Weed control is critical during establishment of new plants and through early growth. As hemp plants mature and establish a canopy, the need for cultivation within rows decreases.

Flowering and Maturation

Figure 2. A field showing well developed female hemp flowers in an organic cannabinoid crop. (Photo by Shawn Lucas)

Hemp has two primary stages in its life cycle: vegetative growth where plants basically get bigger and reproductive growth where plants produce flowers. Most hemp cultivars develop male and female flowers on separate plants. Concentrations of CBD and other cannabinoids, including THC, are highest in mature female flowers (Figure 2) which are the raw product of a cannabinoid crop. Hemp plants are generally photoperiod dependent, flowering based on the hours of daylight available.

Early signs of flowering generally begin to appear when day lengths shorten and approach 13 hours of daylight. Producers in Kentucky should start to watch for signs of flowering in late July to early August. Flowers continue forming into fall and most cultivars become mature and ready for harvest in September or October. Important exceptions to the above information are autoflowering cultivars. These cultivars are not photoperiod dependent, flowering more like a corn crop based on the time they have spent in the field. Autoflowering cultivars generally flower after three to five weeks in the field and are fully mature after seven to ten weeks. These cultivars tend to be smaller and are planted at different spacing (approximately 1 foot in row) than photoperiod sensitive cultivars.

Figure 3. ***Top:*** A hemp plant in early stages of flowering showing female preflowers (pistils) indicated by the yellow arrow. ***Bottom:*** A hemp plant in early stages of flowering showing male preflowers (immature pollen sacs) indicated by the red arrow. For cannabinoid crops male plants should be removed from the field before pollen sacs open and release pollen. (Photos by Jonathan Palmer (Top) and Craig Lee (Bottom). Photos edited by Shawn Lucas).

As flowers mature, growers cull male plants if they are not growing from feminized seed or clones. A lack of male plants in the field should prevent pollination (note that other nearby *Cannabis* could pollinate a grower's crop) and female plants will devote resources to flower production rather than seed production. Culling males involves early identification of male flower structures and removing these plants from the field before pollen is released. Early male and female flowers can be seen in Figure 3. Scouting fields for males is time consuming and culling is laborious, so people often choose to grow "feminized" seed or female clones, however batches of "feminized" seed often produce some male plants and even female clones can produce male flowers under stress conditions. Producers should scout fields periodically for male flowers regardless of planting stock. It is important to scout fields as early in the flowering process as possible because male plants often develop flowers before female plants.

Cannabinoids increase in flowers as plants mature. After eight to twelve weeks of flowering (cultivars vary), female plants will be fully mature. However, well before full maturity, producers should begin monitoring their crop THC and CBD levels. Samples should be collected from the top five inches of flower from five to six different plants. These samples should be mixed together to form an averaged sample and then taken or sent to a lab that tests cannabinoid potency. Crops should be monitored closely as they approach the 0.3% THC legal threshold. In Kentucky, KDA requires two weeks notice of a producer's intent to harvest in order to conduct THC compliance testing. Producers may not harvest until compliance samples are collected and they should make decisions on when to notify KDA of intent harvest based on their own test results. The knowledge that cannabinoid levels will continue to rise between notifying KDA and the date upon which compliance samples are collected should inform that decision making process. Crops that test over 0.3% THC may have to be destroyed. Kentucky hemp growers should refer to the KDA hemp program for more information on compliance (https://www.kyagr.com/marketing/hemp-pilot.html).

Harvest

Physical indicators of mature crops include golden to reddish brown pistils and cloudy trichomes on the flowers (Figure 4) but potency testing (see above) should inform harvest decisions. Hemp harvest can be reminiscent of tobacco harvest. Plants are often harvested by hand. Mechanized equipment is available but is currently very expensive. Large scale operations often have teams of laborers cutting plants, stacking them on trailers or hay wagons, and transporting them to the area where the plants will hang to dry. Growers use different tools for cutting hemp stalks ranging from machetes to sickle-bar mowers to motorized pole saws. Plants are hung in a dark, dry area with good air circulation. To prevent mold, plants should not be so densely packed in the hanging area that air does not move well between them. Tobacco barns are commonly used in Kentucky, as are high tunnels with double layered shade cloth or warehouses with adequate space and ventilation. Some large scale growers use ovens to dry the plants at 120-150°F (higher temperatures will cause degradation of cannabinoids). The goal is to get the plant material to 12% moisture or less to inhibit mold. After drying the material is ready to be marketed. Growers for will often shuck the flowers into large polypropylene mesh supersacks for storage and transport to a processor.

Figure 4. Mature female hemp flower ready for harvest. The inset shows a close view of the reddish brown pistils that indicate maturity in Cannabis. To avoid going over the 0.3% THC limit, actual harvest decisions should be based on results of potency testing as well as physical indicators. (Photos by Jonathan Palmer).

Other Important Considerations

Many pitfalls can be avoided by obtaining seed or clones from trusted sources. Many cultivars have been bred in Colorado, Orgeon or other states that have legalized marijuana and are essentially marijuana cultivars that have been bred for reduced THC. They may not be stable or uniform when grown from seed and they may not perform as expected in Kentucky agroecosystems. This can lead to exceeding the THC compliance threshold, particularly in cultivars having high CBD contents. Preliminary results from work at Kentucky State University has indicated that plants with more than about 8% CBD tend to be close to or over the 0.3% THC threshold. Producers should also be aware that "feminized" seed is often not truly feminized and can have a higher than advertised ratio of male to female plants.

This industry is new and the market is volatile. Prices for hemp grown for CBD extraction dropped by over 78% from fall 2018 to fall 2019 and have remained low in 2020. Many contracts with farmers have been voided by processors and some processors have filed for bankruptcy. Production in 2019 exceeded demand and many farmers were not able to sell their crops. Specific demand for organic crops remains as uncertain as the industry in general.

Hemp may be a new opportunity for organic farmers and is an additional way to diversify a farm operation or crop rotation. There is significant interest from consumers in cannabinoid products derived from hemp. However, farmers interested in trying hemp production should make sure they understand the risks. Good advice for new hemp farmers is to start small, learn the lifecycle of the plant, don't plant or invest more than you can afford to lose, and make sure you have a solid marketing outlet for crops before planting. An excellent resource for developing a production budget is the University of Kentucky's ***Hemp & Enterprise CBD Budget Model*** (see references: Mark and Shepherd, 2020). It is recommended that a lawyer review any marketing or processing contracts. This crop and the associated industry are new to the U.S. agricultural landscape and there are many uncertainties, including a lack of FDA approval on most products. There is also guarded optimism that as the industry becomes more established, more products gain FDA approval, and consumers become more educated on non-intoxicating *Cannabis* products, the cannabinoid market will stabilize and organic products will likely have a share of this market.

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