EXTENSION
AGRICULTURE

THE UNIVERSITY OF VERMONT EXTENSION

NORTHWEST CROPS & SOILS PROGRAM

Industrial Hemp for Flower Production

A Guide to Basic Production Techniques

Hemp is a non-psychoactive variety of *Cannabis sativa* L. The crop is one of historical importance in the U.S. and re-emerging worldwide importance as manufacturers seek hemp as a renewable and sustainable resource for a wide variety of consumer and industrial products. Hemp can be grown for flower, fiber, and/or grain. For years, U.S. entrepreneurs have been importing hemp from China, Eastern Europe and Canada to manufacture travel gear, apparel and accessories, body care and cosmetics, foods like bread, beer, and salad oils, paper products, building materials and animal bedding, textiles, auto parts, housewares, and sporting equipment. Industrial hemp is poised to be a "new" cash crop and market opportunity for Vermont farms that is versatile and suitable as a rotation crop with other specialty crops, small grains, and grasses.

Hemp grown for all types of end-use contains less than 0.3% tetrahydrocannabinol (THC). Hemp varieties intended to produce a health supplement contain relatively high concentrations of a compound called cannabidiol (CBD), potentially 10-15%. Cannabidiol is just one of over 100 cannabinoids found in hemp. Cannabidiol has purported benefits such as relief from inflammation, pain, anxiety, seizures, spasms, and other conditions. In addition to the vast number of cannabinoids, plants are known to produce over 400 other secondary compounds including terpenes, which have other purported health benefits and contribute to plant aromatics.

The CBD is most concentrated in the female flower buds of the plant; however, it is also in the leaves and other plant parts as well. To grow hemp for CBD production, the crop is generally grown intensively as a specialty crop and the flowers are cultivated for maximum growth. The CBD is extracted from the flowers, leaves, and stems using a variety of technologies including more widely used methods such as CO_2 extraction, solvent based extraction (ethanol, butane), and cooking oil extraction methods.

As of April 18, 2019, the State of Vermont has filed its proposed rules for hemp production and processing in Vermont with a number of rules already in effect. In addition to Vermont Hemp regulations, growers must also be in compliance with state Required Agricultural Practices (RAP) found online at https://agriculture.vermont.gov/sites/agriculture/files/documents/RAPFINALRULE12-21-2018_WEB.pdf. Before planting, any person who wants to grow, cultivate, or process hemp in Vermont must do the following:

1. Register with the Vermont Hemp Program.
2. Comply with Vermont Hemp Rules.

Please refer to this link for a detailed outline of proposed rules in Vermont. The proposed rules can be found on the VAAFM website here: https://agriculture.vermont.gov/public-health-agricultural-resource-management-division/hemp-program/hemp-program-rulemaking

Seed/Plant Access

Hemp is an annual crop and hence needs to be planted each year of production. Seed is easy to germinate but can have great variability even within the same cultivar. Plants are most often dioecious, having separate male and female plants, and planted non-feminized seed will often result in a roughly 50/50 split of males and females. Plants can also have the propensity for hermaphroditism (the inclusion of both male and female flowers on a single plant) based on plant genetics and environmental or growing condition stressors such as water or nutrient deprivation or heat stress to name a few.

Cannabidiol (CBD) production focusses on the growth of female plants primarily for the harvest of buds, but also biomass (small stems and some leaves), to extract and refine phytocannabinoids and other compounds. In this case, the hemp flowers are being grown for extraction of CBD.

When determining what type of planting stock to source for your farm, it is important to consider opportunities and challenges associated with selecting non-feminized seed, feminized seed, and vegetative clonal cuttings. Regardless of the type of material or source, be sure to obtain a Certificate of Analysis (COA) outlining cannabinoid profile to make sure you are growing a crop that will be less likely to exceed mandated THC levels.

When planting from seed, consider the two options: non-feminized seed and feminized seed. Non-feminized seed will result in a roughly 50/50 split of males and females, whereas feminized seed should be greater than 90% female. On a large scale, CBD seeds will generally cost between $0.50-1.00 depending on seed type, source and bulk discounts.

Non-feminized seed will be cheaper to purchase but will require you purchase roughly twice as much seed to compensate for males, and will require greater labor in screening for males during the production process. Feminized seed will be more expensive but require less seed and less labor for screening for males throughout production. Plants may require 4-6 weeks of growth before you will be able to determine sex.

Vegetative cuttings and clonal production can be the most expensive option for production and can cost $5-10 for a single female clone if purchasing from an outside source. This will provide you with the most consistency and stability within a variety as a result of preselected traits such as plant growth habit, internode spacing, leaf size, canopy growth, CBD/THC ratios, regulatory compliance, pest resistance, and regional adaptability to name a few.

If looking to produce your own clonal starts from cuttings, the above parameters are but a few aspects to be aware of when selecting traits of a mother plant. After selection, you will need to maintain a controlled environment year round with supplemental lighting (minimum 14 hours of light per day to prevent flowering) and climate control. Mother plants should be healthy and new mothers should be grown as backups on a 3-6 month rotation to ensure perpetuation of selected traits for your cultivar and plant vigor for adequate shoot production.

Cuttings should be sturdy enough to “stick” in the propagation media and have 3-5 nodes per cutting, though fewer can work. There are a wide array of options for rooting compounds and

biodegradable growth media, but plants should be allowed a few weeks to establish root growth before planting out.

Maintain proper sanitation throughout the process using healthy stock plants, clean equipment, and disease free growing media.

When first sourcing plant material, it is best to purchase from companies within your growing region to provide you with material that is well suited for the climate.

Site selection

Site selection is one of the most important factors to consider. Plants require full sun and prefer loose, well-aerated soil, and are intolerant of water logged areas that are greater than 40% clay. While hemp is widely adaptable to a variety of regions, poorly drained soils can hinder plant growth and result in crop failure.

Plants thrive in 70-80^{o} F growing conditions with even watering. Much like other transplanted crops, water is key for establishment and plants will thrive with consistent, even watering which can be supplied via irrigation. While irrigation is not entirely necessary for the crop, you may see bumps in yield with more consistent watering than precipitation can provide, and watering will be required during extended dry spells.

Planting

Transplants should go out after last "at risk" day for frost depending on your hardiness zone. Ideal planting time for many areas in the Northeast will take place from the end of May through the end of June. Seed can germinate at 50^{o} F but should be planted after danger of frost has passed if direct seeding, however it is generally best to plant out selected female plants from seed starts or rooted cuttings.

Plants can be effectively planted into black plastic laid with irrigation, which helps to reduce weed pressure during plant establishment periods. However, plants can be established in no-till systems or direct into fields with other proper weed control strategies and soil conditions.

Plants produced for optimal bud production are often spaced on a 4-6' center for each plant within rows. While number of plants per acre is dependent on plant spacing and row spacing, you will generally be planting 800-1800 plants per acre. Regardless of spacing, be sure to provide yourself with ample space for tractors or harvesting equipment between rows for ease of maintenance or harvest throughout the season.

Fertility Management

Managing fertility starts by taking a soil test to gain an understanding of the nutrients in your soil. Soil samples can be sent to the University of Vermont Agricultural and Environmental Testing Lab or to other accredited labs in the region. Soil tests will help you better understand if your hemp will require additional nutrients to be productive. Generally if a soil test indicates medium levels (or lower) of nutrient availability, then adding these nutrients to the soil will benefit the hemp crop's overall productivity. Remember, a soil test should be taken well in

advance of planting the crop. This will provide time to correct any soil deficiencies prior to planting the crop.

Unfortunately, there is a lack of scientific data available regarding the nutrient requirements of hemp being grown for flower production. The most relevant information can be drawn from the hemp grain and fiber recommendations. These indicate that hemp requires a significant quantity of nitrogen (N) and potassium (K). The recommendations for nutrients are similar to those required to produce a high yielding corn crop. Although phosphorus (P) is required by hemp, the quantities required are much smaller compared to N and K. Hence, if a soil test reports high levels of P and K, it is not likely you will see a crop response from adding these nutrients. If soil test levels are medium to low, follow the corn recommendations as a baseline and monitor the crop. Nitrogen is a different story, as it is not accounted for on a standard soil test because of its dynamic nature in the soil. Generally, hemp will remove 100 to 150 lbs of nitrogen per acre.

Hemp prefers a pH of 6.0-7.5. If the soil test indicates a low pH, the liming agent should be amended to the soil well in advance of planting the crop. Generally, it takes several months for the lime to react with the soil and for the pH to be increased.

Other required nutrient sources can be applied through drip irrigation or as a side dress depending on crop type and growing practices. Adding small amounts of N throughout the vegetative growth period will minimize nutrient losses to the environment. The P and K can be added prior to planting. If large quantities of K are required, split applications may be more advantageous to minimize leaching.

Although micronutrients may benefit hemp flower quantity and quality, there is no evidence to support specific recommendations. Generally, soils low in organic matter, low in pH, and/or sandier textures are at the highest risk for macro and micro nutrient deficiencies. It may be advantageous to apply a general micronutrient package if these specific conditions exist.

Growth

When starting from seed, plants will generally take 3-7 days to germinate and will require a minimum of 14 hours of light in order to maintain their vegetative growing state. Sometime between the first 4-6 weeks, you will also begin to notice the formation of “pre-flowers” which will allow you to determine the sex of plants. Female plants will produce a cluster of white hairs (stigmas) at nodes whereas male plants will produce a small male flower cluster. These males should be removed and destroyed to prevent pollination of female plants later in the season.

Transplants placed out after last frost-free date in your area will begin rapid root and shoot growth with adequate fertility. Depending on soil fertility and compaction, plants may form sprawling roots in the top layer of soil or establish a taproot under less compact conditions and adequate air space as roots forage for nutrients. Plants will similarly begin to produce lateral shoots during the first few weeks of growth that will continue to develop over the course of the season.

Plants will begin flowering late-summer into early fall as daylight decreases. Plants will continue to develop flowers and increase biomass in subsequent weeks as trichomes form and resins develop concentrated in the buds, but found across the entire plant. The majority of cultivars in production will require this change in photoperiod to induce flowering and bud formation, but there are also auto-flowering varieties that begin to flower after 3-4 weeks of growth regardless of photoperiod.

Pest Issues

Regular scouting of hemp is a way to monitor pest populations and potential problems that may arise. To scout your hemp plants, examine the top and undersides of leaves on low and high portions of the plant stems. Choose random plants throughout your field to gain a representative view of the entire planting. Currently, industrial hemp is a minor use crop and there are no registered pesticides available for its use.

Aphids, Japanese beetles, leafhoppers, European corn borers, tarnished plant bugs, and grasshoppers have been observed on hemp fields in Vermont, however, thus far they appear to cause minimal damage to plants. Bertha armyworm has been reported as an occasional pest in Canada, with larvae feeding on the plant. Cutworms are a spring pest and can be identified by areas of dead plants or bare patches. Birds such as blackbirds, sparrows, starlings, etc. have preyed upon hemp seed, which protrudes from the seed head and are easy to pluck leading to harvest loss.

The most frequently observed diseases in hemp have been white mold (*Sclerotinia sclerotiorum)* and gray mold (*Botrytis cinerea)*. White and gray mold infections spread by spores that are carried by wind and insects. Spores infect the stem and grain head in hemp. The resting bodies of the fungus, sclerotia, can overwinter in the soil and remain viable for over 5 years. Moist conditions, high humidity, and warm temperatures (optimal is 68—77^{o} F) encourage spore survival and growth. A four-year crop rotation away from host crops is the best defense for preventing disease.

Early in the season, especially under cool, wet conditions, seedling blight can also be an issue. Seedlings may rot or become stunted, leading to poor establishment and lower yields. Seedling blights are caused by a variety of pathogens including *Pythium* and *Rhizoctonia*. In these cases, use clean media and pots or trays when planting seed, provide adequate spacing between plants to reduce plant to plant contact, and allow for good airflow in any given area. *Pythium* can be introduced via infected plant material or media, or may be present within a greenhouse already. Proper sanitation and well-drained media are key in preventing severe cases of pythium root rot.

Testing requirements

Growers should have plants from each cultivar and cultivation area tested for cannabinoid profile including total CBD and total THC. Total THC levels within each cultivar and cultivation area must remain below the 0.3% THC threshold. Testing should be conducted prior to harvest.

All testing for cannabinoid profile must be completed by a certified laboratory and you should receive a COA outlining the required information to be reported to the State of Vermont. Harvested materials not remaining below the acceptable potency level must be destroyed or disposed of using an approved method by the State.

Depending on end use of the flower crop, a grower may also want to test soils for heavy metals prior to planting as plants are effective accumulators of these potentially toxic metals. Additionally, pesticide residue, mycotoxins, or bacterial and fungal contaminants should also be tested at harvest.

Harvest

Harvest begins after flowers have fully developed, this generally occurs between the end of September and mid-October. The time of harvest will depend on the variety, planting date, and growing region. Russeting of stigmas (white hairs) on buds will be one of the first indicators of bud maturation. As you begin to notice the change in stigmas start looking at trichomes, which should be easily observed with 60x magnification. Trichomes will cover bud and leaf surfaces and will appear as tiny stalks often with bulbous heads. Throughout the maturation process, trichomes will range from clear to amber. Clear trichomes will be underdeveloped lacking full resin development, whereas amber trichomes will often be fully developed but on the verge of degradation. Outdoors, plants can produce amber trichomes due to intense sun exposure, so it is important to conduct visual assessments of trichomes and harvest before the bulbous head of the trichome bursts to maximize resin concentrations.

Cannabinoid testing can help determine harvest timing and also ensure compliance. Cannabinoid profile testing can range from $50-150 depending on desired analytics.

Depending on your drying setup and processing equipment, hemp harvest may take many different forms:

- Whole plant harvest to hang dry.
- Breakdown of plant to individual branches for drying.
- Removal of all flower buds for drying.
- Multiple harvest to remove largest top buds and allow further development of lower buds.

At harvest, plants can be dried before trimming or processed immediately once harvested from the field. It can be easier to trim buds and remove leaves on freshly harvested plants that have not received water in the past two days, though it can take up 6 or more hours for a single person to breakdown, trim, and remove buds from an entire plant depending on plant size. Depending on plant size, this means a single person could be averaging 0.25-0.50 lbs of wet trimmed flower bud per hour.

There are a number of tools available to assist with processing including manual and mechanical “buckers” that assist with bud removal and trimmers to assist with the removal of smaller leaves once buds have been removed from stems. Equipment such as buckers and trimmers can drastically reduce processing time and may be beneficial depending on the size of your

operation, allowing you to process up to 8lbs of wet bud per hour depending on the type of equipment.

The level of leaf removal and manicuring will be dependent on end use and market as labor requirements increase greatly with increased processing. Some additional hand trimming may be required even with the use of mechanized equipment.

Drying

Harvested plants can be hung whole, divided by cutting branches from the main stalk, or immediately trimmed down to buds. Material can be hung upside-down in an indoor facility with minimal direct sunlight, good airflow, and humidity control such as a shed or barn if maintaining whole plants or branches, whereas buds may require some type of containment to dry. Some processors may cut a plant to ensure the center of the plant dries completely, reducing the risk of mold/fungi growth. Plants can be hung with wire or rope, but proper ventilation is key to successful drying and curing.

Commercial driers are also available and can offer stable, controlled environments for drying down plant material. Proper infrastructure for housing driers, unit cost, maintenance and upkeep can be prohibitive, though driers may prove beneficial for those lacking adequate labor or space for drying and processing.

Make sure there is constant air flow by setting up a series of fans running continuously. Plants could take 3-14 days to fully dry down depending on air flow, humidity, and temperature though it is ideal to maintain conditions to minimize the risk of molding.

Ideal drying temperatures for plants should be around 60-70ºF with 45-55% humidity to ensure even drying with minimal damage. Under these conditions, buds should dry down within 3-5 days, though larger buds may take 4 or more additional days to dry. While higher temperatures can allow you to dry down buds at a faster rate many aromatic compounds, such as terpenes, begin to volatilize at temperatures in excess of 70ºF and can also lead to cannabinoid degradation.

List of registered processors in Vermont:
https://agriculture.vermont.gov/sites/agriculture/files/documents/Processors%20sourcing%20from%20VT%20Farmers.pdf

July 2019
Published by the University of Vermont Extension Northwest Crops and Soils Program.