ALT

Hemp 101

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- Hemp:
 - Federal: <0.3% THC</p>
 - VT: <0.3% D9-THC and <1.0%Total THC
 - Type III or Type IV
- Family: Cannabaceae
 - Includes hemp, hops, hackberry
- Genus: Cannabis
- Species: Cannabis sativa L.
 - subsp: indica, ruderalis, etc...







-Herbaceous annual

-Dioecious

-Wind pollenated

-Photoperiod sensitive



Female Plants



• Flowers in axillary inflorescence

• Flowers congested.

• Stigmas are long and covered with receptive papillae.





Male Plants



• 10 to 15% taller and less robust.

• Die after shedding pollen.

- Specialized for pollen dispersal by wind.
- Bees present





CBD, Fiber, and Oilseed Hemp









Hemp Fibers





Retting





Photo courtesy of http://www.hemptrade.ca/eguide/









Hemp Seed Oil

- 30% protein, 25% starch, 30% oil.
- 90% polyunsaturated oils.
- High in omega-3 fatty acids.
- Food, fuel, cosmetics, etc.
- Cake used for food and animal feed.
- Meal fertility source



Hemp Growth Requirements

- Temperature
 & light
- Water
- Soil
- Nutrients
- Weed control





Hemp Growth Requirements

• Adapted to region – fairly cold tolerant.

• Tolerant of hot and arid conditions provided roots can reach water.

• Does not tolerate water logged soils.

• Thrives in full sun.



Hemp Growth Requirements

• Fiber hemp requires about 2,000 GDD

 Oilseed or CBD hemp require about 2,700 – 3,000 GDD



Water Requirements

- Hemp requires at least 20-30 inches of rainfall during the growing period
- Abundant moisture is needed during the germination period.
- The absorption of water increases until flowering begins.
- Then the uptake of water decreases considerably, with a slight increase at late flowering and during seed formation.



Water Requirements

- Hemp requires a plentiful supply of moisture throughout its growing season, especially during the first 6 weeks.
- After it has become well rooted and the stalks are 20 to 30 inches high it will endure drier conditions, but a severe drought hastens its maturity and tends to dwarf its growth.
- In puddled areas of a saturated field hemp will be stunted in two days.
- There is a significant correlation between soil moisture and cannabinoid content. THC & CBD indicated to increase with decreasing moisture and humidity. (Latta and Eaton, 1975; Sikors et al., 2011)





Soil Limitations

Grows best on sandy loams.

• 40% or more clay not generally good.

• Adequate pH – over 6.0 (requires calcium).



Fertility Requirements

Nutrient loving especially N-P-K.

Requires 100 to 200 lbs N per acre

Split applications of N, first one early in growth





Nitrogen

- Both high N and N deficiency can stimulate the formation of male flowers.
- Split applications of N are best to minimize over feeding at any one single stage.
- A deficiency of N causes the entire hemp plant to turn yellow (chlorosis).
- With deficiency growth and flowering are slowed, and the plants will be mostly male.





Phosphorus 50-70 lbs/acre

- Hemp growth, fiber yield, and concentration of THC are positively correlated with extractable phosphate.
- Hemp uses 250% more phosphorus at flowering than during the vegetative phase.
- A deficiency of P shows as abnormally dark dull green leaves with a purple tint on the underside, and downward-curled margins.
- Make sure soil test P is optimum or apply P at planting and potentially close to flowering.



Potassium – 65-70 lbs/acre

- The absorption of K in hemp is highest in the 4th week after germination.
- An excess of K when flowering occurs, will delay maturity and inhibit essential oil production.
- When hemp is cultivated for essential oil, the supply of K should be reduced by 50% during flowering.



Micronutrients

Micronutrient deficiencies often observed in light textured soils that have had low organic matter additions OR when soil pH is not between 6.0 and 7.0

Hemp has an extraordinarily high requirement for Mg.

Hemp requires 250 grams of boron per acre. Boron tends to be deficient in many VT soils.



Table 2.3 Symptoms of Nutrient Deficiency/Excess LEAVES Copper-brown (+N); Copper mottling (-K) Curl (+N, -Mg) Dead areas (+N) Green, dull dark (-P); pale (-S) Margins: Brown (-K) Curled, grey (-K) Downward-curl (-P) Yellow (-Ca, -Mg, -Fe) New Leaves: Brown & white spots (-Ca) Chlorosis (-Fe) Grey-brown & dying (-B) Dark (-Ca) Grey-white spots (-Fe) Yellow edges (-Fe) Yellow & dying (-K) Old Leaves: Chlorosis (-Mg) Yellow (-Mo) Dark-grey (-K) Pimples (+N) Purple (-B); Purple on underside (-P) Spots: Grey-brown necrotic (-Mn) Grey-white patches (-Mg) White (+K)Dark (-K) Twisted (-Zn) Veins: Blackening around (+Ca) Bleaching between veins (-K) Chlorosis between veins (-Zn) Pulpy (+N) Purple (-S) Varicose (-Mg) Yellow between veins (+N, -Mo); Yellow with green margins (-Mn) Yellow-coppery areas, dying leaves (+Water) Wilting (+N) MERISTEMS STEMS Stunted (+K, +Ca, -Mn) Brittle (-Ca) Brown (+N) GENERAL GROWTH Cracked (-B) Dark areas (-Ca) Stunted, flabby (-Ca, -Mn, -B) Dry rot (-B) Herbaceous (-K, +N, +K, +Ca) Hollow females (-Mg); Hollow males (-K, +N, +K, +Ca) Reddish, then black (-P) Solid females (-K) Weak, broken (-Cu)

Results

Nutrient Low Medium Optimum High or Excessive Phosphorus (P): Image: Comparison of the second s

Analysis	Value Found	Optimum Range or Average	Analysis	Value (Found	Dptimum Range or Average
Soil pH (2:1, water)	6.4	na na kanala na kana	Copper (Cu)	0.3	0.5
Modified Morgan extractable, ppm		Zinc (Zn)	0.5	10	
Macronutrients			Sodium (Na)	14.0	20.0
Phosphorus (P)	2.0	4-10	Aluminum (Al)	47	
Potassium (K)	54	100-160	Soil Organic Matter %	5.3	
Calcium (Ca)	1664		Effective CEC, meq/100g	9.6	
Magnesium (Mg)	134	50-120	Base Saturation, %		
Sulfur (S)	8.0		Calcium Saturation	77.4	40-80
Micronutrients			Potassium Saturation	1.3	2.0-7.0
Iron (Fe)	13.5	7.0	Magnesium Saturation	10.4	10-30
Manganese (Mn)	4.9	14.0			
Boron (B)	0.3	0.3			

Recommendations for Pasture, Grass (< 30% legume) - Maintenance (2AM)

Limestone (Target pH of 6.2)	Nitrogen, N	Phosphate, P ₂ O ₅	Potash, K₂O
tons / Acre	lbs / Acre	lbs / Acre	lbs / Acre
0	50	60	80

Seed Purchase

- Grain & Fiber male & female seeds
- CBD
 - male & female seed
 - feminized seed
- CBD Clones
 - female plants
- CBD Starts
 - Gender typed
 - Mixed male & female plants



Plant material

- Grain & Fiber male & female seeds ~\$1.00-2.00/lb
- CBD Flower production
 - male & female seed ~\$0.50/seed
 - feminized seed ~\$1.00-10.00/seed
- CBD Clones \$\$\$
 - female plants
- CBD Starts \$\$
 - Mixed male & female plants





Regular & Feminized Seed

- Regular Seed
 Feminized Seed
 - Less expensive
 - 50% males
 - Need more seed
 - Gender type plants

- More expensive
- Less labor to identify males
- Some plants still produce pollen



Seedling or Clones

Some challenges

- Quality, pests, compliance, volume

- Some advantages
 - Don't need infrastructure (greenhouse)
 - Don't need to learn this aspect
 - Don't need added labor



How Many Seeds/Plants

- $5 \times 5 = 1,742$
- $6 \times 6 = 1,260$
- $4 \times 4 = 2,723$
- $2 \times 2 = 10,890$

Genetics & Planting Stock – Large Expense

\$1 to \$2 per seed = \$1,890/A

\$ 3 to \$8 per plant = \$5,040/A

\$4 to \$8 per clone = \$7,560/A

HEALTHY COMMUNITI

Plant Spacing Study

Plant	Dry matter bud yield†	Unmarketable dry	Dry matter bud violdt	Unmarketable dry
spacing		matter buds ⁺	Di y matter buu yielu '	matter buds ⁺
ft x ft	lbs plant ⁻¹	lbs plant ⁻¹	lbs ac ⁻¹	lbs ac ⁻¹
1 x 1	0.084	0.00	3669	7.16
3 x 3	0.600	0.003*	2894	12.4*
5 x 5	1.35	0.049	2354	86.6
LSD (0.10)	0.093	0.019	411	35.9
Trial mean	0.678	0.017	2973	35.4

† Dry matter is at 0% moisture.

*Treatments marked with an asterisk did not perform statistically worse than the top performing treatment (p=0.10) shown in **bolc**



Transplanting Hemp





Additional Equipment

- Bed Shaper
- Plastic Mulch Layer w/ Irrigation
- Transplanter
- Irrigation
 - Water source
 - Pump, tubing, etc



Transplanting Hemp





Plastic Mulch





Hemp and Plasticulture













Cover Crops & Plastic









Pest and Disease Scouting

- Scout hemp plants once a week
- Choose random plants throughout your field
- Examine the top and underside of leaves on low and high portions of the plant
- Know which pests to monitor over time and which require immediate intervention
- Use pesticide treatments only when necessary







CULTIVATING HEALTHY COMMUNITIES

Aphids

- Give birth to live young: populations increase quickly
- Can develop wings when populations are dense and move to new areas
- Feed on plant sap and secrete honeydew
- Honeydew can lead to black sooty mold

Things to look for

- Varnished appearance of leaves covered with honeydew
- White exoskeletons (molted skins)
- Ladybugs







Cannabis aphid (Phorodon cannabis)

ID Feature: stubby "horns" on forehead



The horns are visible with a hand lens





Two Spotted Spider Mite



- Sexual reproduction: Eggs round and translucent
- Adults and nymphs are small and live in colonies usually on undersides of leaves
- Prefer hot dry environments



Common Arthropod Pests Things to look for

Webbing



White specks or scars on

leaves





Cannabis Russet Mite : A potential threat

- Not in Vermont yet (?)
- Almost microscopic
- Large populations can develop undetected
- Symptoms
 - Yellowing leaves
 - Leaf rolling
 - Loss of vigor

- CAREFULLY SCOUT
 ALL PURCHASED
 PLANT MATERIAL!!
- OUT OF STATE SEEDLING AND CLONE SOURCES COULD HARBOR THIS PEST!



Other Arthropod Pests

Other arthropod pest reported in Cannabis fields





Cannabis flea beetle Hop

Hop aphids



Tarnished plant bugs



Grasshoppers



Bertha armyworm



Cutworms



Stink bugs



Japanese beetle



European corn Borer



Cannabis borer



Common Diseases Botrytis (Grey Mold)





Common Diseases

Botrytis Life Cycle



- Botrytis can live on living or dead plant tissue
- Botrytis kills host cells
- Infected tissue should not simply be extracted



Other Common Diseases

Powdery Mildew



Septoria Leaf Spot

Pythium Root Rot









Disease Control Guidelines

Greenhouse

- Avoid wetting leaves
- Reduce RH below 65%
- Raise Temperature
- Remove plant debris
- Use sterile tools

Field

- Provide adequate spacing
- Avoid wetting leaves when irrigating
- Remove plant debris

As flower buds mature, check for botrytis



Disease Control Guidelines

- Good Sanitation Prevents Most Root Rots
- Take care with recirculated irrigation water
- Clean all surfaces that roots will touch
- Sterilize all pots and tools after removing debris
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Avoid overwatering

- Don't reuse media !!
- Wash hands after handling diseased roots

Vermont Agency of Agriculture pesticide guidelines

Products must meet the following criteria:

- Exempt from a tolerance by US EPA
- Intended for unspecified food crops
- A product must be registered in Vermont (Section 3, or minimum risk)
- Have an agricultural use label for hemp intended for commercial sale

Remember:

- Products must be used in accordance with the label.
- Applicator must be a Vermont certified applicator if applying product on someone else's hemp crop.
- Organic and OMRI listing does NOT automatically make it approved for use on industrial hemp.



Partial list of pesticides allowed in hemp production in Vermont

Active Ingredient

Product Example(s)

Azamax, Azasol, Molt-X

Double Nickel, Serenade,

Azadirachtin / Neem

Bacillus spp. Streptomyces spp Diatomaceous Earth Hydrogen peroxide Cottonseed oil Garlic oil Mint oils Rosemary oil

Sesame oil

Thyme oil Reynoutria

UNIVERSITY OF

sachalinensis

CULTIVATING HEALTHY COMMUNITIES

Agree WG Mycostop, Actinovate Celite 610, Diafil 610 Jet AG Spider Mite Control Captiva Trifecta Crop Control Trifecta Crop Control Organocide 3-in-1 Garden Spray

Thyme Guard

Pesticide Type

Insecticide, Miticide, Nematicide

Fungicide, Insecticide Fungicide Insecticide Fungicide, Algaecide Miticide Insecticide Fungicide, insecticide Fungicide, insecticide

Miticide, Insecticide, Fungicide Fungicide, Insecticide, Bactericide, Virucide

Regalia

Fungicide

https://agriculture.vermont.gov/sites/agriculture/files/documents/PHAR M/hemp/Hemp%20products.pdf

Harvest Timing





When?

- Much information on the internet but not much scientific information on cues for timing.
- Plants do start to "mature" and become "fragrant"
- Look for:
 - -~90% browning on "hairs"
 - Developed, bulbous trichomes
 - Swollen bracts





Certificate of Analysis

State Dependent

Timing & Process

Approved Labs





THCV	ND	ND			
CBD	0.22	2.17			
CBDV	ND	ND			
CBG	ND	ND			
CBC	0.03	0.26			
CBN	ND	ND			
THCA	0.41	4.06	•		
CBDA	10.70	106.97			
CBGA	0.65	6.52			
D8-THC	ND	ND			
exo-THC	ND	ND			
Total	12.03	120.25	0%	Cannabinoids (wt%)	10.7%
Max THC	0.38	3.83			
Max CBD	9.60	95.98			

Ratio of Total CBD to THC 25.1:1

Limit of Quantitation (LOQ) = 0.007 wt%

Max THC (and Max CBD) are calculated values for total cannabinoids after heating, assuming complete decarboxylation of the acid to the neutral form. It is calculated based on the weight loss of the acid group during decarboxylation: Max THC = (0.877 x THCA) + THC. This calculation does not include other cannabinoid isomers (eg. D8-THC and exo-THC). ND = None detected above the limits of detection (LOD), which is half of LOQ.

Harvesting for Flower

- Hand Harvest Labor Intensive
 - Biomass market
 - Flower market
- Mechanical Less Labor
 - Primarily biomass
- Mechanical and Hand Harvest Combo
 - Biomass
 - Flower



Harvest High CBD hemp

- Labor-intensive
 - Specialized equipment is novel.
 - Most work is still manual.



- Time sensitive process
 - Flower can bruise, mold, and get compressed.
 - Drying too fast can decrease flower quality.
 - Drying plenum (heat + air flow) can be used for biomass.



Harvest Material

Flower

- "Smoke flower" dried and cured
 - Needs to be **bucked** & trimmed.
 - One to two weeks to dry.
 - One to six months to cure properly.
- Highest concentrations of cannabinoids are in flowers.
- Premium price, depending on quality.









Harvest Material

Bucking – is a method for removing the flowers from the stalk and branches.

Can be manual and/or mechanical.





Harvest Material Biomass

- Dried plant material; ideal for extraction.
- Includes most plant parts.
- Lower cannabinoid concentration / mass compared to flower.
- Milled, shredded, or ground
- Price = % x mass (total CBD)







Storage

Issues

Cannabinoids and terpenes degrade...

- Heat
- Light
- Oxygen
- Optimal storage after drying & curing
 - Cool to cold
 - Dark
 - Air-tight containers
 - Limited exposure to oxygen-rich air







Extraction of Essential Oils

•CO₂ extraction. The supercritical (or subcritical) CO₂ method uses carbon dioxide under high pressure and extremely low temperatures to isolate, preserve, and maintain the purity of the medicinal oil. This process requires expensive equipment and a steep operational learning curve. But, when done well the end product is safe, potent, and free of chlorophyll.

•Ethanol. High-grade grain alcohol can be used to create high-quality cannabis oil appropriate for vape pen cartridges and other products. But this extraction method destroys the plant waxes, which may have health benefits that are favored by some product-makers.

•Olive oil. Extra virgin or otherwise, olive oil can also be used to extract cannabis oil. However, cannabis-infused olive oil—whether CBD-rich or THC-dominant—is perishable and should be stored in a cool, dark place.



Contact Informati

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Industrial Hemp **NOT Marijuana** NO THC

DO NOT remove plants



You are being photographed and will be prosecuted under Federal law.

SSING

https://www.uvm.edu/extension/nwcrops

