



Meeting the Challenges for Growing Hemp: The Nevada Experience

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Poor Spacing



The richness of growing hemp, with several implicit and incorrect assumptions

- Figure 2000 plants/acre, and hemp production of 0.6 kg (1.3 lbs)/plant of dried buds/flowers and leaves containing 10% CBD
- On a per acre basis, that is 120 kg/acre
- Assume \$5000/kg of CBD
- The yield is \$600,000/acre, but if you do 10 acres, that is \$6,000,000 and if you do 100 acres, that is \$60,000,000

We clearly are all going to get incredibly rich

HEMP ISSUES: Monetizing the crop

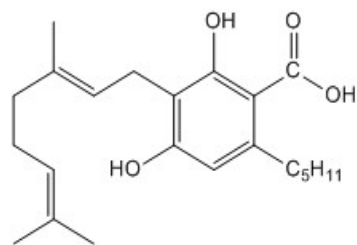
- Regulatory aspects (federal, state and local)
- Hemp strains/seed, plant or clone costs
- Agronomic aspects
- Pests and pest control agents
- Harvesting and drying
- Can you harvest- analytical laboratories/THC
- Processing (extracts, distillate and isolate)
- Marketing the product
- Taxes (They and death will come)

Hemp Products



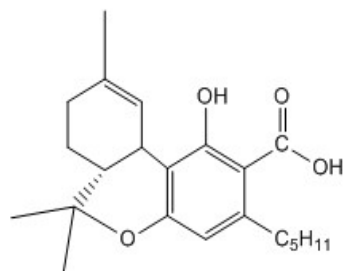
- Cannabidiol (CBD)
- Other legal cannabinoids
- Seed oil (triglycerides)
- Fiber
- Livestock feed

cannabigerolic-acid (CBGA)

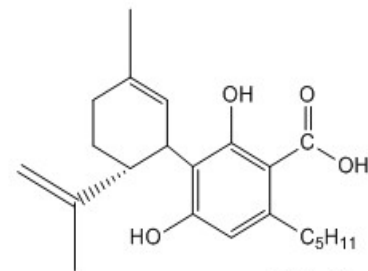


THCA Synthase

CBDA Synthase



tetrahydrocannabinolic acid (THCA)

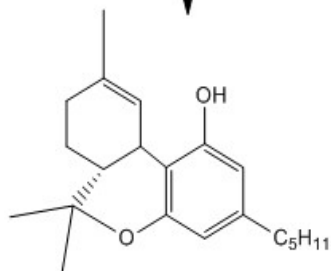


cannabidiolic acid (CBDA)

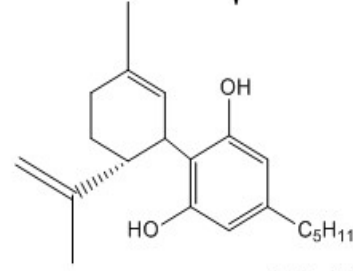
-CO₂ (decarboxylation)

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Δ

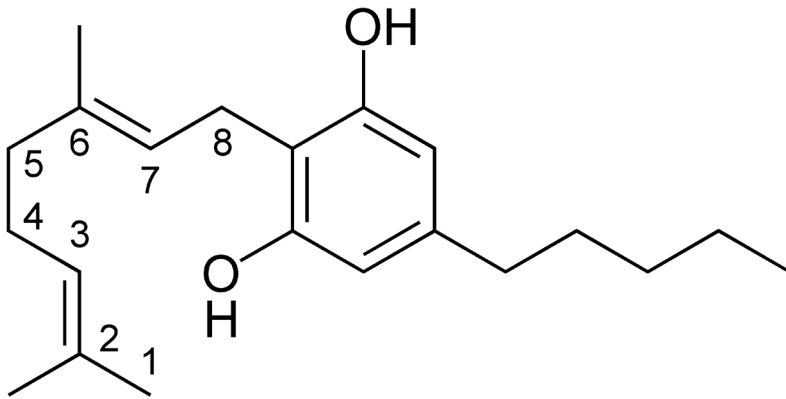


tetrahydrocannabinol (THC)

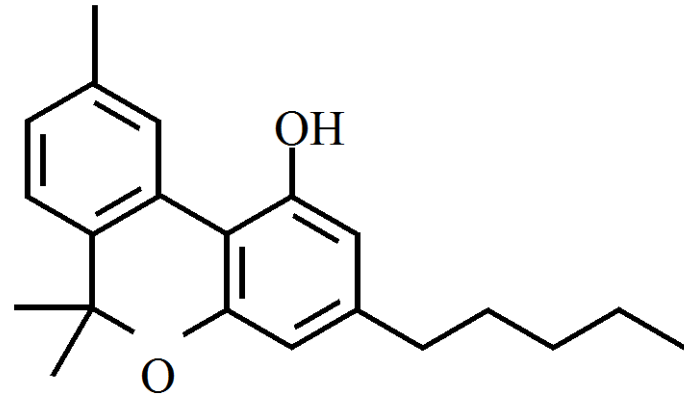


cannabidiol (CBD)

Two additional important cannabinoids (several dozen have been identified)



CBG- Cannabigerol



CBN- Cannabinol

The 2014 Farm Bill defines industrial hemp as:

(2) INDUSTRIAL HEMP.—The term “industrial hemp” means the plant *Cannabis sativa* L. and any part of such plant, whether growing or not, with a delta-9 tetrahydrocannabinol concentration of not more than 0.3 percent on a dry weight basis.

The 2018 Farm Bill defines industrial hemp as:

:

The term “industrial hemp” includes the plant *Cannabis sativa* L. and any part or derivative of the plant including seeds, whether or not it is used exclusively for industrial purposes (fiber and seed). The tetrahydrocannabinols (THC) concentration is the distinguishing factor between industrial hemp and marijuana. Industrial hemp cannot have a THC concentration more than 0.3 percent on a dry weight basis. The term “THC” includes all isomers, acids, and salts of isomers of tetrahydrocannabinols.

So- What does that Mean?

- Although the 2018 Farm Bill now includes THCa (and other isomers of THC), the term “dry weight” is ambiguous.
- Total plant, including stalks and roots?
- Or is it any portion of the plant (buds/leaves)
- Average of the tests done on a crop?
- Does it include laboratory uncertainty (standard deviation)
- If any plant (or part of a plant) exceeds 0.3% THC, does that plant need to be destroyed?

How will samples be taken?

- Buds (high cannabinoid)
- Leaves
- Stalks (and roots)?
- Where on the plant? High, medium or low height?
- Note: When you see an analysis sheet of a hemp crop, make sure you understand what the sample is. Most analyses sheets are only of buds/flowers and leaves, or buds only?



Cherry Wine Hemp



The 2014 and 2018 Farm Bills also require that

1. Hemp growers work on a state regulatory program that meets federal standards, or
2. Work with a valid research organization, when a state has not established a regulatory program.

CBD is no longer a schedule I drug, under the 2018 Farm Bill

The Farm Bill of 2014 contained the following language regarding hemp

. . . . an institution of higher education (as defined in section 101 of the Higher Education Act of 1965 (20 U.S.C. 1001)) or a State department of agriculture may grow or cultivate industrial hemp if—(1) the industrial hemp is grown or cultivated for purposes of research conducted under an agricultural pilot program or other agricultural or academic research; and (2) the growing or cultivating of industrial hemp is allowed under the laws of the State in which such institution of higher education or State department of agriculture is located and such research occurs.

(2) INDUSTRIAL HEMP.—The term “industrial hemp” means the plant *Cannabis sativa* L. and any part of such plant, whether growing or not, with a delta-9 tetrahydrocannabinol concentration of not more than 0.3 percent on a dry weight basis.

State regulatory systems (Nevada)

- Each state has a different regulator systems, since although each state now is examining other state's regulations, there is not much consistency among the states.
- The regulatory agencies that oversee hemp programs vary substantially. Nevada regulates through the Nevada Department of Agriculture.
- For some obvious (but not totally justifiable) reasons, medical and recreational THC marijuana are regulated by the Department of Taxation in Nevada.
- At present there are no hemp regulations on quality or contamination in the Nevada Regulations, unlike the very specific regulations on medical and recreational marijuana.
- It is likely that those will be adopted in the near future.

Growing Conditions

- Variable, but most areas of the US- grows well in northern (cooler) Nevada and also in Southern Nevada (hot)
- 80-120 day growing season (depending on the strain)
- Little indoor growth occurs, except perhaps for specialty strains
- Generally considered a low water requiring crop (much less than alfalfa)

Antelope Damage



The indoor hemp grow













University of Nevada, Reno

The female/male issue

- Cannabis species will produce greater amounts of cannabinoids when female and not pollinated.
- So, growing hemp requires that all males be pulled, prior to the ability to pollinate the females
- Feminized seed is one option- 99+% (?)
- Clones of females
- Carefully walk the fields to remove all males.
- Complication of neighbors not keeping fields clean or growing seed oil or fiber hemp, where males are either required or do not need to be removed.

When should you harvest?

- CBD is maximized: concentration and total amount, but how do you know when is best?
- CBD is high but THC (total) is below 0.3%
- Does the ration of THC/CBD go up or down as you approach harvest, or does it simply stay the same?
- How variable is this ratio and total CBD within a plant and plant to plant?

Hemp Biomass



0.1%

Total Potential THC

3.2%

Total Potential CBD

The photo on this report is of a sample collected by the lab and may vary from the final packaging

Cannabinoids

Cannabinoid	LOQ	Mass	Mass
	%	%	mg/g
THCa	0.1	0.1	1
Δ9-THC	0.1	0.1	1
Δ8-THC	0.1	ND	ND
CBD	0.1	0.9	9
CBDa	0.1	2.5	25
CBC	0.1	0.1	1
CBG	0.1	<0.1	<1
CBN	0.1	ND	ND
THCV	0.1	ND	ND
CBGa	0.1	0.1	1
Total		3.8	38

Test performed via HPLC-UV. Total Potential THC and CBD: Liquid chromatography occurs at room temperature and does not decarboxylate any cannabinoids, thereby yielding separate values for THCa, THC, CBDa and CBD, which are then combined to derive the Total Potential THC and Total Potential CBD result using the following formulae:

Total Potential THC = THCa * 0.877 + Δ9-THC + Δ8-THC

Total Potential CBD = CBDa * 0.877 + CBD

ND = Non Detect; LOQ = Limit of Quantitation; Cannabinoids for flower and trim reported as received.

Hemp Sample



0.9%

Total Potential THC

15.5%

Total Potential CBD

The photo on this report is of a sample collected by the lab and may vary from the final packaging

Cannabinoids

Cannabinoid	LOQ	Mass	Mass
	%	%	mg/g
THCa	0.1	0.9	9
Δ9-THC	0.1	0.1	1
Δ8-THC	0.1	ND	ND
CBD	0.1	0.3	3
CBDa	0.1	17.4	174
CBC	0.1	<0.1	<1
CBG	0.1	0.1	1
CBN	0.1	ND	ND
THCV	0.1	ND	ND
CBGa	0.1	0.5	5
Total		19.3	193

Test performed via HPLC-UV. Total Potential THC and CBD: Liquid chromatography occurs at room temperature and does not decarboxylate any cannabinoids, thereby yielding separate values for THCa, THC, CBDa and CBD, which are then combined to derive the Total Potential THC and Total Potential CBD result using the following formulae:

Total Potential THC = THCa * 0.877 + Δ9-THC + Δ8-THC

Total Potential CBD = CBDa * 0.877 + CBD

ND = Non Detect; LOQ = Limit of Quantitation; Cannabinoids for flower and trim reported as received.



0.4%

Total Potential THC

9.6%

Total Potential CBD

The photo on this report is of a sample collected by the lab and may vary from the final packaging

Cannabinoids

Cannabinoid	LOQ	Mass	Mass
	%	%	mg/g
THCa	0.1	0.4	4 <div></div>
Δ9-THC	0.1	<0.1	<1
Δ8-THC	0.1	ND	ND
CBD	0.1	0.2	2 <div></div>
CBDa	0.1	10.6	106 <div></div>
CBC	0.1	<0.1	<1
CBG	0.1	<0.1	<1
CBN	0.1	ND	ND
THCV	0.1	<0.1	<1
CBGa	0.1	0.4	4 <div></div>
Total		11.7	117

Harvesting and Drying

- Currently a debate exists on the best method of producing a commodity that has value
 - Hand harvesting and drying in large sheds followed by hand removal of the vegetation to produce the buds/flowers and leaves.
 - Machine harvesting and chopping the entire plant.
 - Use of industrial driers
 - Odor may be an issue

Western States Hemp Field, Fallon, NV



Post harvest processing is a critical component for hemp production.

- The harvested hemp separated from the stocks and branches must be dried (most times) to a point that it will not mold.
- Drying excessively in warm air will allow CBD and other cannabinoids to oxidize and be lost.
- While the extent of loss of CBD over time is not known precisely, anecdotal evidence suggests that 1 percentage point is lost each month
- Stored at lower temperatures or under nitrogen will likely decrease the loss of CBD

Processing Hemp: Conversion to a Salable Product

- Extraction produces a product that is generally brown, has a distinct marijuana odor (terpenes), and contains multiple other constituents, but can be used in a variety of products
- Distillation: The second step for purification is generally a vacuum distillation, where the extracted material is heated to around 180-220 °C under a high vacuum. The cannabinoids are distilled and generally are 60-90% of the condensate
- Crystalization: The third step is to dissolve the distillate in a suitable solvent (e.g. hexane) and crystallize the CBC in a cold temperature, often called an “isolate”, and be 99+5 CBD crystals.
- Each of these products can have varying uses.

Extraction of CBD and other Cannabinoids

- Not particularly difficult, but requires a certain amount of training
- Many solvents very flammable- generally will require permits from fire department for storage and utilization of organic solvents.
- Several things can go wrong, so be careful.
- Hemp extractors are on the market, but are generally very expensive, with prices up to \$900,000.

Extraction methods

A variety of extraction methods available

- Supercritical CO₂- Good public acceptance, but not as efficient as other methods and more expensive for equipment
- General solvent extraction using hexane, methanol, methylene chloride works, but extracts too much.
- Butane extractors, used in the THC marijuana business, will work, but strongly not recommended. Flammability is a major problem and they are generally too small to be efficient. Requires specific equipment that handles pressure.

Cold Temperature Ethanol

The steps are simple

1. Cool the ethanol and hemp to -30°C and mix the ethanol and hemp for 30 minutes. Remove the ethanol and rinse the extracted hemp with additional cold ethanol to complete the extraction.
2. Concentrate the extract to remove the ethanol.
3. This extract can be vacuum distilled to give a distillate and crystallized to recover most of the CBD as a near pure product.

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Cold Temperature Ethanol

- Very cold ethanol extracts easily extractable cannabinoids located in the surface trichomes, works well and has very low toxicity.
- In my opinion, this is the best extraction method, and uses relatively inexpensive ethanol (denatured ethanol can be purchased for \$8-15/gallon and reused).

Types of analytes determined in cannabis products (highly variable among states)

- Potency (cannabinoids)
- Residual solvents (in extractables, e.g. butane, propane hexane, etc.)
- Terpenes
- Metals
- Pesticides
- Molds and certain other microbial contaminants
- Mycotoxins (e.g. aflatoxin, ochratoxin A., etc.)
- Water content
- Filth and foreign material (soil, insects feces, etc.)

Metals (mg/kg) to be determined in cannabis

<u>Metal</u>	<u>Nevada</u>	<u>California*</u>
Lead	1.2	0.5
Mercury	0.4	0.1-3
Arsenic	2	0.2-1.5
Cadmium	0.82	0.2-0.5

*Edible and inhaled, respectively

Cannabinoids determined in marijuana

Nevada

THC

THCA

CBD

CBDA

CBN

California

THC

THCA

CBD

CBDA

CBN

CBG

Terpenes determined in cannabis products

Nevada

Alpha-bisabolol
Alpha-humulene
Alpha-pinene
Alpha-terpinolene
Beta-caryophyllene
Beta-myrcene
Beta-pinene
Caryophyllene oxide
Limonene
Linalool

California

Only if advertised

Pesticide Issues

- What chemicals can be legally used on growing hemp?
- If no pesticides exist (particularly insecticides and fungicides) that are legal for use, is there a process for legalizing use of appropriate pesticides?
- What types of data are needed for registration?
- What conflicts exist between states and federal agencies that have hemp programs.
- How can states ensure that pesticide use on hemp does not provide a substantial risk to those who use the products?

No pesticide registrations exist for cannabis (either hemp or THC marijuana)

- Effectively no dissipation data
- Effectively no risk assessments
- A wide variety of chemicals are commonly used, although many growers do not use any agrochemicals for production
- What should be the program for testing marijuana for pesticides?
- What penalties should be imposed for use?
- Are there tolerances that can be applied from other related crops?

EPA (25b) Minimum Risk-Exempt from Tolerance

(examples)

Castor oil (U.S.P. or equivalent)

Cinnamon and cinnamon oil

Citric acid

Corn gluten meal

Corn oil

Cottonseed oil

Lauryl sulfate

Lemongrass oil

Linseed oil

Malic acid

Rosemary and rosemary oil

Sesame (includes ground sesame plant) and oil

Sodium Carbonate Peroxyhydrate

Sodium chloride (common salt)

EPA Registered Pesticides-Exempt from Tolerance

(examples)

Azadirachtin (neem oil)

Bacillus amyloquefaciens

Bacillus licheniformis

Bacillus pumilius strain QST 2808 Bacillus subtilis

Bacillus thuringiensis

Beauveria bassiana strain ANT-03 Beauveria bassiana
strain GHA Beauveria bassiana Condia

Copper hydroxide

Potassium bicarbonate

Potassium salts of fatty acid

Potassium silicate

Mono-and di-potassium salts of phosphorus acid

Kaolin

Sucrose octanoate

Sulfur

Current Synthetic Pesticide Analytes in NV

PESTICIDE	DETECTION LEVEL (PPM)	CROP
Acequinocyl	4	Hop, dried cones
Bifenazate	15	Hop, dried cones
Captan	0.05	Dill, seed
Cyfluthrin and beta-cyfluthrin	4	Hop, vines
Dimethomorph	60	Hop, dried cones
Etoxazole	7	Hop, dried cones
Fenhexamid	30	Cilantro, leaves
Flonicamid	7	Hop, dried cones
Fludioxonil	0.02	Herbs and spice, group 19
Imidacloprid	0.05	Borage, seed, Mustard, black, seed, Mustard, field, seed, Mustard, Indian, seed, Mustard, rapeseed, seed, Mustard, seed
Myclobutanil	9	Cilantro, leaves
Pentachloronitrobenzene (quintozene)	0.2	Mustard greens (Tolerances with regional registrations)
Pyrethrin	1	
Spinetoram	1.7	Spice, subgroup 19B, except black pepper
Spinosad	1.7	Spice, subgroup 19B, except black pepper
Spirotetramat	10	Hop, dried cones
Thiamethoxam	0.02	Borage, seed, Mustard, seed
Trifloxystrobin	11	Hop, dried cones

Synthetic Pesticides Used on Marijuana

(a partial list from the American Herbal Pharmacopoeia)

• abamectin	Insecticide/acaricide
• acequinocyl	Insecticide/acaricide
• bifenazate	acaricide
• bifenthrin	insecticide
• chlomequat chloride	plant growth regulator
• cyfluthrin	insecticide
• daminozide	plant growth regulator
• etaxazole	acaricide
• fenoxycarb	insecticide
• imazalil	fungicide
• imidachlorprid	insecticide
• myclobutanil	fungicide
• Paclobutrazol	plant growth regulator
• pyrethrins	insecticide
• spinosed	insecticide
• spiromesifen	insecticide
• trifloxystrobin	fungicide

US Pesticide Registration (US Code 7 U.S.C. 136)

- Agrochemical companies submit new or older chemicals for registration to the US EPA
- Data on toxicology and environmental fate is submitted
- Crop specific dissipation data under actual conditions used
- Detailed risk assessments conducted on real exposure issues
- Tolerances established on each crop or groups of crops

Can the FIFRA 24(c) process be used to register pesticides for a “special need”?

Under the authority of §24(c) of FIFRA, states may register an additional use of a federally registered pesticide product, or a new end use product to meet special local needs. EPA reviews these registrations, and may disapprove the state registration if, among other things, the use is not covered by necessary tolerances, or the use has been previously denied, disapproved, suspended or canceled by the Administrator, or voluntarily canceled subsequent to a notice concerning health or environmental concerns.

The pesticide industry appears to be strongly opposed to any registration of a pesticide on cannabis, due to the issues of risk to a high value product, and a belief that the cannabis industry is not completely trust worthy.

Hemp needs for pest control agents

- Data needed to determine dissipation rates of pesticides under the conditions.
- Better data and policy on dosing is needed
- The U.S. EPA, FDA and USDA all need to participate in this evolving business.
- Prohibitions on research and the risk of conducting research on pest control agents on marijuana is contrary to the needs of states. Congressional actions may be required.
- A coherent and coordinated response to use of agrochemicals on hemp and marijuana is required for all of the states.

Oil Seed Hemp



Oil Seed Hemp

- The product is similar to rapeseed, corn or safflower oil
- Composed primarily of triglycerides, but has a high content of highly unsaturated oil
- Very low in cannabinoids
- Requires both male and females for seed production
- A common problem with this type of hemp is shatter.
- Birds love the seeds also
- Must not be grown in proximity to CBD hemp.
- No idea on the economics

A brief comment on hemp fiber

- The primary economic driver for hemp is CBD.
- Hemp fiber is a useful product
- Potentially useful for a variety of products, including clothing
- Can CBD hemp stalks be used as a secondary product from CBD production?
- Requires a decorticator- strips and separates the various components of woody plant material \$5000-\$1.5 million



Fiber from Hemp

- **Bast Fiber**
 - Primary bast fibres - make up 70-90% of the bast (bark). They are characterized by long length (up to 50 mm), high cellulose (50-70%) and low lignin (about 7%) content. These fibers are the most valuable part of the stalk.
 - Secondary bast fibers - comprise the remaining 10-30% of the bast fibers. They are shorter (approximately 2 mm), more lignified and hence of lower value for some applications (i.e. textile). Low stand density of hemp crop favours development of this type of bast fibre.
- **Hurd Fiber:** The short fiber (about 0.5 mm) found in the inner woody core of hemp stalks. Hurd accounts for 70-80% of the stalk and typically contains 20-30% lignin. For millennia, hemp was grown for bast fiber, primarily for textile applications, while hurd was considered a waste by-product of bast production.

Hemp Farming: Critical Points

- Where will you get the seeds or plants/clones?
- How will you know the quality and consistency of those plants?
- THC content? CBD content? If you get a Certificate Analysis, ask where that sample was located, and what parts of the flower. Will they provide a guarantee of CBC and THC content?
- What are fertilization and irrigation needs? How will they be used?
- Insects and other pests? How controlled?
- How will you harvest and dry the hemp?

Hemp Farming: Critical Points (cont.)

- How will you initially process the hemp to remove the parts that contain the CBD?
- How will the hemp be stored and for how long?
- Can you sell the wet or dried plant parts directly, or do you need to find an extraction/processing company? How long will it take for them to extract/process the hemp?
- Do you have an extractor lined up to extract the hemp?
- Are you going to distill the hemp extract, and crystallize the CBD (isolate)?
- Who will buy the extract? What type of marketing activity will be required?