



Hemp 101, everything you want to know

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Outlines:

- Hemp vs. Marijuana
- Origin of diversity
- History
- Production
- Uses
- Breeding
- Conclusion remarks



What exactly is hemp, Is it legal and safe to use, and how exactly can hemp be used? Dive in to find answers to these questions and more.

How is Hemp Different from Marijuana?

They aren't all the same thing.

Cannabis is a classification of plants with various species, and Hemp and Marijuana are both species of plant within the Cannabis family.

Although Hemp and Marijuana are both species of Cannabis, they have several distinct differences.

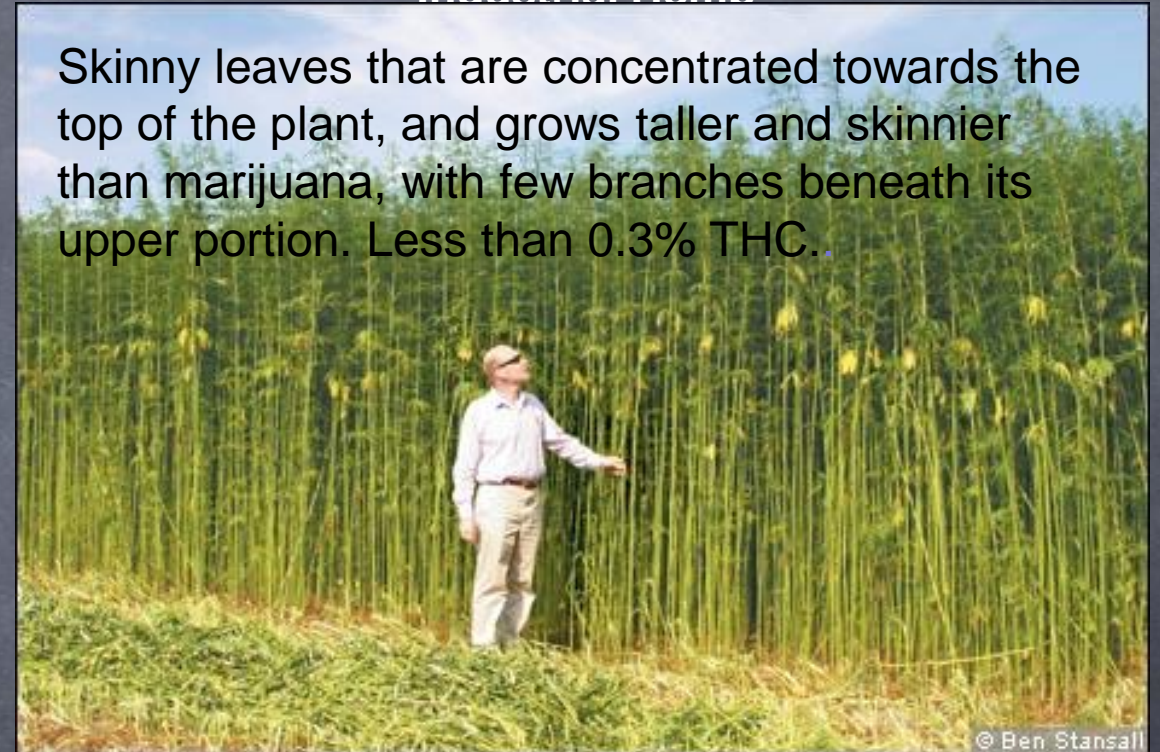
Comparison

Marijuana



The marijuana plant features broad leaves, dense buds, and has a bushy appearance

Industrial Hemp



Skinny leaves that are concentrated towards the top of the plant, and grows taller and skinnier than marijuana, with few branches beneath its upper portion. Less than 0.3% THC..

Both types of plant are *Cannabis sativa*, but are grown and have been bred differently

Comparison

Marijuana



Industrial Hemp

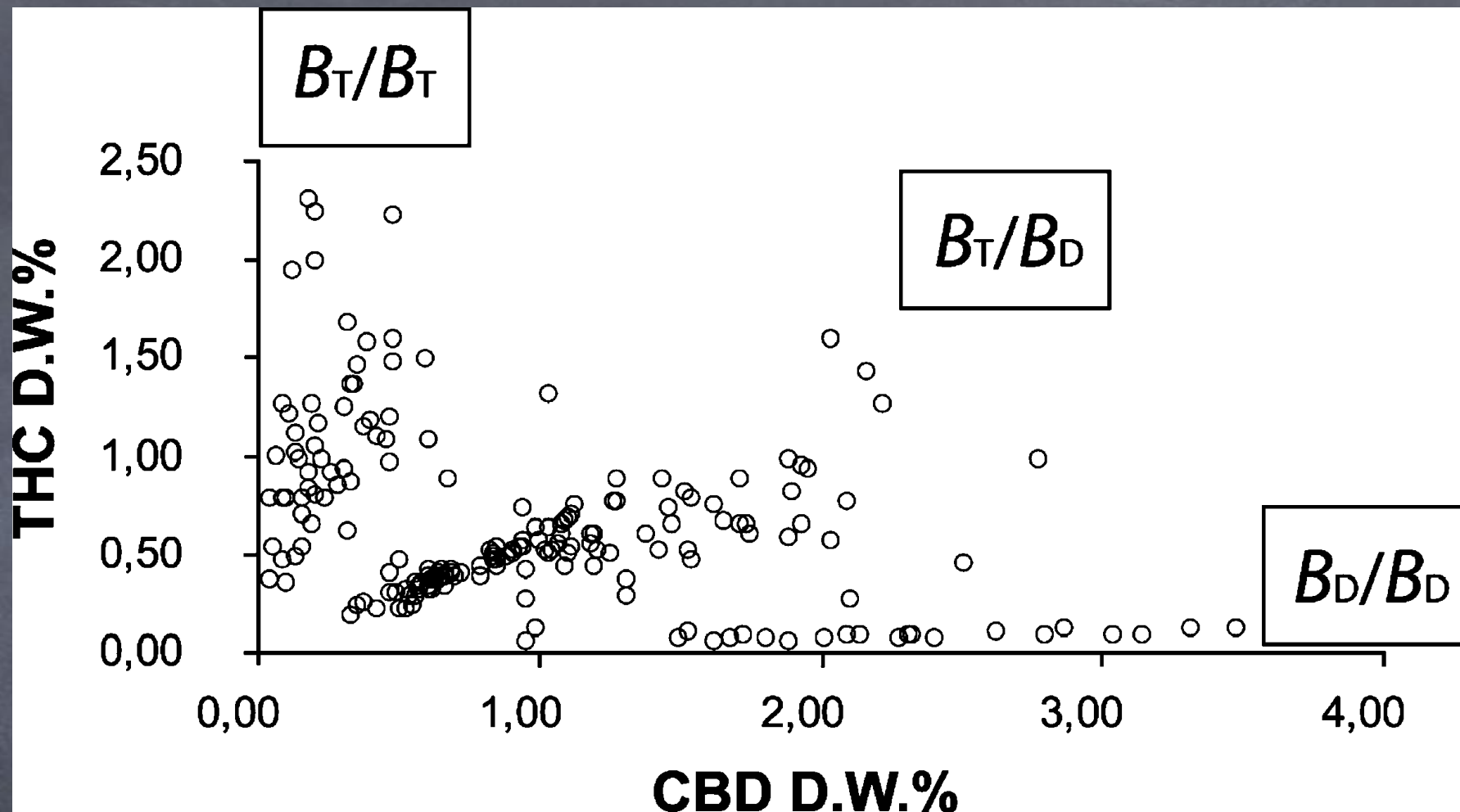


Both hemp and marijuana can produce THC and CBD.

Today, it is generally accepted that three major “chemotypes” (i.e. “chemical phenotypes”, plants characterized by a defined cannabinoid profile) exist in *C. sativa*; these chemotypes were formally defined about 30 years ago (Small and Beckstead, 1973) on the basis of the content ratio of the two major cannabinoids found in hemp, 9-tetrahydrocannabinol (THC) and cannabidiol (CBD), expressed as percent of the inflorescence dry matter.

The three chemotypes (I, prevalent THC; II, THC and CBD; and III, prevalent CBD) were found in several ecotypes and varieties.

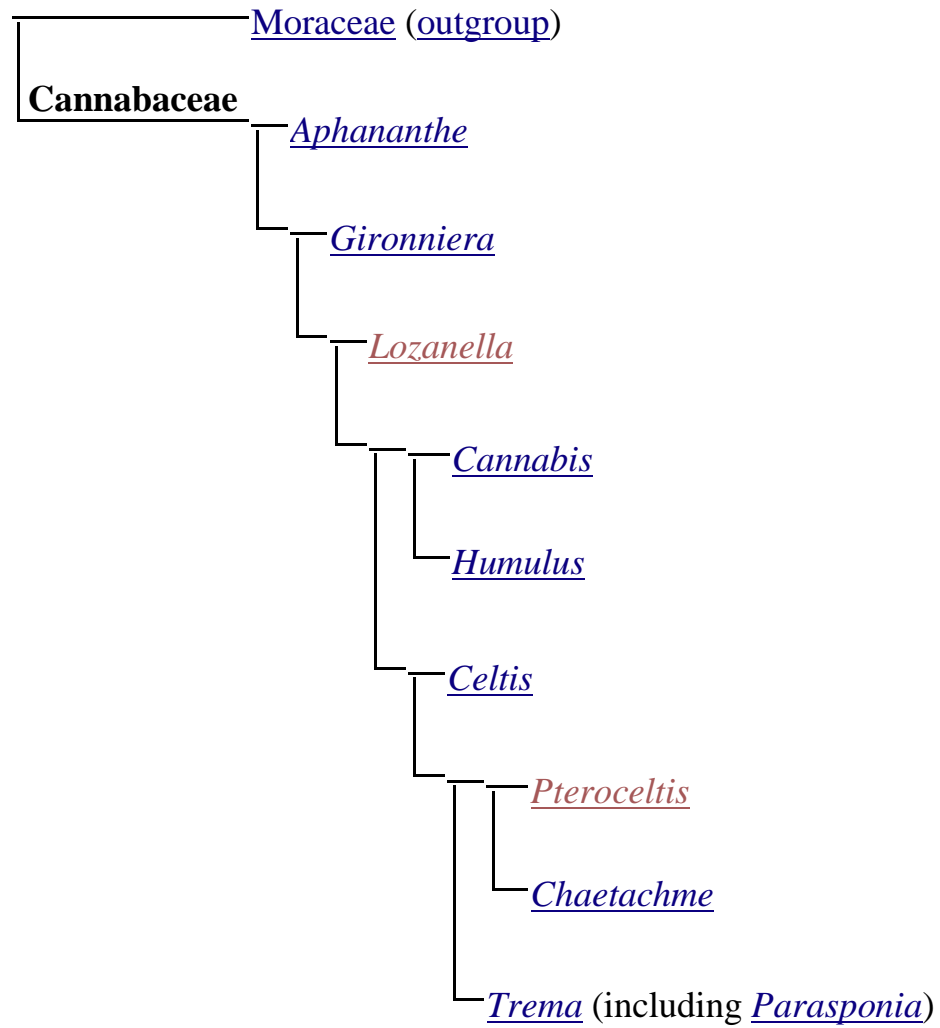
The tripartite distribution of chemotypes had suggested a simple genetic determinism, based on one or few genes. However, only recently accurate progeny analysis experiments demonstrated the existence of one locus, named B, with at least two alleles, BT and BD, each responsible for the synthesis of the two most common cannabinoids, THC and CBD, and probably coding for the respective synthases



Chemotype distribution of the old Italian fiber cultivar “Eletta Campana”. This tripartite distribution is typical of old ecotypes before the counter-selection for THC begun, and directly visualizes the distribution of BD and BT alleles

Phylogeny

Modern [molecular phylogenetics](#) suggest the following relationship





Sativa

Indica



SATIVA

SATIVA

INDICA

INDICA

RUDERALIS

History

Hemp, or industrial hemp (from Old English *hænep*), typically found in the northern hemisphere, is a variety of the *Cannabis sativa* plant species that is grown specifically for the industrial uses of its derived products. It is one of the fastest growing plants and was one of the first plants to be spun into usable fiber 10,000 years ago (Canadian Journal of Criminology & Criminal Justice, 57 : 528–554).

Prohibition

Viewing hemp as a threat, a smear campaign against hemp was started by competing industries (cotton and wood), associating hemp with marijuana. This was an defining moment in the history of hemp!

When Congress passed the Marijuana Tax Act in 1937, the decline of hemp effectively began. The tax and licensing regulations of the act made hemp cultivation nearly impossible for American farmers. Anslinger, the chief promoter of the Tax Act, argued for anti-marijuana legislation around the world. The legislation passed in 1961 by the United Nations.

1942-1945: The Japanese attack on Pearl Harbor halted the importation of Manila hemp from the Philippines, prompting the USDA to rethink their agenda and creating a call to action with the release of the film *Hemp for Victory*, motivating American Farmers to grow hemp for the war effort. The government formed a private company called War Hemp Industries to subsidize hemp cultivation. One million acres of hemp were grown across the Midwest as part of this program. As soon as the war ended, all of the hemp processing plants were shut down and the industry again disappeared. However, wild hemp may be found scattered across the country.

1950s. In 1957, the 20th century's last commercial harvest of American hemp takes place in Wisconsin fields

The Early 21st Century—A Renaissance for American Hemp?

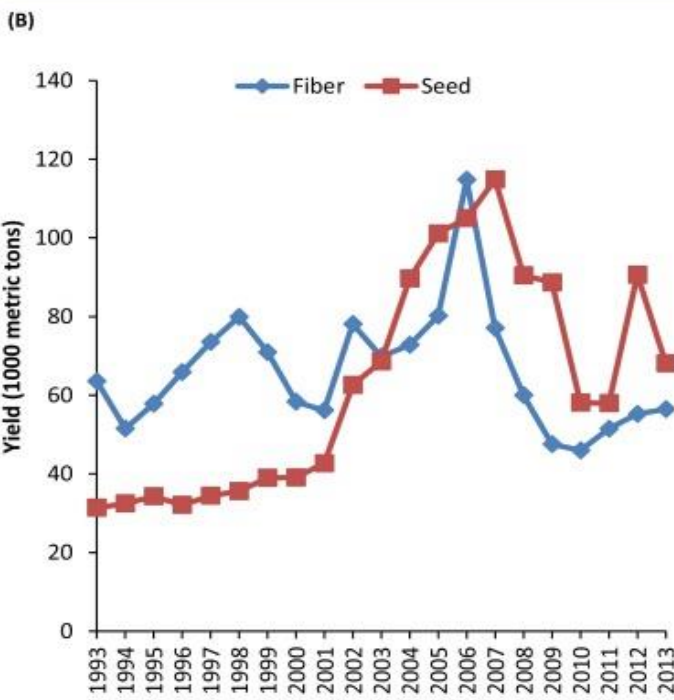
2007: The first American hemp permits issued in more than 50 years are granted to two North Dakota farmers, bringing renewed excitement for the latent potential of domestic hemp.

2014: In a monumental tide shift, Congress passed a Farm Bill allowing state agriculture departments and research institutions to oversee pilot research programs for hemp cultivation. As Kentucky, Vermont, and Colorado become the first states to pass legislation establishing pilot programs, a new era dawns on American hemp.

2016: With more states implementing pilot programs, the U.S. retail market for hemp grows to \$688 million, and a Colorado hemp farm earns the first Organic certification from the USDA.

2017: A mere three years after the passage of the 2014 Farm Bill, the hemp advocacy group Vote Hemp reports more than 25,000 acres of American hemp being grown by nearly 1,500 farmers across 19 different states. In addition, 32 different research institutions are involved in hemp research.

2018: As Congress discusses new measures to remove federal restrictions on hemp, the Council of State Legislatures reports the number of states legalizing hemp cultivation growing to around 40—and inching upward with each passing week. Amidst this mounting support, the Congressional Research Service releases a new report showing a healthy optimism for hemp's commercial potential, balanced with a frank admission of the uncertainties still shrouding the plant's future prospects.



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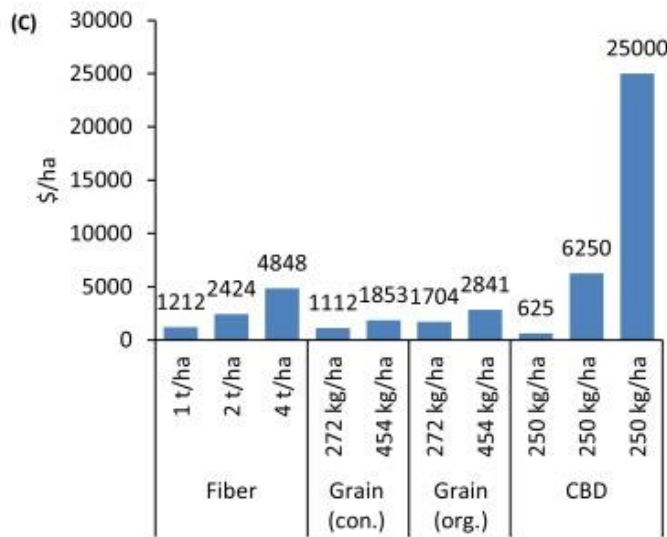
Country	Fiber (ha)	Seed (ha)	Total ha†
Austria	600	—	600
Canada*	n/a	n/a	34262
Chile	4500	2200	6700
China	5000	5500	10500
Czech Republic	200	—	200
France	600	7706	8306
Hungary	300	1400	1700
Italy	425	—	425
Netherlands	1284	—	1284
North Korea	20000	—	20000
Poland	70	60	130
Romania	1600	1440	3040
Russia	4000	1644	5644
South Korea	12	—	12
Spain	10	2	12
Turkey	20	1	21
Ukraine	2000	2100	4100
Total	40621	22053	90906

Global Production of Hemp Fiber and Seeds. (A) Countries cultivating (green) or utilizing natural hemp populations for textiles (purple; Nepal and Bhutan). (B) Global production of hemp for fiber and seed from 1993 to 2013. (C) Countries producing hemp. Data was collected from the FAO for the year 2013. Total land area may be smaller depending on the quantity of dual-purpose (i.e., cultivars used for seed and fiber production) hemp planted. Annual statistics are from the FAO. Abbreviation: ha, hectares. *Value is from Health Canada for the year 2015. †Total production area assumes a single-purpose crop.



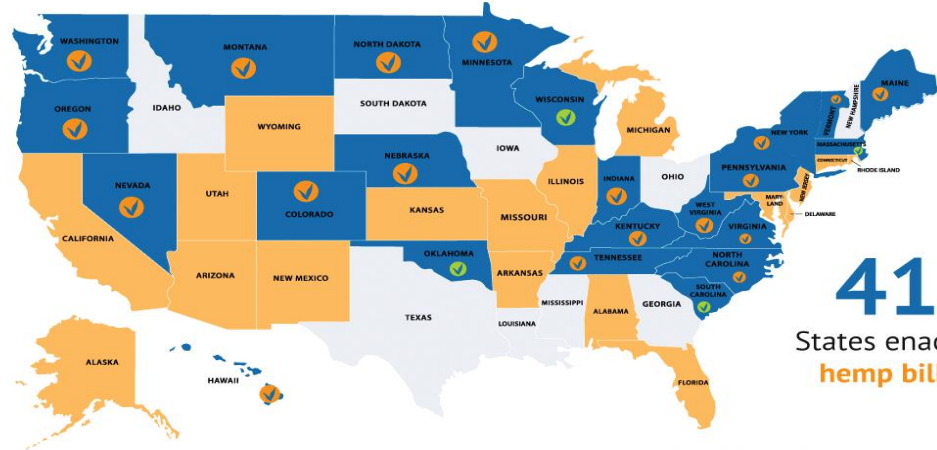
(B) Table showing USA states growing hemp, number of hectares planted, and the number of participating universities and colleges.

State	Year	Area planted (ha)	# Universities
Kentucky	2014	13.35	6
	2015	373.12	8
	2016	1021.83	10
Colorado	2015	930.78	1
	2016	2396.35	2
Hawaii	2015	0.10	1
	2016	0.00	1
Indiana	2015	1.62	1
	2016	0.81	1
Maine	2016	0.40	0
Minnesota	2016	20.64	1
Nebraska	2016	0.00	1
Nevada	2016	87.53	1
New York	2016	12.14	3
North Dakota	2015	0.08	1
	2016	28.33	1
Oregon	2015	20.23	1
Tennessee	2015	283.28	2
	2016	91.05	2
Vermont	2015	8.09	1
	2016	24.28	1
Virginia	2016	14.97	3
West Virginia	2016	4.05	1
Total	2014	13.35	6
Total	2015	1617.31	16
Total	2016	3904.73	29



Trends in Plant Science

Hemp Production in the USA. (A) USA states currently able (green) and those pursuing legislation (red) to grow hemp, according to the 2014 Farm Bill. States that conducted hemp trials in 2016 are denoted with a blue star. Currently, 33 states meet the qualifying criteria. (B) USA states growing hemp, number of hectares planted, and the number of participating universities and colleges. (C) Revenue of hemp fiber, grain (conventional and organic), and phytocannabinoid (CBD) products per hectare. Fiber values assume a price of \$1.21/kg of actual fiber. Assuming bast fibers make up 25% of the stem dry matter, then 1, 2, and 4 metric ton/ha are equal to 4, 8, and 16 metric ton/ha of stems, respectively. Grain production assumes a price of \$1.65 and \$2.54 per kilogram of conventional or organic seed. Phytocannabinoid prices were obtained from hemp producers and CBD processors. CBD prices are complex, ranging from \$2.50 to 10.00/g of pure CBD. Higher prices are paid for crops with higher percentages of CBD in flower material. Here, revenue per hectare was calculated using \$2.50/g for 1%, \$5.00 for 5%, and \$10.00 for 10% CBD concentration in flower material.



41
States enacted
hemp bills

- New states which started in 2018 (4 states)
- States which grew hemp in 2017 (19 states)
- States with enacted hemp legislation (41 states)



78,176

Acres of hemp grown in 23 states



40

Universities conducted research



3,544

State licenses issued

State	2017 Acres	2018 Acres
Colorado	9,700	21,578
Hawaii	1	2
Indiana	5	5
Kentucky	3,271	6,700
Maine	30	550
Massachusetts	N/A	21
Minnesota	1,205	710
Montana	542	22,000
Nebraska	1	0.5
Nevada	417	1,881
New York	2,000	2,240
North Carolina	965	3,184
North Dakota	3,020	2,778
Oklahoma	N/A	445
Oregon	3,469	7,808
Pennsylvania	36	580
South Carolina	N/A	256
Tennessee	200	3,338
Vermont	575	1,820
Virginia	87	135
Washington	175	142
West Virginia	14	155
Wisconsin	N/A	1,850
Total	25,713	78,176*

*Includes 10,090,188 square feet of greenhouse or indoor cultivation

Hemp research at the UNL

Objective : Identify suitable cultivars and production strategies of hemp for Nebraska

Experiments conducted: We have obtained seeds of two industrial hemp (*Cannabis sativa* L.) certified varieties, 50 lbs each of Canda and Delores that were purchased from Parkland Industrial Hemp growers, Canada. The seeds were arrived in July of 2016 and it was too late to conduct any field planting. In October 2016, we planted 50 seeds each of the six varieties under a greenhouse conditions located at East Campus Greenhouse Complex. The seeds were planted individually in 6 inch pots under 14 hrs. Lights and 80oc during the day and 70°c at night. The varieties did bloom after 45 days from planting and reached the height of only 6 -12 inches.



The Industrial hemp trials were conducted at the University of Nebraska Research Center at Mead, NE. in 2018 and were consisted of a factorial design of N rates, plant densities, and varieties, and two water regimes (rain-fed and fully irrigated). Seeds were planted on April 27. The N rates were 0, 45, and 90 kg ha⁻¹ applied before planting. The plant density treatments were 150,000 and 300,000 viable seed ha⁻¹. The N rate and plant densities treatments were applied in 8-row main plots that were split to plant four rows of two varieties in a non-random manner. The hemp varieties were Deloras and Canda. Four rows were harvested at the end late October to determine grain yield. The row spacing for the 8-row plots was 76 cm between rows, and the plots length were 12 meters. Plants started flowering June 7 at about 2 feet tall.



In addition to the field, I am conducting research in the greenhouse in an effort to develop varieties that are suitable to our region.



Wild hemp (Feral hemp);

Responses to feral cannabis vary by time period and jurisdiction, with some entities putting out efforts to eradicate the plant, while others consider it a very low priority. The DEA's [Domestic Cannabis Eradication/Suppression](#) program was founded in 1979 and provides federal funds nationwide to eradicate cannabis. In 1991, the program claimed to have eradicated 118 million feral cannabis plants, mostly in Indiana and other Midwest states.

A 2003 report noted that 99% of the cannabis eradicated under this program in 2003 was feral cannabis, not cultivated plants.

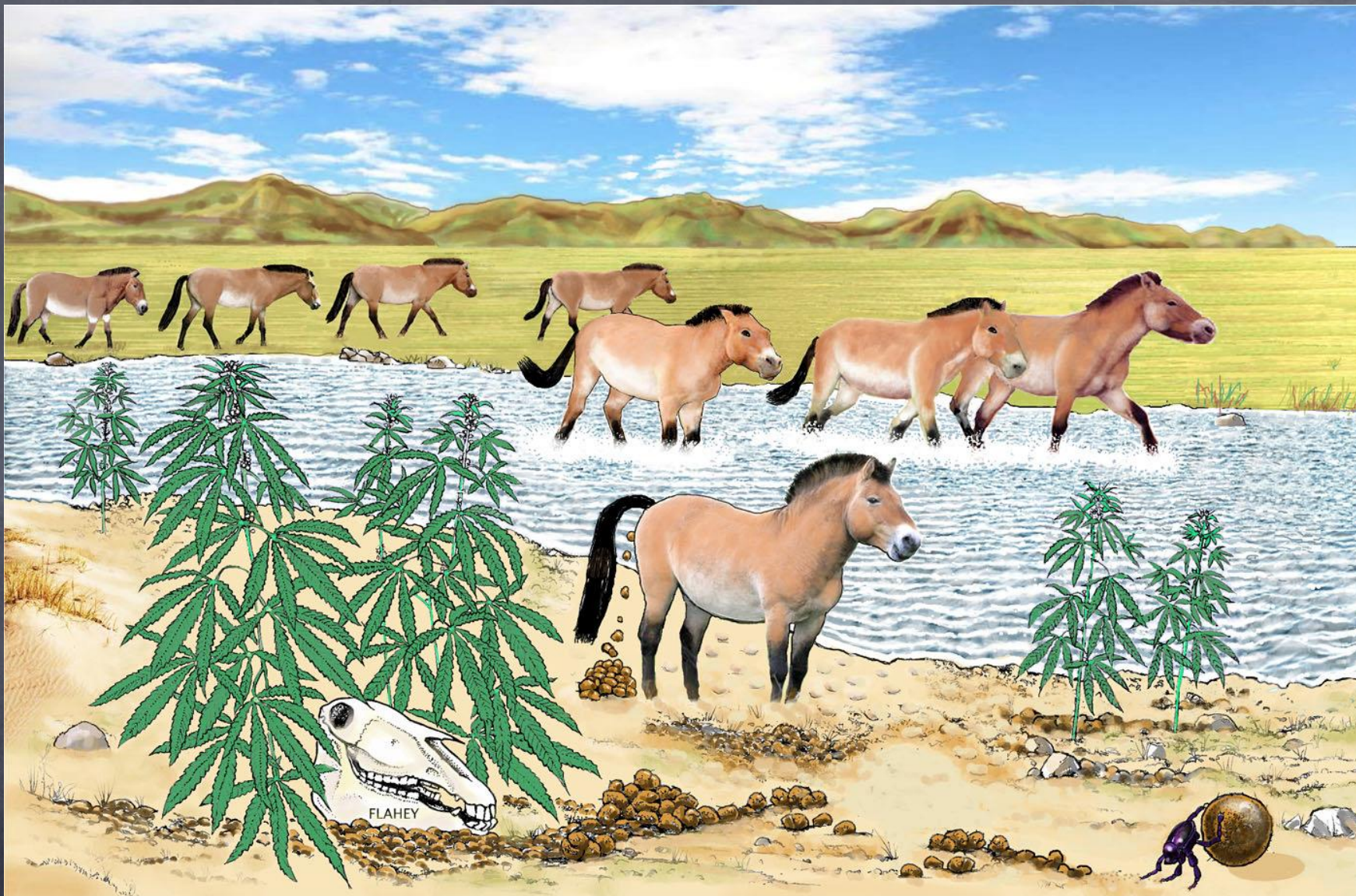
In Indiana, where feral cannabis was most concentrated, authorities have largely ceased eradication attempts, with one police spokesman stating "You can eradicate ditch weed as well as you can eradicate [dandelion](#)."

Wild hemp in Nebraska

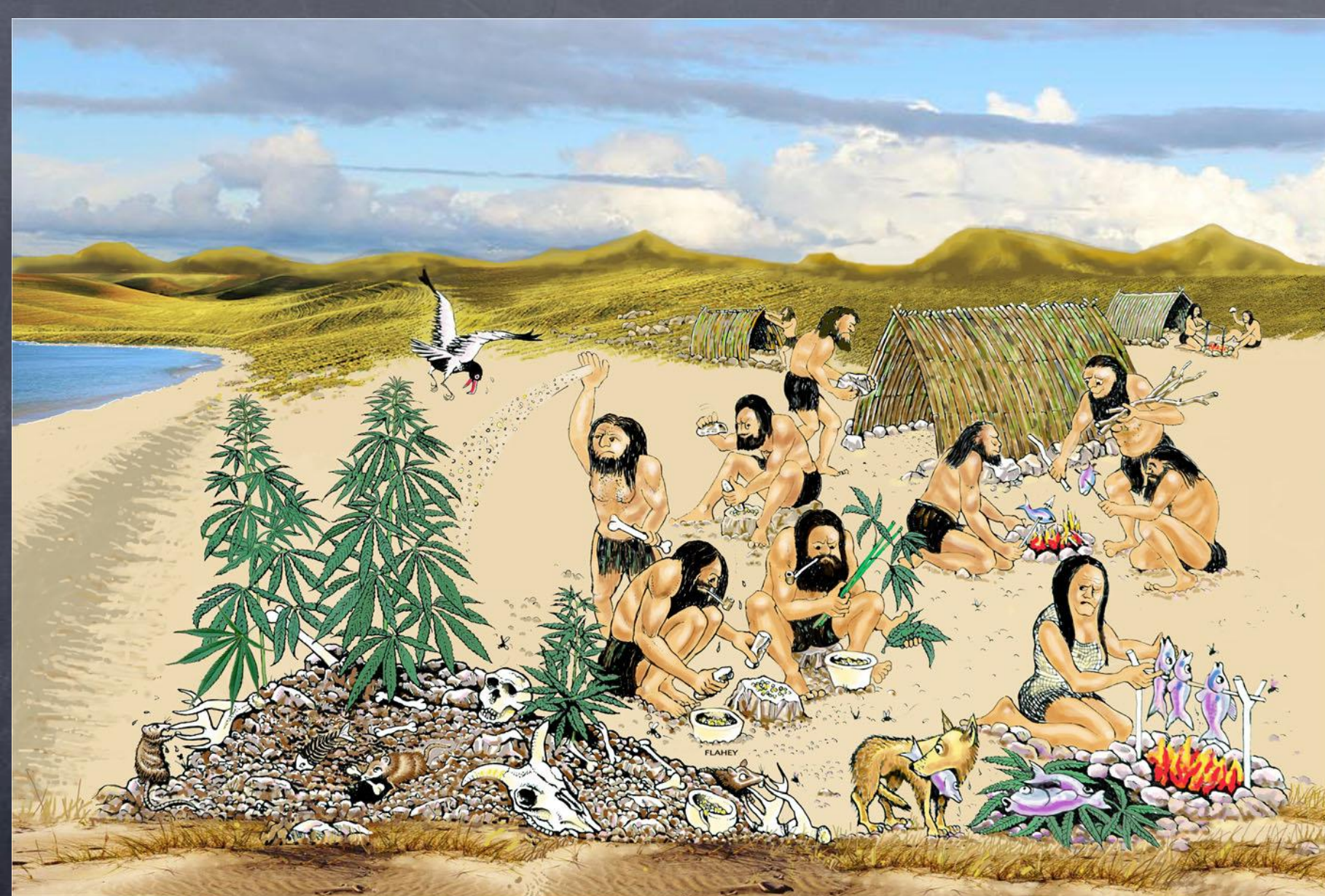




Ruderal (weedy) hemp near Ottawa, Canada. This photo shows several characteristic habitat features of *Cannabis sativa*: (1) The plants are in an open, sunny location. (2) They are growing near a manure shed, in nitrogen-rich soil. (3) A stream is nearby, maintaining a moist substrate. (4) The soil near the stream is alluvial(sandy and well-drained). (5) Competition from other plants is limited



An interpretation of the pre-human ecology of *Cannabis sativa*. The habitat requirements of modern ruderal hemp suggest that the ancestral plants thrived near streams frequented by mammalian herds.



An interpretation of the early domestication of *Cannabis sativa* in accord with the “camp-follower” and “dung-heap” hypotheses of crop origin. The plant would have been collected from the wild as a source of stem fiber, edible seeds, and inebriating resin. Seeds discarded on refuse dumps near temporary camps would have found ideal conditions (manured soil, an open sunny location, probably proximity to a water supply, and limited competition), and consequently would have become desirable companions for mankind. The pipe smoking shown represents artistic license, as ancient methods of smoke inhalation in the Old World are controversial (Clarke & Merlin, 2013).

Hemp Production

Hemp is best adapted to well-drained soil with a pH between 6.0 and 7.0. Ideally, hemp should be planted in May to early June in most areas. Some Canadian varieties are short season and could be planted through mid-to-late June and still mature before frost.

Hemp is a short-day plant and will only begin to mature when day length is less than 12 hours of sunlight.

Hemp grown for seed is generally grown with medium to shorter varieties. Under current law, varieties must be sourced from other countries since shipment of seed between states is not permitted.

Varieties come in various heights, including those that are medium height (6–7 feet tall), semi-dwarf (4–5 feet tall), and dwarf (3–4 feet tall).

In the United States, medium to taller varieties are preferred because there are no herbicides labeled for hemp.

Planting:

Hemp may be drilled or broadcast. Drilling is recommended for uniformity.

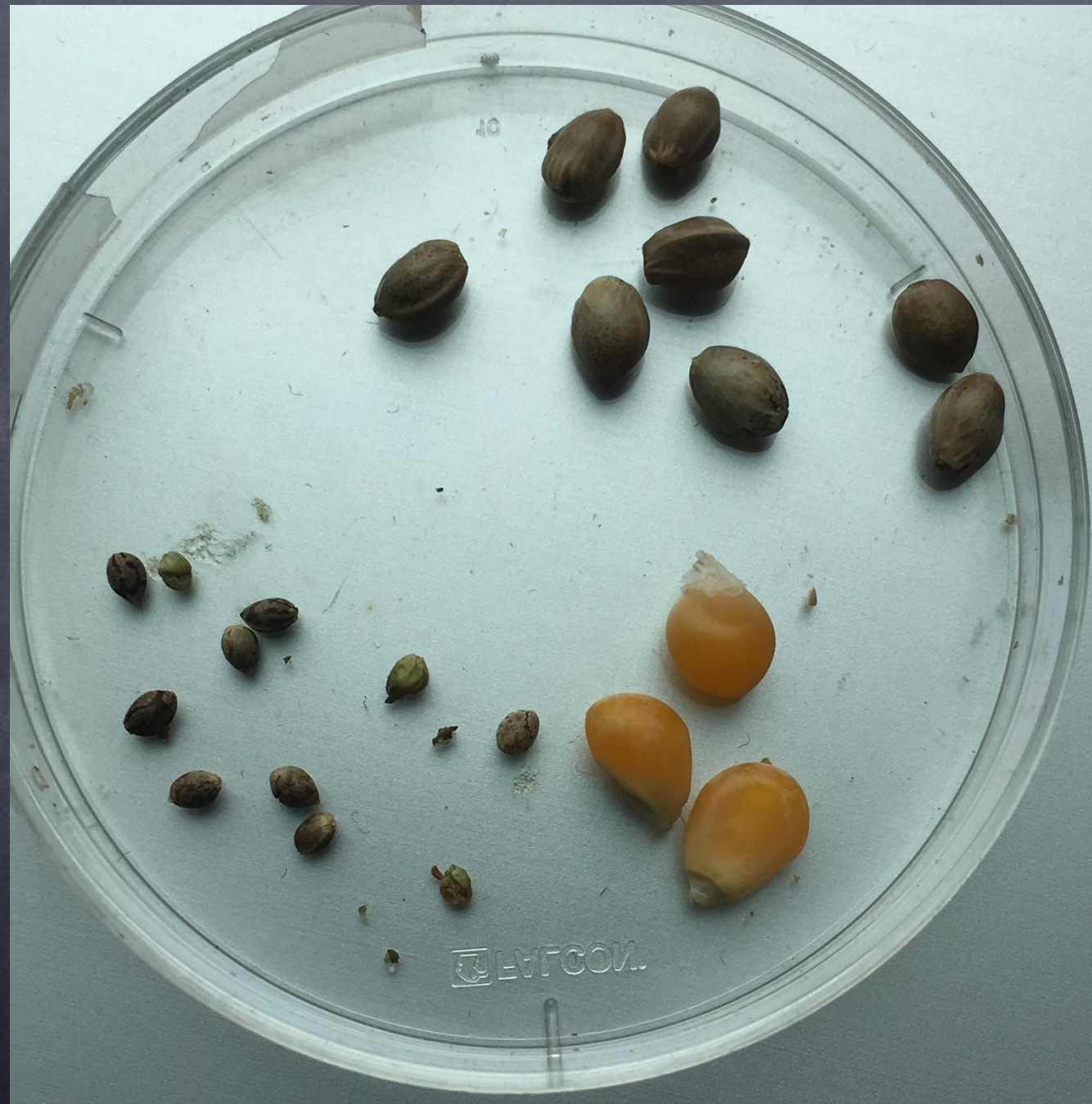
Planting depth is between 0.5 and 1.0 inch, although greater depths are occasionally recommended (up to 2 inches in Poland).

Row spacing for fiber should be four to seven inches, 20-30lbs/acre (Variability in germination can be a problem among hemp seed lots. Using plants/acre is a good criteria due the difference in seed size and weights.

The **seed crop** is planted much less densely (the seed crop is not a weed controller) at **about twenty-inch spacing**, approximately **10lbs/acre**.

Hemp can be planted early. Recommended soil temperature for planting is 8-10°C. In

This early emergence character of hemp is a component of its weed suppression.



There is a big variation in seed size and weight among hemp seeds

Big seeds: $0.42 \text{ g}/10 \text{ seeds} = 10,761 \text{ seeds/lb}$
> 12/64 inch

Small: $0.048 \text{ g}/10 \text{ seeds} = 94,166 \text{ seeds/lb}$
2/64 inch

Fertilizers:

80-110lbs/acre available nitrogen (N); 60-90 phosphorus (P); 135-160 potassium (K); 14-18 calcium (CaO). This considerable range leaves much open to the farmer's experimentation.

Fiber and seed crops are handled differently: ratio N:P:K 1:0.7:1.5 (fiber) 1:0.8: 1 (seed).

Hemp works well into "organic" agriculture.

Naturally, the soil nutrient status should be thoroughly tested and periodically monitored. Although hemp is reported to accept soil acidity as low as pH 5.5, neutral pH is recommended. Lime accordingly

Yield: Hemp may potentially yield 25 t ha⁻¹ above ground dry matter, 20 t ha⁻¹ stem dry matter and 12 t ha⁻¹ cellulose but in many cases the yield varies.

The yield of the dry bast fiber varies from 1.2 to 3.0 t ha⁻¹, and seed yield from 0.7 to 1.8 t ha⁻¹.

With estimated production expenses of \$286, net returns for hemp for fiber ranged from -\$116 to \$473 per acre.

Returns for hemp seed were estimated to range from \$60 to \$800 per acre

Return for hemp CBD ranges from \$5000 to \$100,000.

Harvesting





Retting

- Field retting: The first phase of transforming the plant to fibers : Mother Nature takes over. Sun, dew and rain help detach the fibrous skin from the central wood, the stems take on a beautiful russet hue. To assure even and complete retting, the stems should be turned over when they start changing in color from green to pale yellow. Under optimal weather conditions, this stage can be reached two to three weeks after cutting.
- Water retting, through full immersion
- Direct use of enzymes

cannabis seeds

After a plant is pollinated, the cannabis seeds will ripe in about six (6) weeks but could be ready earlier. When seeds are mature they will split the calyxes open and make the cannabis seeds visible.

The seeds that are most ripe are seeds that have a dark brown or grey color and well-mottled (tiger striped) and will set loosely within the calyx. Seeds that are not viable and immature will be green, yellow or white in color as well as will be in sealed calyxes.

If you have seeds that are not mature by the end of the plants life-cycle then you can eat the immature cannabis seeds. Plants that are sativa dominant tend to allow seeds to fall from their small, lightly packed buds and while indica dominant plant seeds tend to stay within the large, densely packed buds.



Diseases and Pests:

More than 50 different viruses, bacteria, fungi and insect pests are known to affect the Hemp crop including white mold. Rotations are very important, especially growing hemp after grain crop. However, Hemp's rapid growth rate and vigorous nature allow it to overcome the attack of most diseases and pests. No pesticides for hemp or seed treatments yet. Good crop establishment to control weeds.



White mold



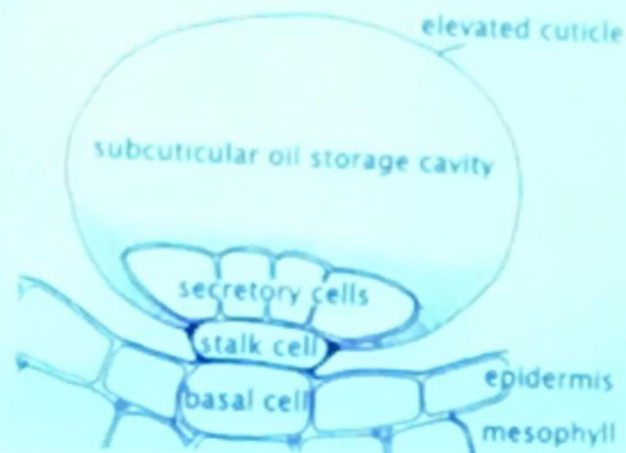
Powdery mildew



Aphids



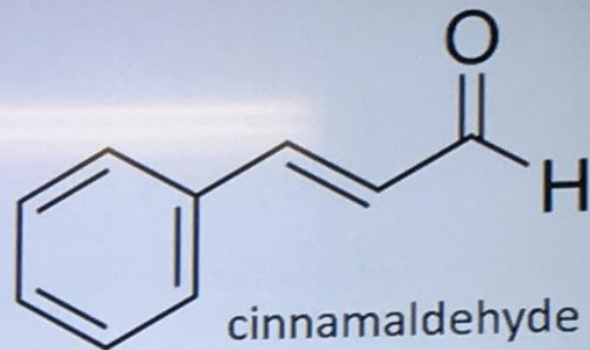
Spider mites



Ingredient Selection

- Fungicide

- Target pathogen = powdery mildew
- Cinnamon oil
 - cinnamaldehyde – inhibit enzyme synthesis
 - Linalool – naturally exuded when plants are under attack by powdery mildew

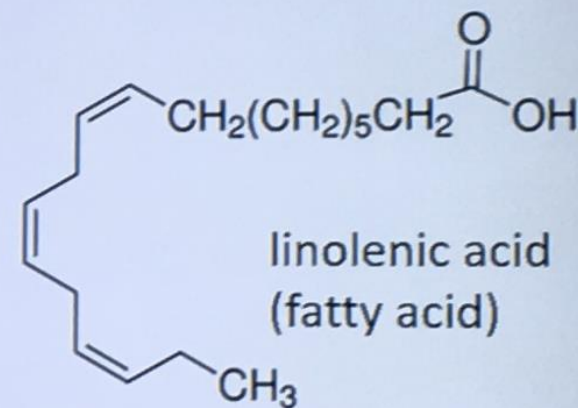


- Thyme oil

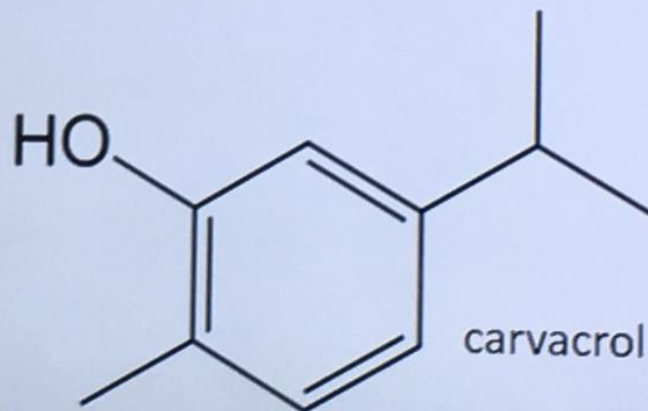
- thymol – synergistic with linalool
- carvacrol – harms cellular membranes

- Linseed oil

- fatty acids – disrupt cellular membranes

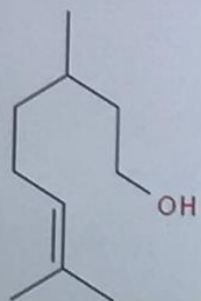
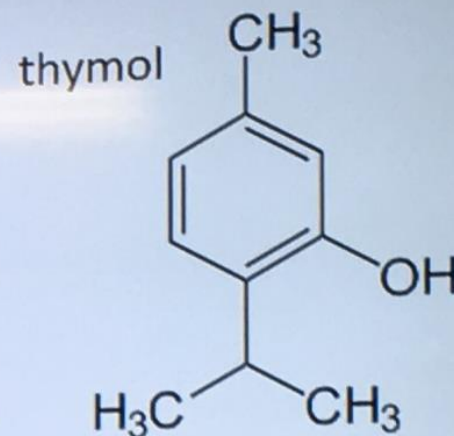


- Multiple modes of action



Ingredient Selection

- Miticide/Fungicide
 - Target pests = mites and powdery mildew
 - Clove oil
 - eugenol – interferes with cell's ability to utilize glucose; harms cellular membranes
 - β -caryophyllene – attractant for beneficial insects
 - Thyme oil
 - thymol – feeding deterrent; alters conditions inside of cell resulting in growth inhibition
 - carvacrol – kills eggs and harms cellular membranes
 - Citronella oil
 - citronellol – causes leakage of cellular contents
 - citronellal – kills larvae, feeding deterrent, insect repellent
 - geraniol – kills eggs; attractant for beneficial insects
 - Evidence of activity against dozens of different pests



citronellol



Weed Control

There are no in-crop herbicides registered for use on industrial hemp.

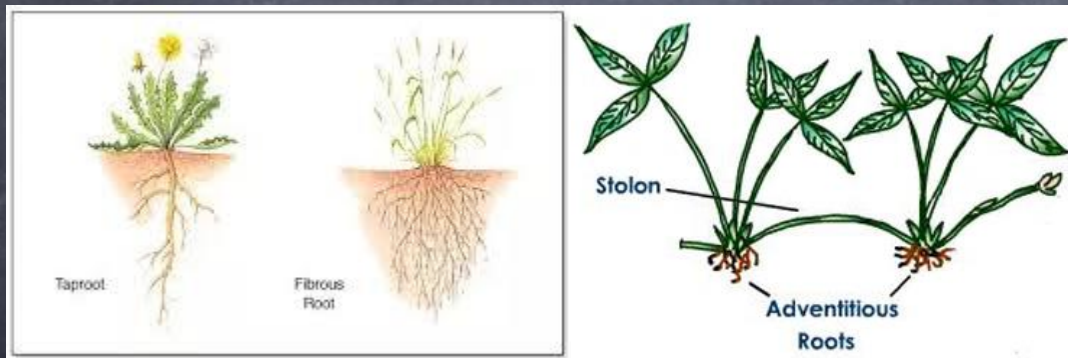
Pre-seed burn-off with glyphosate is the only option for conventional growers. Hemp is very competitive with weeds as it develops in height and plant density.

Following seeding recommendations coupled with pre-seed herbicide burn-off or pre-seed tillage would allow hemp plants to become established before most weeds emerge and it would optimize its competitive advantages.



Hemp is an annual broadleaf plant with a taproot. ... Soil moisture will affect the ability of the root to penetrate deep into the soil profile, hemp can demonstrate adaptations to a variety of soil moisture conditions.

Plants have three types of root systems: 1.) taproot, with a main taproot that is larger and grows faster than the branch roots; 2.) fibrous, with all roots about the same size; 3.) adventitious, roots that form on any plant part other than the roots.



The **MANY** USES of Hemp

Hemp is the strongest natural fibre in the world, known to have over 50,000 different uses!

TEXTILES

- Clothing
- Diapers
- Handbags
- Denim
- Shoes
- Fine fabrics

PAPER

- Printing
- Newsprint
- Cardboard
- Packaging

INDUSTRIAL PRODUCTS

- Oil paints
- Varnishes
- Printing inks
- Fuel
- Solvents
- Coatings

FOODS

- Hemp Seed Hearts
- Hemp Seed Oil
- Hemp Protein Powder
- EFA Food Supplements

BODY CARE

- Soaps
- Shampoos
- Lotions
- Balms
- Cosmetics

Stalk

INDUSTRIAL TEXTILES

- Rope
- Canvas
- Tarps
- Carpeting
- Netting
- Caulking
- Moulded parts

BUILDING MATERIALS

- Fibreboard
- Insulation
- Acrylics
- Fibreglass substitute

Leaves

- Very absorbant and good for animal bedding
- Mulch and compost

Roots

- Organic compost and nutrients
- Remedy for conditions such as arthritis or joint pain, fibromyalgia, and eczema.

THE BENEFITS OF CULTIVATING HEMP

Hemp can yield 3-8 dry tons of fibre per acre. That's four times what an average forest can yield. Hemp cultivation requires no chemicals, pesticides or herbicides.



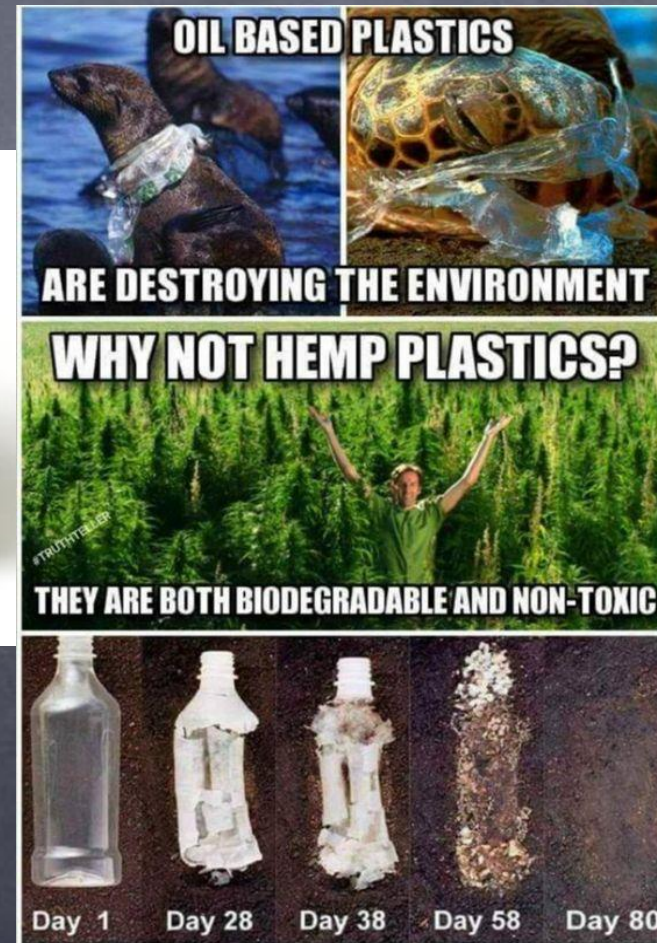
Hemp

makes more fuel, fiber, food and medicine than any other plant, and it was the first crop sown, over 12,000 years ago.

An acre of Hemp produces 300 gallons of oil, 3 tons of protein and 30 tons of fiber a year.

Hemp as paint & plastic

Hemp oil extract can also be used as an ingredient in nontoxic, biodegradable inks, paints, and varnishes. It is an ideal raw material for plant-based plastics such as cellophane as well as more recently developed cellulose-based plastics. Henry Ford himself manufactured the body of an automobile from hemp-based plastic in 1941. The plastic was much lighter than steel and could withstand ten times the impact without denting.



Concrete from hemp

Madame France Perrier builds about 300 houses per year out of hemp in France. Years ago she researched ways to petrify vegetable matter. During her studies, she found evidence in ancient Egyptian archaeological sites of hemp-based concrete. When she discovered the ingredients of the mix, she duplicated the method. She **mixes hemp hurds (the inner fiber) with limestone and water, which causes the hemp to harden** into a substance stronger than cement and only one sixth the weight. Madame Perrier' blocks is also more flexible than concrete, giving it a major advantage over conventional building materials, especially in areas throughout the world that are prone to earthquakes.



Designed to build, not to smoke.

HEMPCRETE

Strong, Lightweight & Breathable

Energy Efficient

Incredible Insulation

Naturally Non-toxic

Lasts 100's of Years

Flame, Water & Pest Resistant

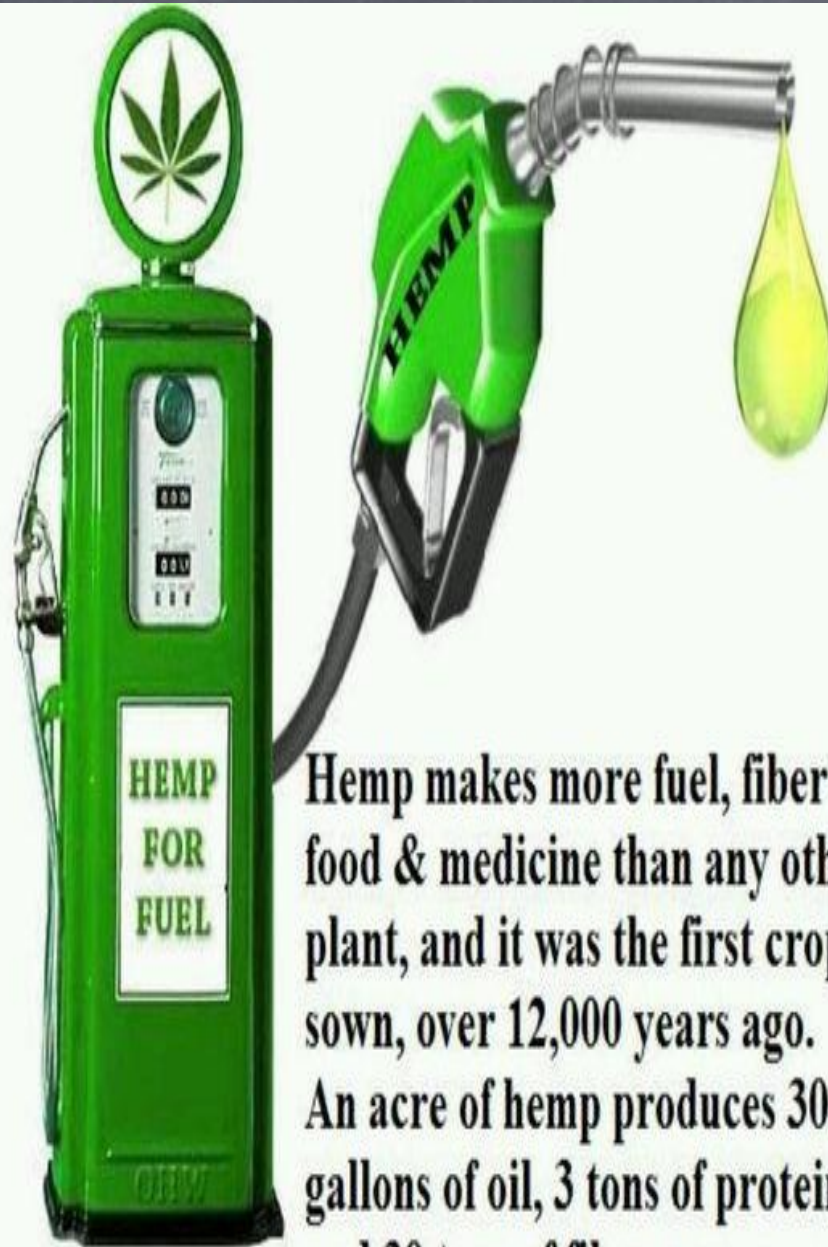
Hemp + Lime + Water

CARBON NEGATIVE

EDMED
FB.COM/EDUCATIONNUTRICATION

The image is a promotional graphic for Hempcrete. It features a central 3D rendering of a rectangular block of the material. Surrounding the block are several text labels connected by thin lines, highlighting its properties: 'Strong, Lightweight & Breathable', 'Energy Efficient', 'Incredible Insulation', 'Naturally Non-toxic', 'Lasts 100's of Years', and 'Flame, Water & Pest Resistant'. To the left of the block, the ingredients 'Hemp + Lime + Water' are listed. At the top, a cannabis leaf icon is next to the slogan 'Designed to build, not to smoke.' and the word 'HEMPCRETE' in large, bold, black letters. At the bottom left, the words 'CARBON NEGATIVE' are enclosed in a dashed-line box. At the bottom right, the logo 'EDMED' and the website 'FB.COM/EDUCATIONNUTRICATION' are visible.





Hemp makes more fuel, fiber food & medicine than any other plant, and it was the first crop sown, over 12,000 years ago. An acre of hemp produces 300 gallons of oil, 3 tons of protein, and 30 tons of fiber a year.

Best source for reinforcement



Made from Hemp fibers
Stronger than steel.



- **PEBL**
- **Car-bike hybrid
2013**

- **Eco-friendly car**
- **Hemp composite body**
- **Motive Industries, 2010
Canada**

Hemp Grain: Highly Nutritious

Protein 30%

Lipids 25%

Fiber

More digestible than Soy – plus all 9 essential amino acids

Increased Omega 3 in laying hens, better lipid profile than soy

Better rumen function in cattle than soy





CBD hemp:

- Majority of growers – grow only female plants.
- Desire bushy plants with large number of flowers.
- Current Production models tobacco or vegetable.
- CBD Levels are highest in the floral materials.
- Both field & greenhouse production.
- production is 1 lb/plant Of dry matter for CBD extraction. One pound worth between \$10-50 depends on the CBD concentration.





CBD hemp plant grown in OR, 10 feet and 35 feet in diameter

Hemp for CBD

How much CBD is produced per acre of hemp?

On average, hemp crop should produce about 10 percent CBD content, and should bring about \$25 to \$35 per pound. With a yield of about one pound per plant and up to 2,500 plants per acre, that's around \$60,000 per acre. It could go higher or lower, based on the CBD%.

Oil from seeds per acre:

4,000 pounds of hemp seed per acre. When cold-pressed, the 4,000 pounds of hemp seed yield over 150 gallons of hemp seed oil and a byproduct of 3,000 pounds of high protein hemp flour. Seed oils are both a food and a biodiesel fuel.

Breeding goals:

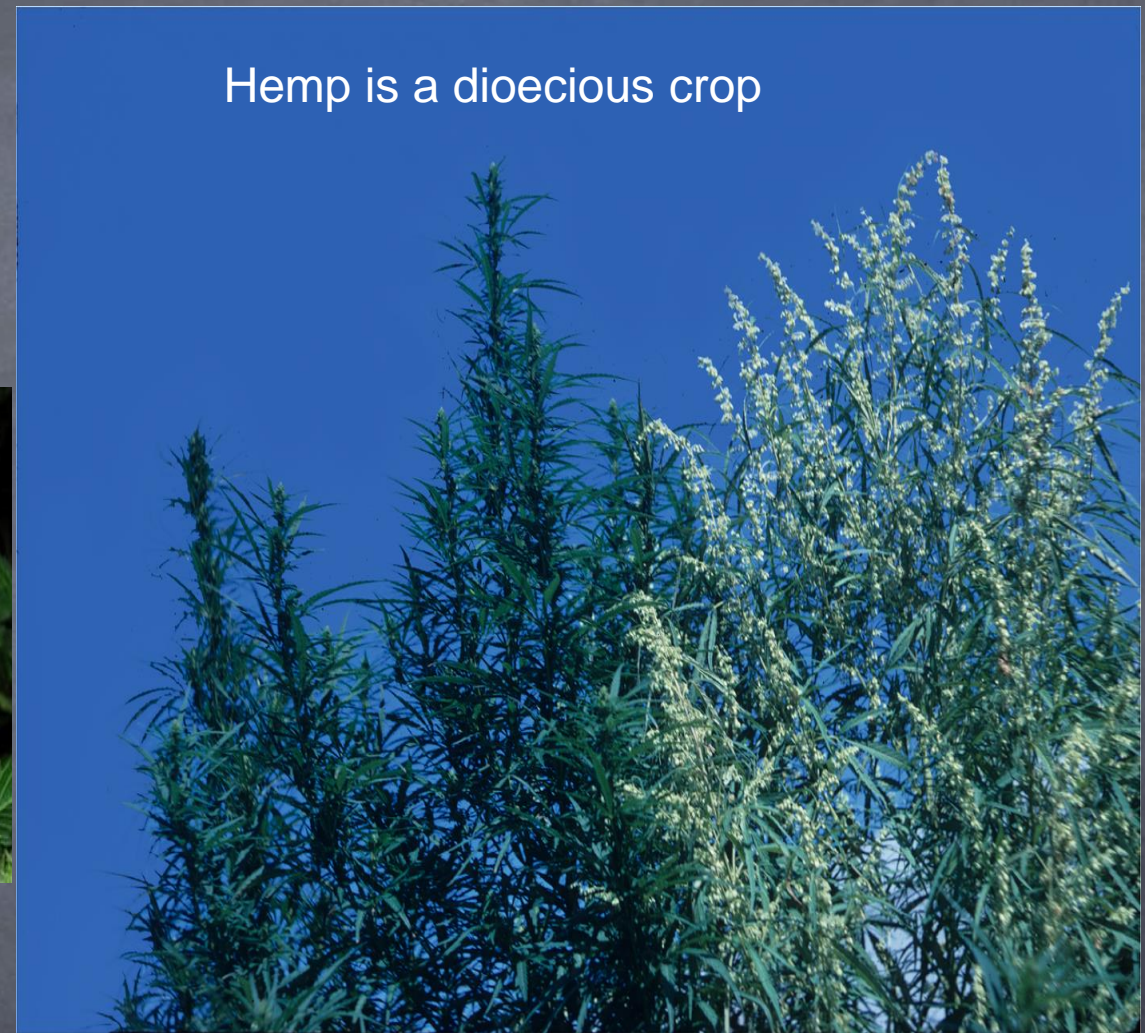
As a semi-domesticated plant, hemp has many desirable traits that require improvement including:

Eliminating **seed shattering**, enhancing the quantity and quality of stem fiber, and increasing the accumulation of phytocannabinoids.

Methods to manipulate the sex of hemp plants will also be important for optimizing yields of seed, fiber, and cannabinoids.



Seed
shattering



Hemp is a dioecious crop

How to produce hemp seed for planting:

Seeds can be produced by selecting appropriate male and female. Pollen from male can be transferred manually or by winds.

Pollination occurs when male pollen comes into contact with the female pistil. Depending on which plant variety you choose to breed the female flowers will be ready to be pollinated within two (2) to twelve (12) weeks after the flowering cycle has been introduced to the plants.

You can leave the bag over the branch for two (2) days to ensure pollination occurs. Many times cannabis breeders will contain the male pollen and pollinated-female plants in a separate room to prevent other cannabis plants from being fertilized.

After a few days in the pollination room, the female plant is sprayed with water to destroy the pollen that remains on the plant before the female plant is moved back into the flowering room. This is to prevent any remaining pollen from fertilizing other plants.

Male Plants – Proven male plants are probably some of the most prized and important parts of any cannabis breeding program. The reason is that male plants are “silent carriers” for the genes that produce buds. The only way to know for sure what traits a male plant will pass onto female offspring is to breed it with different known female plants and see how the offspring turn out. After a lot of testing, a grower can create or find a male plant that is known to give desirable traits to its offspring.

For example, you could find a male plant that tends to make offspring whose buds smell like blackberries. Even though the male plant never grows buds at all, it is silently carrying the bud trait of smelling like blackberries. This type of knowledge can be extremely useful if you’re trying to cross a male with your female plants.

The process of picking males for a breeding program is time-consuming and you’ll need to keep great notes about each offspring of a male plant in order to learn what silent traits the male plant is carrying for its female offspring.

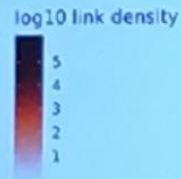
Pollen viability:

Pollen that is harvested can be stored for several months when it is stored in a freezer. To store pollen in the freezer you will first need to use a fine screen to filter out the plant leaf matter from the anthers that may have fallen into the bag.

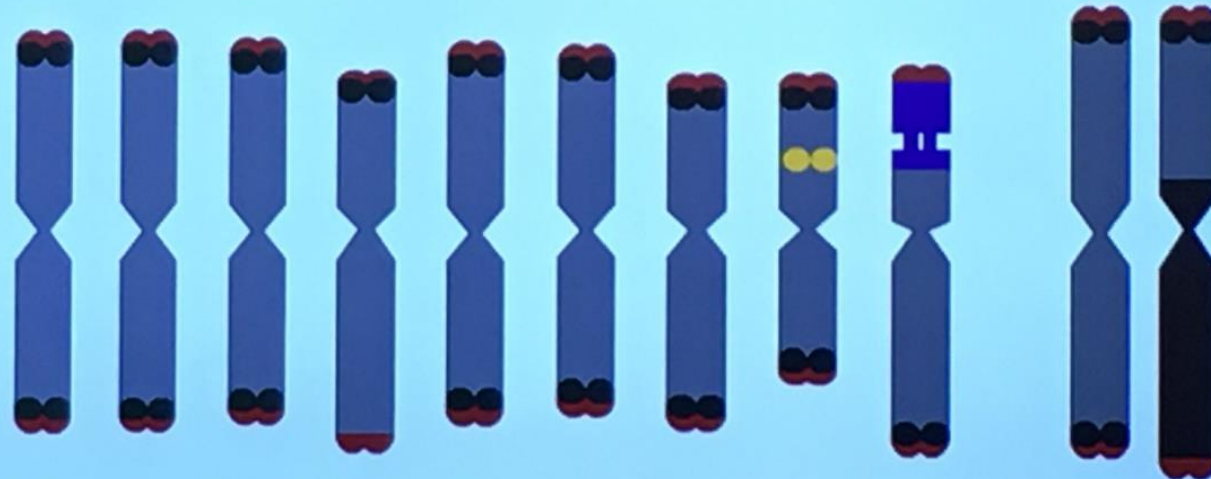
You can then place the pollen in a sterile container, tube or sealed bag to make sure that the pollen for cannabis seeds is clean and sterile. When you are freezing the harvested pollen you will not want to continually freeze and thaw it out since this will diminish the viability of the pollen. Use only what is needed and leave the rest frozen.

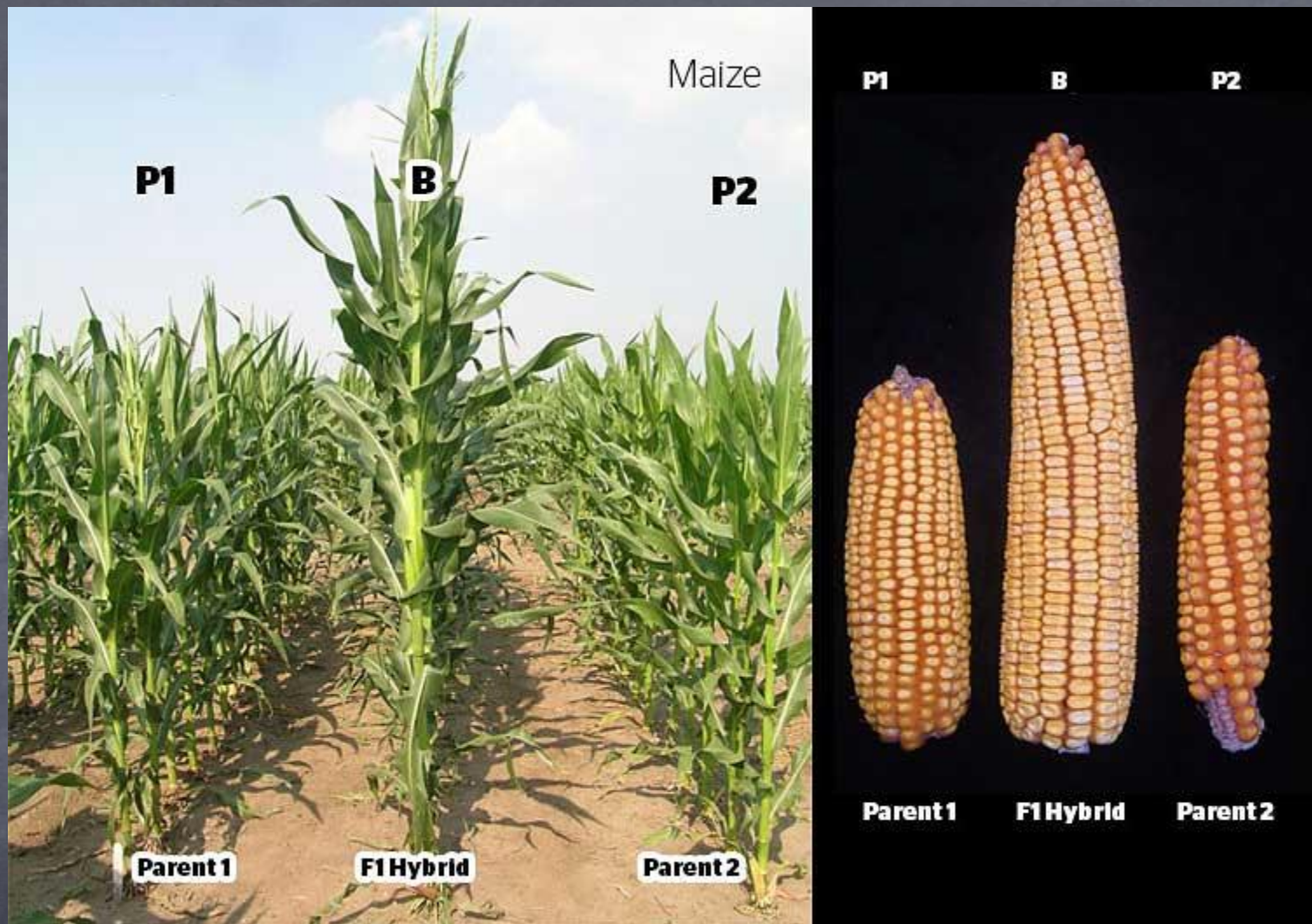
Hemp is annual, diploid with $2n=20$ chromosomes

- 10 Pseudo-chromosomes
 - 54 - 100 Mb each
 - 802 Mb
- Rab1 configuration? Geek out!



Divashuk et al. 2018



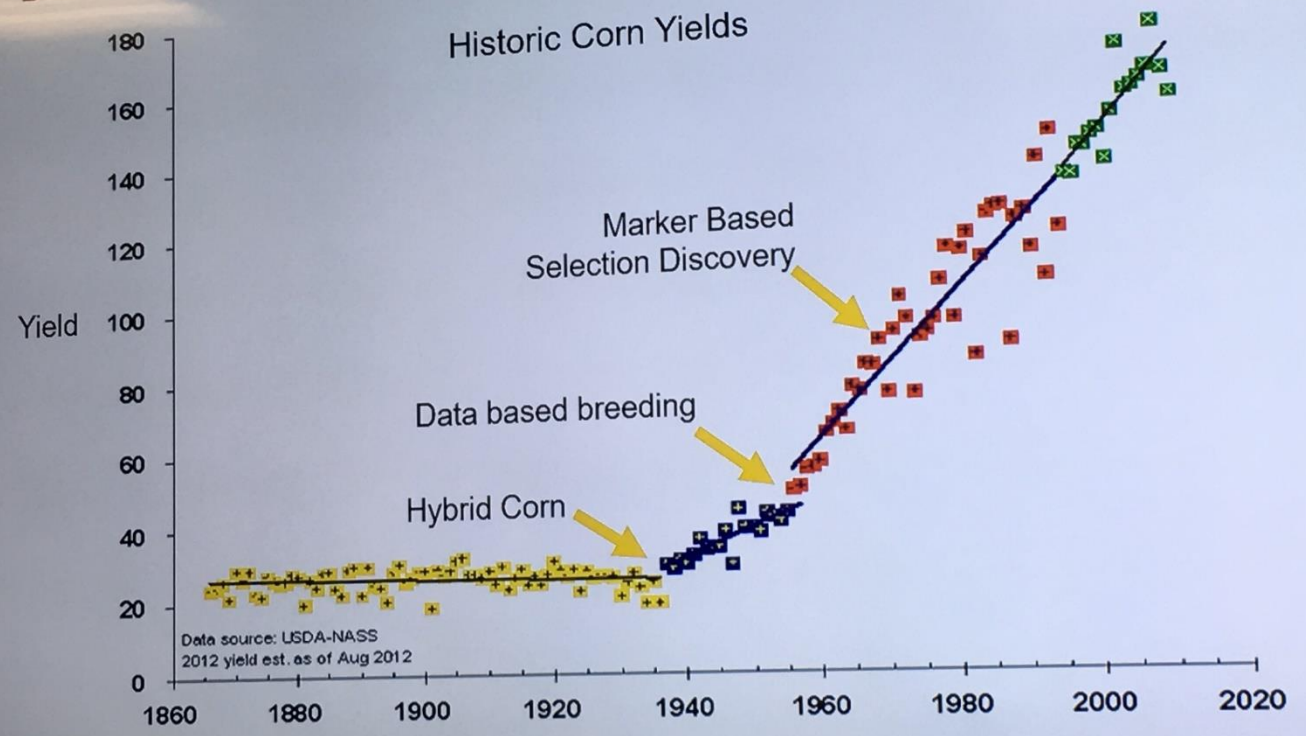


The growers of corn have found a great F1 cross that produces better results than any individual strain on the market. Notice how the F1 offspring seems to be better than its parents in almost every measurable way. By crossing the same two “parents” every time, corn breeders know that every one of the F1 offspring will perform the same way, get similar yields, and be ready to harvest at the same time. That’s the power of hybrid vigor!

Breeding + Genetics Accelerates Innovation & Value



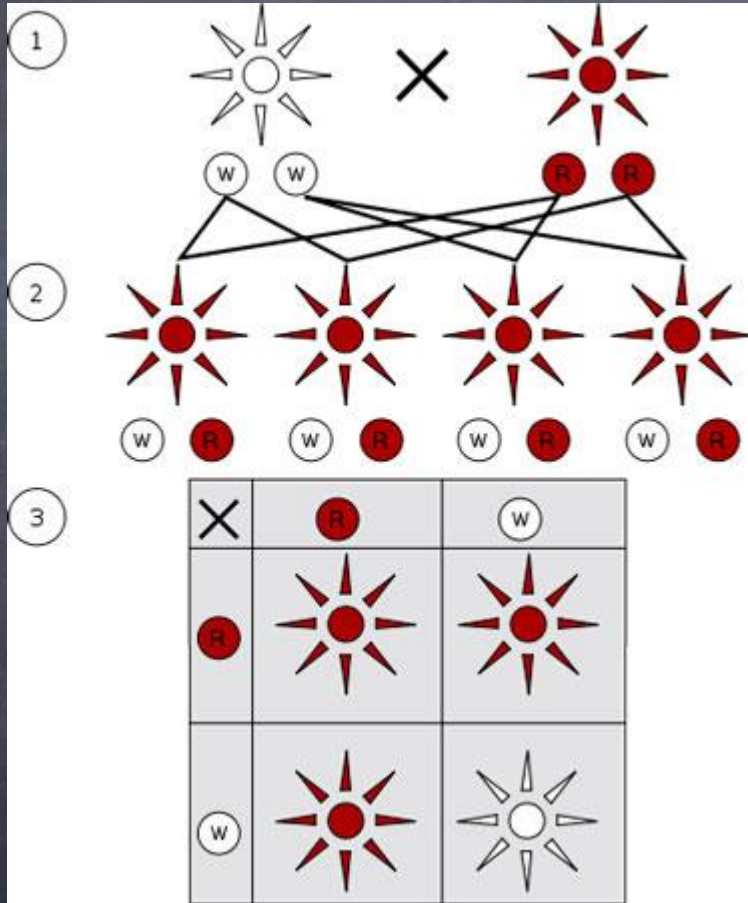
Because of prohibition, there is much work to do with hemp genetics.



Cannabis is not an easy plant to breed, and presents two major obstacles to the improvement by genetic procedures.

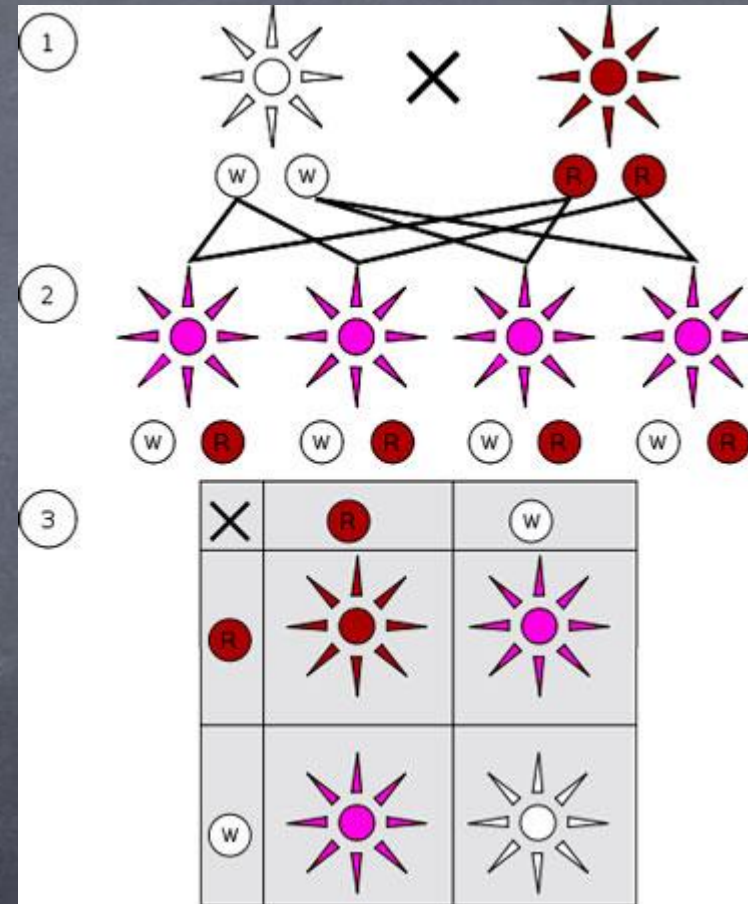
It is usually **dioecious**, that is the plants cannot pollinate themselves, and are therefore outcrossing by nature. The reaction of plant to **day length** is another constraint of the hemp biology, since it affects the phenological development, length of biological cycle, and yield. Besides, the farmers require the development of a range of varieties to cover different cropping conditions.

Mendelian Inheritance Example – Complete Dominance

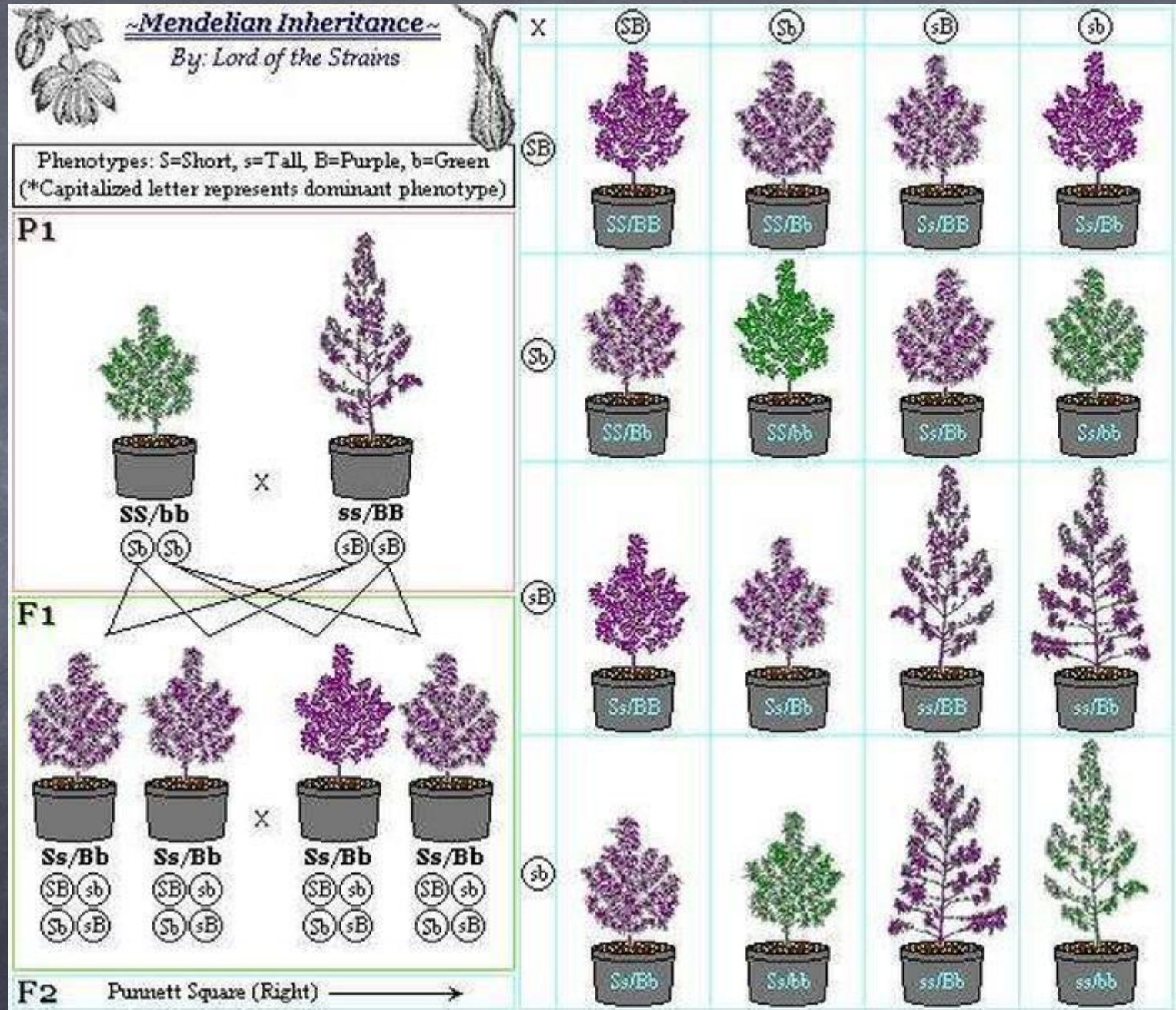


- (1) Parent generation
- (2) F1 generation
- (3) F2 generation

Incomplete Dominance



How to develop a segregating population in hemp



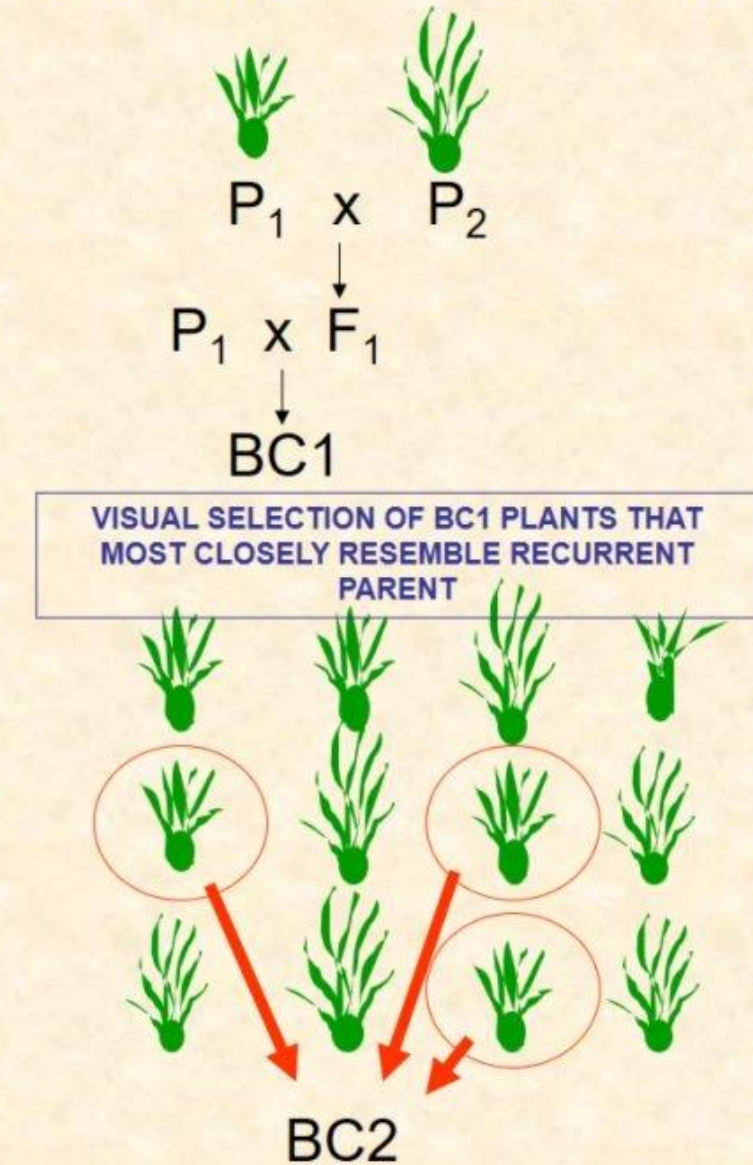
Selfing:

F1 seeds can be produced with just a female marijuana clone. These seeds carry only the genetics of the mother. In order to accomplish this, the grower must reverse the sex of the female to induce self-pollination. Most home breeders will purposefully stress the flowering female to produce a few seeds. Selfing is commonly applied to clone-only marijuana varieties to convert it to F1 seed form.

Backcrossing:

You first need to identify a recessive donor male or a male with a desirable trait worth adding to the progeny. The female will be retained as a mother to keep taking cuttings from.

CONVENTIONAL BACKCROSSING



Source: knowledgebank.irri.org

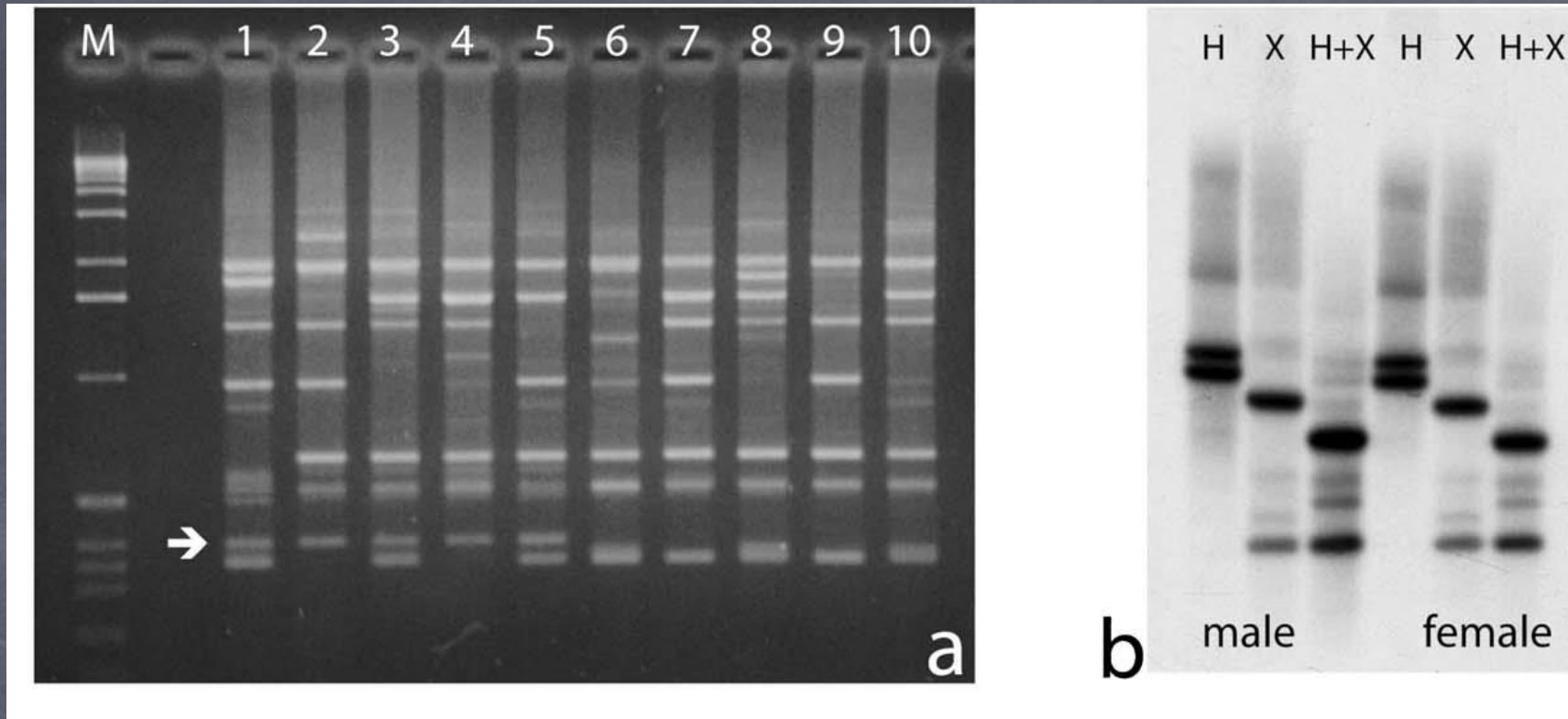
Mass selection was used in the past to select the most important cultivars, such as Carmagnola in Italy (Ranalli, 2004) or Novosasdka konoplia in Yugoslavia (Berenji et al., 2013).

In mass selection pollination cannot be controlled and any improvement in fiber content is very slow.

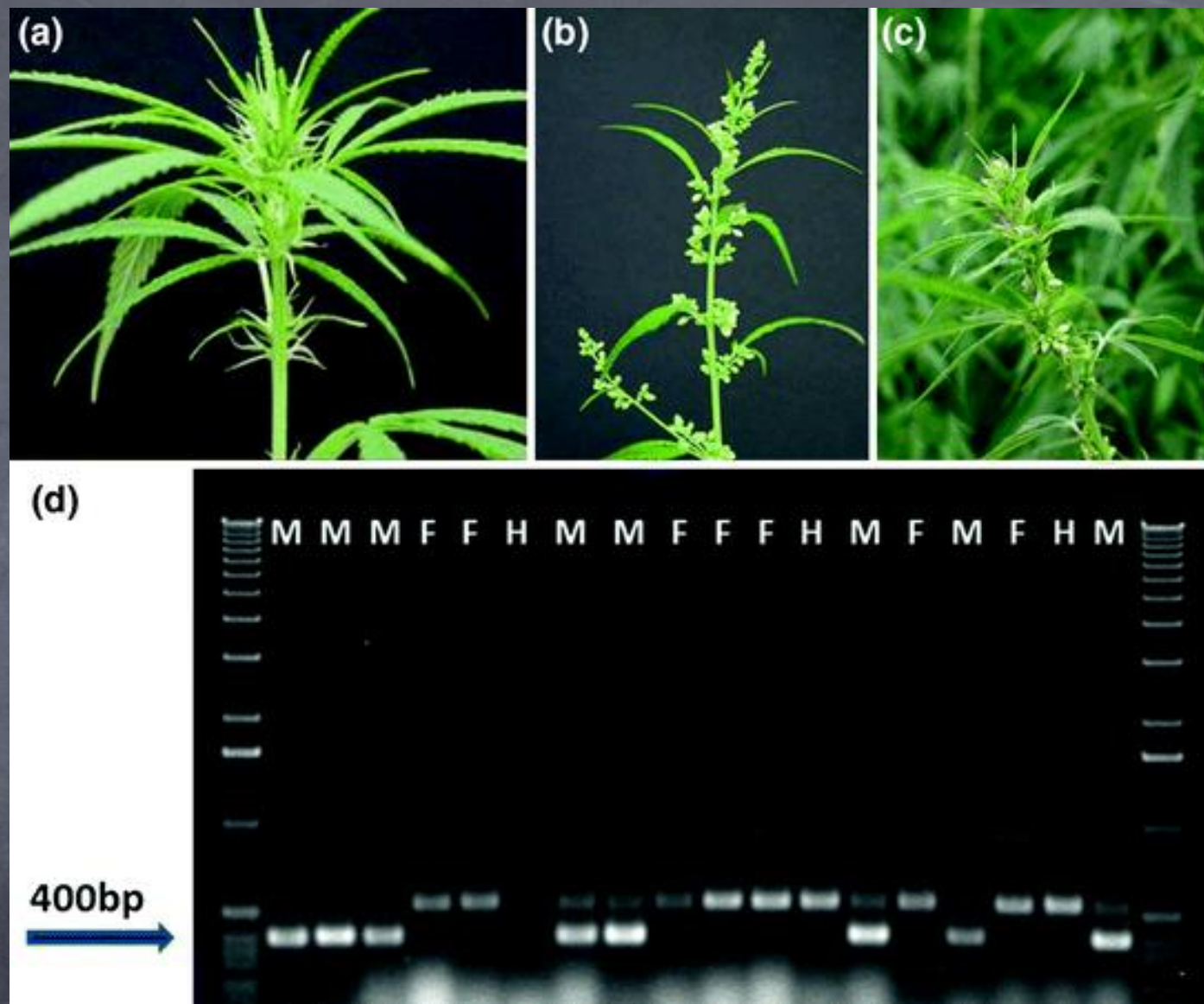
A large contribution to the increase of stem fiber content was obtained by the application of the Bredemann method (Bredemann, 1942), that consisted in the individual selection of male plants on the basis of the fiber content, measured on a longitudinal section of the stem.

Molecular markers employed in MAS should:

- (i) co-segregate or be tightly linked (ideally, less than 1 cM) to the trait object of selection;
- (ii) Cheap
- (iii) its validity should be recognized in a laboratory-independent manner, i.e. it should be reliable and reproducible in different laboratories



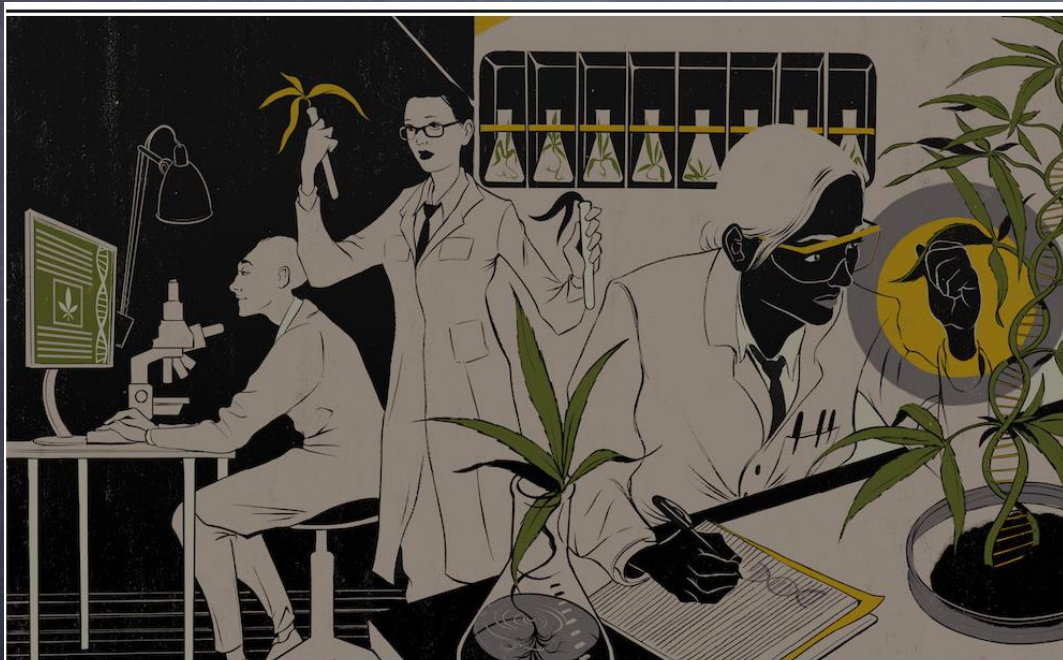
RAPD pattern generated by the primer OPA08 (Operon Technologies, USA). The arrow indicate the 400 bp male-associated marker, present in the male plants (lanes 1–5) and absent in the female plants (lanes 6–10). M, molecular weight standard. (b) Hybridization pattern obtained using the cloned 400 bp RAPD fragment visible in a) on digested DNA from male and female plants restricted with HindIII (H), XhoI (X) and with both enzymes (H + X). Note the absence of male–female polymorphism. Mandolino et al. 1997, 1998.



Female (a), male (b) and monoecious (c) inflorescences of *Cannabis sativa*. d MADC2 sequence-based marker useful for the identification of sex in dioecious plants. M male plants; F female plants; H monoecious plants. Female and monoecious plants cannot be distinguished. C. Onofri 2017

A draft genome and accompanying transcriptome of *C. sativa* were published in 2011 and a large scale study of the genetic structure of marijuana and hemp types was published in 2015

Investors rush to patent genetically modified cannabis molecules. With hemp production and consumption on the rise, how much will genetic engineering play into hemp's development as a commodity crop?



The Future of GMO Hemp



Hemp Breeding Limitations

Germplasm collections are a fundamental source of genetic and phenotypic diversity for plant breeding and research. Currently, access to and utility of accession collections remain limited due to the lack of a core Cannabis germplasm collection. As **THC levels may limit germplasm utility in many regions**, accessions with $<0.3\%$ THC should be used to form a hemp-only germplasm core collection. Establishment of **a core collection encompassing the range of hemp genetic and phenotypic diversity would increase the utility of germplasm resources and be invaluable for breeding and genetic analyses**. Comparisons of accessions present in existing collections are needed to help establish such a core collection. Similarly, **centralized and curated collections of hemp mutants are not available**. The development of mutant germplasm collections will provide a rich source of genetic variation for studying gene function and improved traits for breeding.

Hemp pollen can travel long distances. Studies in southern Spain identified Cannabis pollen in atmospheric samples which arrived from the extensive marijuana fields in Morocco over 100 km away. Long-distance pollen dispersal causes difficulty for breeding programs which require spatial or mechanical methods for germplasm isolation. Cost-effective and efficient methods are needed that will allow breeders to develop multiple new hemp varieties simultaneously in a limited growing area.

Summary of Cannabis germplasm resources

Cannabis genetic resource collection	Location	Link	Online database	References
Centre for Plant Breeding and Reproduction Research (CPRO)	Netherlands-Wageningen	http://www.ecppbr.nl/	n/a	De Meijer and van Soest, 1991 ; De Meijer et al., 1992 ; Hillig, 2005b ; Gilmore et al., 2002
Ecofibre Global Germplasm Collection	Australia, Queensland	http://www.ecofibre.com.au/	n/a	Welling et al., 2015
HortaPharm B.V., Amsterdam, Holland (now merged with GW pharmaceuticals)	Netherlands, Amsterdam	n/a	n/a	Ranalli, 2002 ; Hillig, 2005b ; Datwyler and Weiblen, 2006
Institute of Natural Fibers and Medicinal Plants (INF&MP)	Poland-Poznan	http://andymr.edu.pl/cgi-bin/admin/www.ecppbr.org.pl/Presentations/Fibre_crops_NL_2006/Czech%20country%20report_n.pdf	http://archive.ecppbr.org/	Mankowska and Silska, 2016
Istituto Sperimentale per le Colture Industriali (CRA-ISCI)	Italy, Bologna	http://archive.ecppbr.org/cgi-bin/admin/www.ecppbr.org.pl/Presentations/Fibre_crops_NL_2006/Italy%20country%20report_n.pdf	http://archive.ecppbr.org/	Mandolino et al., 1998 , 2001 ; Pacifico et al., 1998
Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Germany, Gatersleben	http://archive.ecppbr.org/cgi-bin/admin/www.ecppbr.org.pl/Presentations/Fibre_crops_NL_2006/Germany%20country%20report_n.pdf	http://ipk.gatersleben.de/doku.php?id=ipk:germany	Small and Marcus, 2003 ; Höppner, 2006
National Cannabis Collection (NCC)	Hungary, Tápiószéle	http://archive.ecppbr.org/cgi-bin/admin/www.ecppbr.org.pl/Presentations/Fibre_crops_NL_2006/Hungary%20country%20report_n.pdf	http://archive.ecppbr.org/	Simon, 2008
Research Institute of Crop Production (RICP; owned by AGRITEC Ltd)	Prague, Ruzyne	http://archive.ecppbr.org/cgi-bin/admin/www.ecppbr.org.pl/Presentations/Fibre_crops_NL_2006/Czech%20country%20report_n.pdf	http://archive.ecppbr.org/	Small and Marcus, 2003 ; Pavelek, 2006
Vavilov Research Institute (VIR)	Russia-St Petersburg	http://www.vir.nw.ru/	http://91.151.189.38/vir6/	Clarke, 1998 ; Small and Marcus, 2003 ; Hillig, 2005b
Yunnan Academy of Agricultural Sciences (YAAS)	China, Kunming	http://www.university-directory.eu/China/Yunnan-Academy-of-Agricultural-Sciences.html	n/a	HuaDong and YingFang, 2012 ; Salentijn et al., 2014

What are Feminized Seeds?

While it's basically not possible to determine the sex of a seed from a random bag of seeds, a practice known as feminizing is becoming quite popular. Feminized seeds are selectively bred to produce female plants, however, some growers do worry about some feminized seeds turning into hermaphrodite.

Methods for Feminizing Cannabis Plants

If you have some experience growing cannabis and would like to bend a crop to your will to ensure that the seeds will be female, there are a few feminizing methods you might try. One such technique is to literally - **stress out a healthy female plant by interrupting the light cycle during flowering, called Rodelization Feminizing.**

-In the colloidal silver feminizing method, distilled **water is mixed with pure silver and sprayed on female plants.** This method works best when the plants are flowering. This results in pollen sacs being formed, which will allow the seeds to produce female plants.

-Feminizing via the silver thiosulfate technique involves carefully selecting a nearly mature female plant, then **spraying it with 50/50 mix of sodium thiosulfate and silver nitrate. This triggers a gender change,** from female to male. Place this plant back with the others to pollinate other female plants, and female seeds are created.

-Pollinating female flowers by monocious pollen= >90% females



Hemp can be propagated directly by seeds or by clones that can be transplanted either to the field or a greenhouse.



What Are the Biggest Obstacles When Growing Hemp?

Hemp is often attributed with miraculous potential for sequestering carbon, reducing agricultural pollution, and allowing farmers to make large profits on marginal land. But the reality is not so simple. Here are some things to keep in mind before deciding if hemp is the right crop for you.

You need a lot of land: This is a crop suited for industrial applications, not farmer's market sales. As with most grains, it's tough to be profitable growing hemp without planting at least 50 acres or so.

The "red-tape quotient" is high: Because of its legal limbo, hemp growers need special licenses from their state, which means fees and paperwork. Growers may also be subject to a criminal background check. In states where it is legal, farmers must have their hemp plants tested to ensure they are below a certain threshold of THC content. If your plants are found to have too much THC, they may be destroyed.

Suitable seed can be hard to find: Hemp growers are generally required to plant seed that has been certified for low THC content, but the seed industry lags behind the demand and there are potential complications with the feds when shipping cannabis seeds across state lines.

The future of cannabis breeding

Currently, several laboratories in the U.S. are constructing genome maps for *Cannabis sativa*. We've long had the DNA sequence for cannabis, but we don't yet have the genetic map. A map will tell us where the genes are located on the DNA sequence. This is important, because until we have this map, most breeding procedures are just guesswork. We're relying on trial and error to breed the traits we want, which means wasted seeds and wasted resources.

But with a genetic map, we'll know which strains to cross to get the traits we want—and we'll keep those traits in the lineage.



“In the 18 years of my career in computational biology,” said Syngenta's Keith Allen, speaking during last October's CannaGrow Expo in Denver, “I haven't seen a field advance in genetic understanding as quickly as I have with the cannabis plant.”



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How far did you
travel to get to
Strawberry Fields?



**How far did you
travel to get to
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Thank you. Questions??

