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Cannabinoid Contents and Ratios UNDULATE Throughout Hemp's Growth Cycle, and

Expediting the Degradation of THC to CBN via Natural and Genetic Research

The requirement of 0.3% THC by weight for Industrial Hemp is difficult to manage and attain. Individual cannabinoid densities/ratios undulate throughout the cannabis plant's life or growth cycle. The vegetative state ranges from the seedling to the beginning of flowering. The "veg" state lasts approximately 8 weeks, while the final flowering stage lasts approximately 8 weeks. Segments of the vegetative growth phase include the seedling, teen, and pre-flower.

There are approximately 130 cannabinoids produced within the cannabis plant. The two most common cannabinoids in Industrial Hemp are CBD and THC, followed by the minor or "micro" cannabinoids of CBG, CBN, CBC, THCV, CBDV and more. Genetics are the leading determinant of cannabinoid presence and percentage by overall weight in the plant. However, it has become very clear that the cannabis plant is one of the most adaptive plants found in nature. Thus, the natural environment (previous crop, soil biome, soil type, water pH, ambient temperatures, rainfall vs. irrigation, pestilence, viruses, bacterium, and much more) that the Industrial Hemp plant is grown in can profoundly affect the epigenetics (<https://phys.org/news/2013-03-epigenetics-unveils-environments-world.html>) of the plant; thereby, dramatically altering the plant's individual content cannabinoid content. For example, Apothio has been awarded a U.S. patent affecting the natural selection, of genetics and epigenetics of cannabis via aquaponics, natural biomes, and weather conditions to naturally raise or lower key cannabinoid contents, especially THC and CBD.

Another citation supporting similar findings from agroclimatic changes in humidity, rainfall and sun exposure had significant effect upon the THC levels produced within the Industrial Hemp plant. Sikora, Vladimir & Berenji, Janoš & Latković, Dragana & Berenji, Janos & Dragana, Latkovic. (2011). *Influence of agroclimatic conditions on content of main cannabinoids in industrial hemp (Cannabis sativa L.)*. Genetika. 43. 10.2298/GENSR1103449S. 2011): Influence of agroclimatic conditions on content of main cannabinoids in industrial hemp (Cannabis sativa L.)-Genetika, Vol 43, No. 3, 449 -456. Per this article's Abstract: "In a six-year field experiment eight industrial hemp varieties were examined for Δ^9 -tetrahydrocannabinol (THC) and cannabidiol (CBD) contents. The study analyzed the influence of growing degree days (GDD), soil temperature at 5 cm, air humidity, and growing season precipitation on the levels of the main cannabinoids in this crop. Agroclimatic conditions do not influence THC and CBD contents in industrial hemp in the same way. THC synthesis and accumulation are under the significant positive influence of GDD and air humidity and under the negative influence of precipitation, while soil temperature at 5 cm has no significant effect on it. Soil temperature at 5 cm has a significant positive effect on the CBD content, as do GDD. Precipitation has a negative influence on the CBD content of industrial hemp, while air humidity has no influence on it".

Since Industrial Hemp became federally legal to research in February 2014, Apothio has closely mapped the undulation of both CBD and THC grown within the Hemp plants. For example, the data below is collected in 2019 from an Orange Optics *"Light Lab"* Chromatograph. The following offers summary data demonstrating statistically significant undulations of both CBD and THC, as well as the CBD to THC ratios throughout the plants' growth cycles. This observation is concerning as the guidelines for Industrial Hemp testing begin to emerge from the State of California. These guidelines assume that the Delta-9 THC level (% by mass) is linear throughout the plant's life, and this assumption is completely incorrect. The THC content undulates up and down for more reasons than anyone can currently define. Thus, ensuring that the Delta-9 THC level remains below 0.3% at all stages of the plants' lives will require good planning and a significant amount of luck. Based upon Apothio's experience as a California Industrial Hemp Research, Development and Commercialization Institution, our research Team has also learned that there are additional concerns to understand when testing for Delta-9 THC:

- Who is performing the tests? Historically, the cannabis testing labs have done a very poor job in testing accuracy, reliability, and consistency for both Industrial Hemp and Marijuana testing. Some of the reasons observed for poor testing outcomes are:
 - Training protocols of those performing the test from the field all the way to the laboratory really matter.
 - Mishandling of the plant material adversely affects outcomes.
 - Contamination of the testing equipment from previous laboratory tests.
 - What type of machinery is being used to test the plant material? For example, gas chromatography artificially increases the natural THC content by about 15%. uHPLC has emerged as superior cannabis testing equipment.

Summarily, we agree that Industrial Hemp must have a testing protocol to ensure that the plants' Delta-9 THC must remain 0.3% by mass. However, as the industry emerges in California and nationwide, Apothio strongly urges those creating the rules and applying the tests to proceed with common sense and caution. Admit that nature thrives on variability, and the 0.3% THC content can be monitored in the field, while fully managed in the laboratory.

Any high quality laboratory can manage a field of Industrial Hemp to ensure that all byproducts sold from that field never exceed 0.3% THC content. This can be consistently achieved through good genetics, cultivation, extraction and laboratory practices; such as:

- Extraction techniques that reduce, dilute or eliminate THC concentration,
- The blending and/or dilution of higher THC concentrates into lower THC concentrates.
- More importantly than THC mitigation in the extraction/laboratory is the mitigation of herbicides, pesticides, and heavy metals. Again, technology ensures that the farmer can sell his or her Industrial Hemp crops.

These are the most practical and immediate concerns for Kern County and its Farmers.

Chromatographic Examples of Hemp Clones and Cannabinoid Undulations:

Changes in CBD to THC Ratios Throughout the Plants' Growth Cycle:									5/15/2019
Parent Plant's Name	Fem	Male	From 2018 Seed	Clone	CBD:THC Ratio	CBD %	THC %	Stage	Test Date
#1191 Clone	X		X		5 to 1	1.10%	0.22%	Teen	4/9/2019
#1191 Clone	X		X		37 to 1	0.37%	ND	Veg	11/9/2018
Feminized KY Cherrywine Plant #2	X		X		5 to 1	1.10%	0.23%	Pre-Flwr	5/15/2019
Feminized KY Cherrywine SD #2	X		X		200 to 1	2.00%	ND	Veg	4/19/2019
Smk NA #525		X	X		6 to 1	93.00%	0.15%	Teen	9/16/2018
Smk NA #525		X	X		129 to 1			Veg	10/28/2018
2018 Stenderup Plant #8 Test 4	X		X		8.3 to 1	1.25%	0.15%	Teen	5/13/2019
Plant #8 (Big Stenderup/Carlos)	X		X 2018 Farm		45 to 1 (2 tests)	0.45%	ND	Veg	3/15/2018
Carlos Broken Branch	X		X		9 to 1	0.97%	0.11%	Veg	7/27/2018
UK 205 Carlos Broken Branch	X		X		100 to 1	1.00%	ND	Veg	7/1/2018
NA-OG #104 (3 tests total)	X			X	10 to 1	1.20%	0.12%	Veg	7/28/2018
NA-OG #104 (3 tests total)	X			X	110 to 1	1.10%	ND	Veg	6/1/2018
Smk NA # 81 (CBN Male)		X	X		1.6 CBN:1.0 CBC	0.18% CBN	0.11% CBC	Veg	11/9/2018
Smk NA # 81 (CBN Male)		X	X		0.46 CBN: 1.0 THC	0.11% CBN	0.24% THC	Veg	8/14/2018
"Ditto" (CBN in the Female Plant)	X		X		0.44% CBD:0.53% CBN			Veg	10/28/2018
"Ditto" (CBN in the Female Plant)	X		X		1.32% CBD; "ND" THC or CBN		(Post-Flwr)	Re-Veg	5/23/2019
"Teddy" (Unk 160 No Tag #1)		X			CBC only	"ND" CBD	"ND" THC	Veg	3/26/2019
"Teddy" (Unk 160 No Tag #1)		X			0.67% CBC	"ND" CBD	0.49% THC	M-Flwr	5/23/2019

Expediting the Degradation of THCA to CBN via Natural and Genetic Research

Historical data demonstrates that the THCA/Delta-9 THC concentrations in the plant begin to significantly increase in the Industrial Hemp plant during the teen phase, while CBDA/CBD begins to concentrate the most during the final flowering phase.

Of great importance from within Apothio's Industrial Hemp genetics, if these cannabis plants are allowed to continue growing into the latest phases of mature flowering, the THCA will degrade to Delta-9 THC, and the Delta-9 THC will degrade to the non-psychoactive cannabinoid, CBN.

Summarily, by law the Industrial Hemp plant has a maximum allowable content by weight of 0.3% Delta-9 THC content, which equates to 0.35% content by weight of THCA. THCA's conversion rate to Delta-9 averages 87% within the plant. There are two ways for the THCA/Delta-9 THC content will reduce in the mature flower of the Industrial Hemp plant.

The first mechanism of THC reduction in the plant is through natural, environmental, chemical degradation of THC to CBN (Cannabinol). Chemical degradation of Delta-9 THC happens to all cannabis plants. In this case, because of heat, oxygen, and sunlight, Delta-9 will slowly,

naturally degrade to the non-psychoactive CBN. Over the past 5 years of Industrial Hemp research, Apothio has learned that there appears to be an “innate process or stabilizing molecule” in the plant that slows and reduces the rate of degradation of Delta-9 THC to CBN. Through natural genetic selection, Apothio has worked to reduce or eliminate the production of this THCA/Delta-9 THC “innate process or stabilizing molecule” throughout the plant’s life cycle. In other words, Apothio is researching the ability to grow Industrial Hemp plants that allows any THCA/Delta-9 THC produced by the plant to quickly degrade from THCA to Delta-9 THC to non-psychoactive CBN during the plant’s growth cycle. Thus, every field of Industrial Hemp planted by Apothio includes this research project. Through objective data, Apothio has found that the THCA to Delta-9 THC to CBN research protocol is working. Apothio has found within its broad experience and portfolio of Industrial Hemp genetics that the longer the Industrial Hemp plant is allowed to grow and mature in the field, the lower the THCA/Delta-9 concentration within the plant becomes. As demonstrated in the above chart, Apothio has a series of male plants that completely convert the THCA to Delta-9 to CBN within the plant long before the plant reaches maturity. The female plant is more difficult to influence within this category; however, Apothio have found several female varieties that also accelerate the chemical and internal degradation of THCA to Delta-9 to CBN.

Combining the two pathways of “natural” and “genetic” THC degradation makes the research project worthy, every field growing Apothio’s Industrial Hemp is a research site per state and federal guidelines, while also improving the chances that every Apothio plant growing is a safer plant the longer it grows in the fields.

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