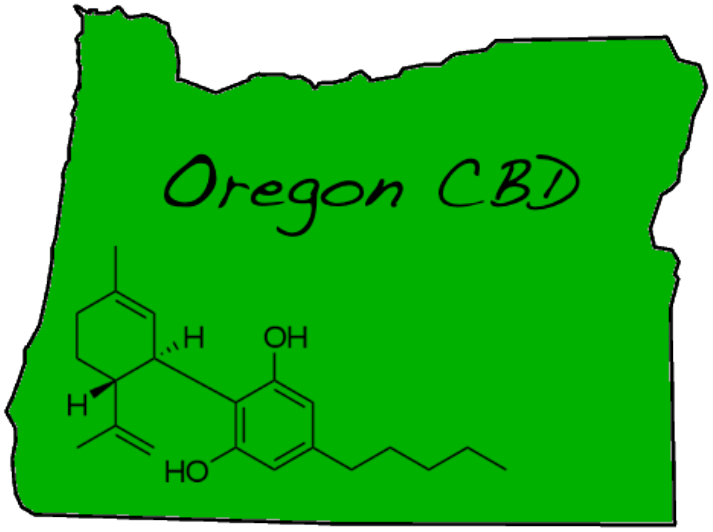

Feminized Seed and the Ethics of Cannabis Farming

A Jack Hempicine LLC Company

Feminized Seeds and the Ethics of Cannabis Farming

Question: You advertise "feminized seed". How is this different from "regular" (male / female) seed? What are the advantages of all female seed? Will I get hermaphrodites with your product?

Answer: In 2017 (and beyond), we only offer seed that will produce female plants. This is made possible by using a chemical reversal process on a targeted female plant to produce viable pollen, which is then used to pollinate other female plants in a controlled environment[1]. Because there are only female sex chromosomes to contribute in these pairings, all resulting progeny are female. There is no increased risk of hermaphrodites when using properly bred feminized seed compared with regular seed or growing from clone. We do this to maximize per acre yields, minimize labor costs, and, critically, to reduce the risk of cross-pollinating neighbors. This brief white paper provides data-driven conclusions on cross-pollination concerns, describes the financial benefits of feminized seed for farmers, and explores our process of producing feminized seed.

I. *Cannabis* Cross Pollination

The possibility of cross-pollinating another farmer's crop provides the most critical reason for exclusively using feminized seed. Cross-pollination (or simply pollination) is one of the most economically damaging events that can occur in cannabis farming if the goal is to produce seedless flowers or pure seed for planting. Oregon had its first major taste of this phenomenon in the 2016 production season, costing recreational growers, medical growers, and other hemp farmers (including us) in the Willamette valley millions of dollars in lost revenue. Despite this calamity and the severe risk of repetition, there are still no laws, policies, or agency rules in place to address *Cannabis* cross pollination concerns—which means that the industry must self-regulate for now. To effectively self-regulate, all *Cannabis* farmers must be educated on the potential impact of pollen.

The previously accepted science on *Cannabis* pollen travel was presented to the Oregon legislature in 2015 while discussing coexistence between new hemp farms and existing medical / adult use. In these discussions, researchers from Oregon State University presented the standards adopted by Canada's hemp industry for seed production in their recommendations for isolation distances between *Cannabis* farms, while noting that existing science had demonstrated pollen travel distances of up to 7 miles[2]. To meet the highest purity designation in Canada ("foundation seed"), individual varieties must be at

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[1] See Ram, Mohan and R. Sett. 1982. "Induction of fertile male flowers in genetically female Cannabis sativa plants by silver nitrate and silver thiosulphate anionic complex." *Theoretical Applied Genetics*. 62(4): 369-75.

[2] See Dr. Russ Karow's 2/23/15 testimony to the Oregon legislature's Committee on Implementing Measure 91. https://olis.leg.state.or.us/liz/2015R1/Downloads/CommitteeMeetingDocument/48208

least 3.1 miles away from any other hemp farm[3]. Industry expert Andrea Hermann (and my former colleague at OSU) suggested that hemp production with regular seed should be isolated from other cannabis farms by at least 10 miles[4]. During this time, I testified that the existing *Cannabis* production sector was too socially and economically important to allow unregulated hemp grows to sprout throughout the state; I suggested that hemp license holders should be limited to growing female clones or using feminized seed west of the Cascades unless they could demonstrate that their activities would not deleteriously impact other *Cannabis* farmers. Our calls for oversight on this issue went unheeded in 2015 and set the stage for problems in 2016.

One male plant in a back yard or a single hermaphrodite in a field does not pose significant risk of cross pollinating other crops (more on this in a bit); however, the 2016 season demonstrated that the dense concentrations of males used in grain or fiber production have the potential to travel very large distances in either direction from a pollen pollution point source. We collected data on one farm in particular that was responsible for a massive pollination event near our R&D facility; the owner planted over 38 million regular seeds on 75 acres (see Figure 1 in Appendix A). The resulting field produced pollen that reached other farms as far as 14 miles away, contaminating at least 3 separate OLCC licensed adult-use grows, dozens of medical grows, countless adult use personal grows, and ten other hemp farms (including two of ours) in the valley. We were able to confirm this pollen source as the contaminant because the seed used to plant this large farm turned out to be low cannabinoid, but high THC (meaning it was <u>not</u> industrial hemp, a fact confirmed after the (ir)responsible farmer failed ODA compliance testing); the resulting seeds it created in other farmers' true hemp plants all had CBD to THC ratios of 1:1 and grew like a fiber crop. The seed vendor did not test the seed before selling and neither did the farmer before broadcasting this ticking time bomb into the soil. Both parties share moral culpability for the damage wreaked in this situation.

After hearing other horror stories from growers around Oregon, we are convinced this was not an isolated incident. Identical seed was planted in several locations around the state with similar outcomes (and also led to crop embargo by ODA due to high THC content). Additionally, many first-year hemp farmers who planted regular seed unwittingly left males in their fields, some purposeful and some on accident. In some cases these males were from legitimate hemp crops, while others were derived from varieties that failed ODA THC compliance tests because they were not hemp. Upon close examination of cross-pollination potential, all but a handful of the hemp farmers who are selling seed for 2017 derived from their 2016 outdoor crops sit squarely in contamination zones where male plants were used outdoors (see Figure 2 in Appendix A). The only way to guarantee that a crop was not contaminated by rogue male pollen is to grow out hundreds of plants and test each one—if other seed vendors are not doing this

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[3] While 3.1 miles is enough distance to prevent *significant contamination* (> 5%) of a <u>seed</u> crop by other seed producers (simply due to the proximity and heavy pollen load of males), it is not a large enough buffer to prevent pollination entirely.

[4] See the discussion by Joy Beckerman at:
http://www.marijuanaventure.com/myths-realities-hemp-cross-pollination/

(to our knowledge, they are not—as a buyer, you should definitely ask!), unacceptable risk is placed on farmers and the cycle of contamination is likely to continue into another growing season. This is reckless and irresponsible, especially in a state where *Cannabis* is the most valuable agricultural commodity[5].

One final story about the danger of pollination to drive this point home: in the mid-1990s, Spanish air quality scientists were shocked to find high levels of cannabis pollen in their spore traps when collecting data to warn citizens of potential allergens during the late summer[6]. They traced the pollen back to Morocco (a prolific hash producing nation) and tracked its dispersion across Spain, demonstrating that it covered over 250 miles of coast line and traveled over 100 miles inland—after crossing 25 miles of open water on the Mediterranean sea. This incredible distance was made possible by very dense plantings, dry summer conditions, and strong prevailing winds, but the collected data (6 years worth) and subsequent peer-reviewed paper demonstrated that pollen traveled hundreds of miles in each year of the study[7].

While the legal ramifications have yet to be fully worked out on this issue, agricultural attorneys have suggested that hemp farms who pollinate others are likely liable due to the fact that their activities are grossly negligent and meet the definition of an "ultra-hazardous farming activity"[8]. Proving liability is possible through modern genetic sequencing and costly legal battles; guilty parties could be on the hook for those expenses if fault is demonstrated. With millions of dollars flowing into Oregon from out of state investors looking to cash in on our adult use legalization, we are convinced that negligent hemp farmers will be held accountable in the 2017 season if they destroy the value of anyone's crop.

In short, we support responsible hemp grain production and the individuals engaged in that subsector, but it produces a low-value commodity compared to phytocannabinoid farming; furthermore, it precludes any farmer within a 15-mile radius from growing seedless flowers, thereby excluding the majority of Oregon *Cannabis* farmers from meaningful economic activity. This is simply unacceptable. Hemp farming with regular seed is ethically questionable west of the Cascades due to the severe hazard it imposes on neighbors and a very risky enterprise for farmers due to the lack of contaminated seed offered in Oregon. Unless you are farming a very small plot and have unlimited resources at your disposal, a field of regular plants are likely to release pollen and contaminate other farms. Even if you are in a secluded location—i.e. more than 15 miles away from any other cannabis producers—you still run the risk of planting contaminated seed and failing your ODA THC inspection by using unverified regular seed. If we are

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[5] Details on farm-gate value of Oregon Cannabis market described here: http://www.capitalpress.com/Oregon/20150331/osu-expert-says-skilled-farmers-would-swamp-pot-market

[6] See Marlise Simmons' article in the New York Times here: http://www.nytimes.com/1995/06/18/world/signs-in-wind-of-morocco-drug-crop.html

[7] Cabezudo, Baltasar, Marta Recio, Jose Sanchez-Laulhe, Maria Del Mar Trigo, Francisco Toro, and Fausto Polvorinos. "Atmospheric Transportation of Marihuana Pollen From North Africa to the Southwest of Europe." *Atmospheric Environment*. 31(20): 3323-3328.

[8] Applicable Oregon case law is found in *Koos and Koos v. Roth* (1981).

going to grow Oregon's nascent hemp industry into a national leader of cannabinoid production, irresponsible seed vending and farming practices like this must cease.

II. Financial Benefits to Farmers

Outside of respecting other farmers' right to grow, the most obvious benefit of feminized seed is that it essentially doubles the productivity of an acre of farmland by reducing the number of non-useful plants (i.e. males) from 50% to 0%—every plant is female and therefore useable. Furthermore, by eliminating males from your field, females will produce significantly larger yields and contain higher average cannabinoid content than they would if pollinated. Our experiments during the 2016 season indicate that a fully pollinated flower crop is about 40% seed by weight and contains 30% less cannabinoids overall. Additionally, farmers do not have to "rogue" males from the field; this is a time consuming, labor intensive process which must be completed within a 2 week period and with 100% accuracy after regular plants (male / female) show sex, otherwise males will drop their pollen and taint the entire crop (1 true male is enough to heavily pollinate an acre of females) and destroy the value of your flowers. On a small scale, pulling males is expensive and/or time consuming; on a large scale, it is simply impossible to accomplish with enough accuracy to be a worthwhile endeavor. In short, feminized seed allows farmers to increase their bottom line by at least 130% per acre and produce a much higher quality product, while simultaneously minimizing labor costs and foregoing the intensive process of cloning tens of thousands of plants for field production (which we discuss in our 2017 seed catalog).

III. Hermaphrodites in Feminized Seed—Is it a Problem?

Cannabis has an XX/XY chromosomal sex determining system, which is rare in the plant world[9]. True female plants (XX) can be easily and rapidly identified using qPCR techniques[10] for use in feminized breeding projects; when true females are combined for seed production, the resulting progeny are 100% female. The major concern of most farmers regarding feminized seed stems from the belief that rates of hermaphrodites—i.e. plants with both male and female reproductive organs—will increase. This is simply false when proper breeding techniques are used, though we must distinguish between hermaphrodites (genetically determined intersex plant) and hermaphroditism—the former can be selectively removed from gene pools while the latter is a condition that can affect any female plant when stressed. All things being equal, the rate of hermaphroditism appearing in a field of plants is the same with regular seed, feminized seed, or clones. The exponential increase in Oregon *Cannabis* farm size in the past two years has allowed us to collect the data necessary to demonstrate this point.

Hermaphroditism naturally occurs in *Cannabis* populations, though female plants generally remain pollen-free as long as environmental conditions are favorable. Periods

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[9] See Divashuk, Mikhail, Oleg Aleandrov, Olga Razumova, Ilya Kirov, and Gennady Karlov. 2014. "Molecular Cytogenic Characterization of the Dioecious *Cannabis Sativa* with an XY Chromosome Sex Determination System." *PLoS ONE*. 9(1): e85118.

[10] See http://www.medicinalgenomics.com/sex-testing-validation-data/

of stress caused by water management issues (drought or overwatering), nutrient availability, animal predation, temperature fluctuations, darkness interruption, or simple senescence at the end of the season can be enough to cause females to sport viable male flowers in an attempt to make seed. 28 million years of *Cannabis* evolution has led to the development of very robust reproduction strategies! In short, it is not surprising to see the occasional true female plant attempt to self-pollinate regardless of how it was propagated (seed vs. clone); our data suggests that around 1 in every 2000 plants in a field (1 per acre using our recommended planting strategies) will show hermaphroditic tendencies. This is a small enough problem to defuse by maintaining good field conditions and performing regular visual inspection of plants.

In 2015, we planted 1500 identical female clones on 3.5 acres. Of these clones, only one showed signs of hermaphroditism and, luckily, it was sterile (see Figure 3 in Appendix A). We expanded in 2016 to six different farm sites around Oregon and used both clones and seed to produce our plants. Data in Table 1 show that, over this 2-year period in diverse environments, 0.05% of our female plants used in production—whether grown from clone or seed—sported male flowers and had to be removed.

Table 1.

Rates of Hermaphroditism in Industrial Hemp (2015-16)

County	Type	Propagation Method	Plant Count	Hermaphroditic *n*
Benton	Field	Clone	1500	1
Benton	Field	Seed	22,450	12
Clatsop	Field	Clone	144	0
Josephine	Field	Clone	193	0
Lane	Field	Seed	4000	2
Polk #1	Field	Clone	724	0
Polk #2	Greenhouse	Seed	1500	1
Total			**30,511**	**16**

In short, we are confident that our seed will perform similarly to female clones and/or regular seed in terms of hermaphroditism occurrence; our field trials suggest that, on average, 1 out of every 2000 female plants will produce male flowers at some point during an outdoor growing season, generally in response to localized environmental stress. Growers must remain vigilant to this possibility, particularly during hot / wet spells, at the commencement of flowering, and nearing harvest, regardless of their plant propagation strategy.

IV. Our Feminized Seed Production Process

We use Ram and Sett's (1982) research on the reversal of female *Cannabis* plants to induce pollen production using silver thiosulfate (STS). STS is registered for use as a pesticide in many countries, though its primary use is in the cut flower industry to keep recently harvested plants alive and more vibrant before sale. The EU conducted a large-

scale study of STS toxicity study in 2013 and concluded that it poses no risk to mammals and low risk for other organisms[11]. In feminized *Cannabis* seed production, its application to a female plant halts ethylene production and results in the formation of male flowers. We use this technique to reverse targeted female plants in climate and light controlled greenhouses, then collect pollen on fine-mesh screens (see Figure 4 in Appendix A). If properly stored, this pollen can last years! We only use STS in a controlled environment, use appropriate safety precautions, and discard all plants sprayed after collecting pollen.

We utilized three separate farms in very different ecotypes to generate our 2017 production seed. Our "50/50" series was produced outside of Astoria on the Oregon coast using pollen collected from our MGO line; prevailing winds push east and prevent any contaminated air from the Willamette valley to touch receptive females. This site was 44 miles from the nearest hemp farm. Our "Early" series was produced in the mountains of southern Oregon (see Figure 5 in Appendix A), 21 miles from the nearest hemp farm, using pollen from our reversed SMGO line. We produced an additional 15 million seeds at our Willamette valley R&D facility last summer using light deprivation techniques and pollen from our MGO line as well (see Figure 6 in Appendix A); however, this seed was contaminated by the above-mentioned hemp farm and was a total loss. Unlike other seed vendors, we refuse to sell a tainted product. To maintain purity, we now only produce seed in the Willamette valley during the winter when no external pollen sources exist to contaminate our crops and closely monitor other hemp sites that are within 20 miles of our secondary seed production sites in Clatsop and Josephine counties to ensure they are only growing female plants.

[11] See the full study here: http://onlinelibrary.wiley.com/doi/10.2903/j.efsa.2013.3136/epdf

Appendix A

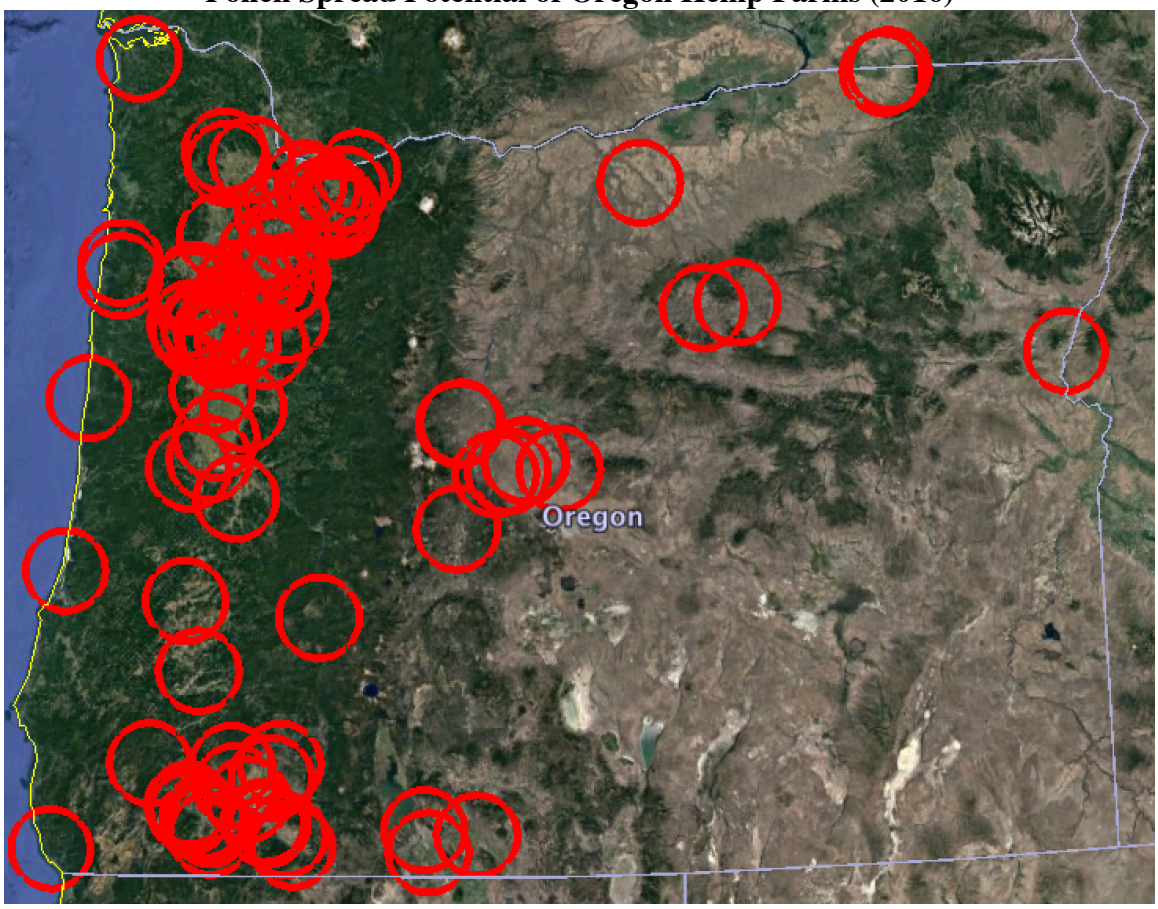
Figure 1.

The Willamette Valley's Pollen Source

Here's the 75 acres planted four miles up the road from our R&D facility and that decimated other *Cannabis* producers throughout the Willamette valley in 2016. Most of the pollen had dropped at this point in the summer. This farm failed ODA testing, as these plants were 6:1 THC to CBD—not hemp! We love hemp and will continue to champion it because of its incredible usefulness—healthy food, strong fibers, and healing compounds abound! That said, not all of those uses are compatible; fiber and grain production preclude the possibility of growing for healing compounds by destroying the yield and content of cannabinoid producing flowers.

Figure 2.

Pollen Spread Potential of Oregon Hemp Farms (2016)



The picture above highlights how potentially disastrous Oregon's nascent grain and fiber hemp industry could be to seedless *Cannabis* producers. The red circles provide a visual representation of the established 14-mile data-driven "danger zone" around each hemp farm location registered with ODA in 2016. If each of these farms grew for grain or fiber, it would be virtually impossible to grow seedless *Cannabis* west of the Cascades. We heard very few reports of pollination events in southern Oregon, while the Willamette valley was decimated from south Benton county to the Washington state line.

Figure 3.

2015 Field Production Clone Sporting Sterile Male Flowers

As any indoor grower can attest, growing from clone is definitely not a guaranteed way to eliminate hermaphroditism. Female clones can sport male pollen sacks when exposed to stress, and some do so regularly as they senesce. Of 1500 identical clones grown on 3.5 acres in 2015, this was the only one that produced male flowers. It had been attacked by rabbits, flooded by broken irrigation mains, and had a flashlight directed at it for a few seconds one night.

Figure 4.

Collecting Female Pollen

After chemically reversing our target female plant during flowering, we manually remove flower clusters and sieve out viable pollen using a fine mesh screen. The pollen is then packaged and refrigerated, ensuring long-term viability and faithful reproduction of our seed lines. We prefer to pollinate receptive females by hand using makeup brushes. It is incredibly tedious, but ensures high pollination rates and optimal seed set timing in our greenhouses and isolated production fields.

Figure 5.

Mountain Grown Seed:
The "Early" Series, Responsibly Produced in Remote Josephine County

We completed a really big family project this season on top of a mountain in rural Josephine county, where our "early" series of seed was produced. Female production clones (Special Sauce, Otto II, BaOx, Therapy, and AC/DC) were pollinated by the SMGO line that we have been working on for the last 3 years. Resulting seed is 100% female, has varietal CBD to THC ratio averages ranging from 30:1 to 40:1, is guaranteed to pass ODA THC testing requirements if sampled 30 days before harvest, and will all start flowering in mid-July. We view these seeds as one of our biggest technical achievements of 2016, having identified two separate genetic pathways that can be utilized to control flower timing.

Figure 6.

Light Deprivation Feminized Seed Production in Summer 2016

100% of the seeds produced from this light deprivation production run were destroyed due to contamination from our neighbor. We had a very low contamination rate, but refuse to sell a subpar product that could endanger farmers with (a) males and (b) potentially high THC seeds. We lost 1.5 million seeds out of this greenhouse and are still dealing with the repercussions in our MGO line breeding project.

Keep Western Oregon
Pollen Free in 2017

Just Say No To Males!