Cultivation & Growing

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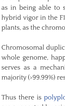
An Introduction to Cannabis Genetics, Part III

By Dr. CJ Schwartz

4 Comments



Dr. CJ Schwartz discusses polyploidy, epigenetics, sex determination and GMOs as they relate to Cannabis.

Polyploidy in Cannabis

Polyploidy is defined as containing more than two homologous sets of chromosomes. Most species are diploid (all animals) and chromosomal duplications are usually lethal, even partial duplications have scientific evidence (Down's syndrome). Plants are unique as in being able to somewhat "tolerate" chromosomal duplications. We often observe hybrid vigor in the F1, while the progeny of the F1 (F2) will produce mostly sickly or dead plants, as the chromosomes are unable to cleanly segregate.

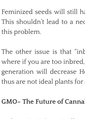
Chromosomal duplications, either one chromosome or the whole genome, happen frequently in nature, and actually serves as a mechanism for evolution. However the vast majority (~99.99%) results in lethality.

Polyploids are generated when chromosomes fail to separate (non-disjunction) during pollen and egg generation. The chromosomes normally exist in pairs, thus having only one, or three, interfere in pairing in subsequent generations.

Thus there is polyploidy in Cannabis, and a few examples are supported by scientific evidence. The initial hybrid may show superior phenotypes and can be propagated through cloning, but there may be little potential for successful breeding with these plants.

Epigenetics and Phenotypic Consistency in Clones

One mechanism of turning off genes is by the DNA becoming physically inaccessible due to a structure resembling a ball. In addition, making molecules similar to DNA (RNA) that prevents expression of a gene can turn off certain genes. Both mechanisms are generally termed epigenetics.



These mice are genetically identical, yet their coat color phenotype is variable. Something above or beyond (epi) the gene (genetic) is controlling the phenotype.

Epigenetic regulation is often dependent on concentrations of certain proteins. Through the repeated process of cloning, it is possible that some of these proteins may be diluted, due to so many total cell divisions and epigenetic control of gene expression can be attenuated and results in phenotypic variability.

Sexual reproduction, and possibly tissue culture propagation, may re-establish complete epigenetic gene regulation, however the science is lacking. Epigenetic gene regulation is one of the hottest scientific topics and is being heavily investigated in many species including humans.

Hermaphrodites and Sex Determination

Cannabis is an extremely interesting genus (species?) for researching sex determination. Plants are usually either monoecious (both male and female organs on a single plant) or dioecious, separate sexes. Sex determination has evolved many times in many species. Comparing the mechanisms of sex determination in different organisms provides valuable opportunities to contrast and compare, thereby developing techniques to control sex determinations.

Cannabis is considered a male if it contains a Y-chromosome. Females have two X chromosomes. Even though female Cannabis plants do not have the "male" chromosome, they are capable of producing viable pollen (hermaphrodite) that is the source of feminized seeds. Therefore, the genes required to make pollen are NOT on the Y-chromosome, but are located throughout the remainder of the Cannabis genome. However, DNA based tests are available to identify Male Associated Sequence (MAS) that can be used as a test for the Y-chromosome in seedlings/plants.

The sex organs on a Cannabis plant identified.

Natural hermaphrodites may have resulted from Polyploidization (XXXY), or spontaneous hermaphrodites could be a result of epigenetic effects, which may be sensitive to the environment and specific chemical treatments.

Feminized seeds will still have genes segregating, thus they are not genetically identical. This shouldn't lead to a necessary decrease in health, but could. A clone does not have this problem.

The other issue is that "inbreeding depression" is a common biological phenomenon, where if you are too inbred, it is bad...like humans. Feminized seeds are truly inbred. Each generation will decrease Heterozygosity, but some seeds (fines) may be unhealthy and thus are not ideal plants for a grower.

GMO– The Future of Cannabis?

Is there GMO (genetically modified organism) Cannabis? Probably, but it is likely in a lab somewhere...deep underground! Companies will make GMO Cannabis. One huge advantage to doing so is that you create patentable material...it is unique and it has been created.

The definition of a GMO is...well, undefined. New techniques exist whereby a single nucleotide can be changed out of 820 million and no "foreign" DNA remains in the plant. If this nucleotide change already exists in the Cannabis gene pool, it could happen naturally and may not be considered a GMO. This debate will continue for years or decades.

Proponents of GMO plants cite the substantial increase in productivity and yield, which is supported by science. What remains to be determined, and is being studied, are the long-term effects on the environment, ecosystem and individual species, in both plants and animals. Science–based opponent arguments follow the logic that each species has evolved within itself a homeostasis and messing with its genes can cause drastic changes in how this GMO acts in the environment/ecosystem (Frankenstein effect). Similarly, introducing an altered organism into a balanced ecosystem can lead to drastic changes in the dynamics of the species occupying those ecological niches. As in most things in life, it is not black and white; what is required is a solid understanding of the risks of each GMO, and for science to prove or disprove the benefits and risks of GMO crops.

cannabis | chromosome | clone | diploid | epigenetics | Focus Article | genetically-modified organism | geneticist | genetics | genotype | GMO | hermaphrodite | hybrid | marijuana | phenotype | phenotypic plant | polyploidy | seed | sex determination | sicentific | tissue culture

About The Author

Dr. CJ Schwartz
Founder and Chief Executive Officer
Marigene

Dr. CJ Schwartz received a BS degree from The University of Minnesota–Twin Cities in Genetics and a Ph.D from University of Wisconsin–Madison in Biochemistry. His post–doctoral research was at the Salk Institute for Biological Sciences in San Diego, CA, where he focused of natural genetic variation of flowering time in plants. As a genetic scientist at UW–Madison, he studied flowering time variation in dedicated bioenergy crops. Dr. Schwartz has over fifteen years of plant genetic variation and gene discovery experience. In 2014, he founded Marigene & Hempgene to provide the cannabis industry with the same high quality genetic research experienced by other high value crops for strain improvement.

Comments

N. Stuart
May 7, 2019 at 11:58 am

Does feminized seeds decrease RNA/DNA strands? I am a MMJ patient and prefer t grow cannabis naturally without altering genetics (using hormones to make all plants /seeds female).

What happens to future generations if cross F1 Fem with ordinary cannabis? Does it weaken it? Is it now GMO cannabis because it was altered?

Reply ↓

DocPromeda
August 14, 2019 at 6:27 pm

Not if feminised parental was turned hermaphrodite by stress not solutions such as colloidal silver, etc. But the consistency in what percentage of seeds produced from a photoperiod plant and the feminised, will be lowered due to this, as in how many will be hermaphrodite or have some genetic mutation

Reply ↓

K
September 16, 2019 at 1:03 pm

Where can i learn more about Cannabis genetics? how can i create a stable strain? Avoiding the F2 problem?

Reply ↓

Dave Boone
December 28, 2019 at 10:55 am

Thank you for the articles. It's been over 25 years since I had a genetics class in college, and the articles are refreshing my memory. That said, I have a question regarding feminized seeds that become hermaphrodites.
I purchased and successfully grew some feminized seeds of the strain AK–47. However, they turned hermaphrodite. None of the seeds produced male plants. My question is, will the seeds produced by the hermaphrodite, have much phenotypic variation from the feminized seeds? That is, will the quality of the plants produced by seeds from the hermaphrodites, be markedly different from the original seeds I purchased?

Reply ↓

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Upcoming Events & Webinars

September 8, 2020 - December 22, 2020
The Cannabis Quality Conference & Expo
With the COVID–19 pandemic continuing to take a toll on live events, Innovative Publishing Company, Inc. has made the careful decision to convert the Cannabis Quality Conference, which historically has taken place in Schaumburg, IL to a virtual conference. Every Tuesday, beginning on September 8 through November 10, the Cannabis Quality Virtual Conference Series will host two presentations and two sponsored Tech Talks, followed by a panel discussion with attendees. The abstract submission portal is open and registration will open soon.