A Study of the Leaf Striping in Barley (*Hordeum vulgare)*

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1 Background, Purpose, and Hypothesis

Gregor Mendel, who is known as the "father of modern genetics", studied variation in plants. From his experiments, Mendel made two generalizations, the Law of Segregation and the Law of Independent Assortment, which later became known as Mendel's Laws of Inheritance. Not long after these laws were put forward, Carl Correns noticed some unique patterns of inheritance in Four O'Clock plants, *Mirabilis jalapa*.[1]

The leaves and stems of some of these plants would occasionally be variegated, showing patches of green and white in a swirl-like pattern, instead of the usual solid green colour. It was also found that a variety of leaf patterns were found on branches within the same plant. Correns performed some cross-pollination studies and noticed that if the seed came from a solid green branch, it never produced variegated progeny, even if the pollen was from a flower on a variegated branch. It was observed that no matter what type of leaf pattern existed on the branch that donated the pollen, the seed would always produce leaves with the colour pattern on the maternal branch. Furthermore, it was found that if the maternal branch was variegated, the progeny would appear as either green, white, or variegated leaves but never in any predictable Mendelian ratio. Correns began to believe that the maternal parent determined the phenotype of the offspring leaf colour.

In order to comprehend this proposed uni-parental mode of inheritance, it is important to understand that a plant's progeny inherit their cytoplasm exclusively from

[1] Miko, I. (2008). Non-nuclear genes and their inheritance. In T. McGuire (Ed.), *Uniparental modes of inheritance* Nature Education. Retrieved from http://www.nature.com/scitable/topicpage/non-nuclear-genes-and-their-inheritance-589

the maternal parent. The cytoplasm is full of cellular organelles, including chloroplasts. Genes inside organelles have their own patterns of self-replication, and when these genes are passed from one generation to the next, it is known as cytoplasmic inheritance.

The pattern of inheritance of the leaf colour in the Four O'Clock plant suggests cytoplasmic inheritance, and that white leaves or any white patches on a leaf are caused by cells that carry a defective gene in their chloroplast DNA. Because non-nuclear inheritance does not follow patterns of independent assortment and segregation, Mendelian ratios were not seen on seeds from the variegated branches. The contents of the cytoplasm and the non-nuclear genes in the chloroplast and mitochondria are squeezed into sub-compartments, at random during cell division in the meristems, and during gamete production in meiosis. In the Four O'Clock plant, this produces some flowers with abnormal chloroplast DNA, and others with a mixture of the normal and abnormal chloroplast DNA. It is the egg cells with the normal chloroplast DNA that develop into green progeny, while the abnormal DNA develop into white progeny. The egg cells carrying a mixture of normal and abnormal chloroplast DNA develop into variegated progeny. Therefore, in Four O'Clock plants, the chloroplast genome is transmitted through the maternal parent, and therefore, maternal inheritance plays a major role in the variegation of plants.[2]

The majority of research on cytoplasmic inheritance has been performed with the Four O'Clock plant. For this investigation, the impact of cytoplasmic DNA on chloroplast striping in barley leaves was studied. The purpose of this experiment is to determine

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[2] *Cytoplasmic inheritance*. (2011). Unpublished raw data, University of Toronto, Toronto, Canada. Retrieved from http://www.utm.utoronto.ca/~w3bio/bio207/lectures/cytoplasmic_inheritance.pdf

whether the variegated leaf striping in barley is controlled by the cytoplasmic genome, nuclear genome, or both.

If striping is controlled by chloroplast genes, the progeny whose maternal plant exhibited leaf striping will also exhibit a similar type of leaf striping. If there is a recessive, defective nuclear gene, the striping will only be expressed in the presence of the homozygous, recessive nuclear gene.

2 Procedure

1. A single plant containing stripes was found in a field and brought to the Department of Agriculture at the University of Guelph in September 2011.
2. The plant was brought into the growth room, where it was grown at the appropriate conditions.
3. The plant self-pollinated and the seeds from the self-pollination were planted in the growth room. Most of the plants exhibited stripes like the stripes on the original plant, therefore showing that there was a genetic component to the striping.
4. Twenty-five plants were grown in the growth room.
5. The plants that exhibited the most distinctive striping were used in reciprocal crosses with normal barley as both male and female to determine whether the striping was due to nuclear or cytoplasmic inheritance.
6. Normal plants from the same genetic background as the original plant were used in reciprocal crosses to test chloroplast genes vs. nuclear genes.
7. The self-pollinated progeny were grown to evaluate striping at the same time as the progeny from the crosses.

8. Data was collected to determine if the striping was nuclear or maternal inheritance.
9. Another round of reciprocal crosses were planted to validate data.
10. A portable photosynthesis system was obtained and used to determine the energy production in normal, striped and defective leaves.
11. A BX-51 Olympus microscope was used to determine if there are structural differences between light and dark green sectors on the leaves.

3 Results and Conclusion

The results from the first reciprocal crosses were not what was expected. As stated in my hypothesis, the female striped plants that were crossed with the normal male should have exhibited striping in its progeny; however, it resulted in no striping because it obtained a dominant gene from the nucleus of the normal (male) plant. The use of striped plants as the male also resulted in no striping, as the defective chloroplasts of the female were not transmitted through the pollen. Further crossing is in progress where striped plants were crossed with non-striped plants from the same genetic background.

A portable photosynthesis system was also used to determine the energy production in normal, striped and defective leaves. The results have shown that the normal plants produce the most energy whereas the defective plants produce almost none to no energy; therefore undergoing photorespiration.

4 Acknowledgements

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5 References

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