

AI vs. Eye: Handling Hair Within Automated Grapevine Downy Mildew Phenotyping

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Introduction

Grapevine Downy Mildew is a devastating disease that can cause up to a 60% loss in revenue annually without management (Leroy et al. 2013). Phenotyping for downy mildew disease development allows for identifying resistant grapevines, mapping the genetic basis of resistance, breeding of disease resistant cultivars, and reducing heavy spray regiments (Cornell Grapes).

The purpose of this project was to conduct a quality control analysis of grapevine downy mildew severity measurements obtained using the BlackBird robotic imaging system (Fig 1). The BlackBird system utilizes high-resolution camera, X-Y-Z movement and focusing, and processes images using a convolutional neural network (Sapkota et al. 2025). These results can be used to improve disease phenotyping, quickly screen hundreds of genotypes, and support future grape breeding efforts. Almost 1,000 accessions covering 20 species and diverse hybrid backgrounds were analyzed, which is the most diverse background of grapevines tested by this system to date.

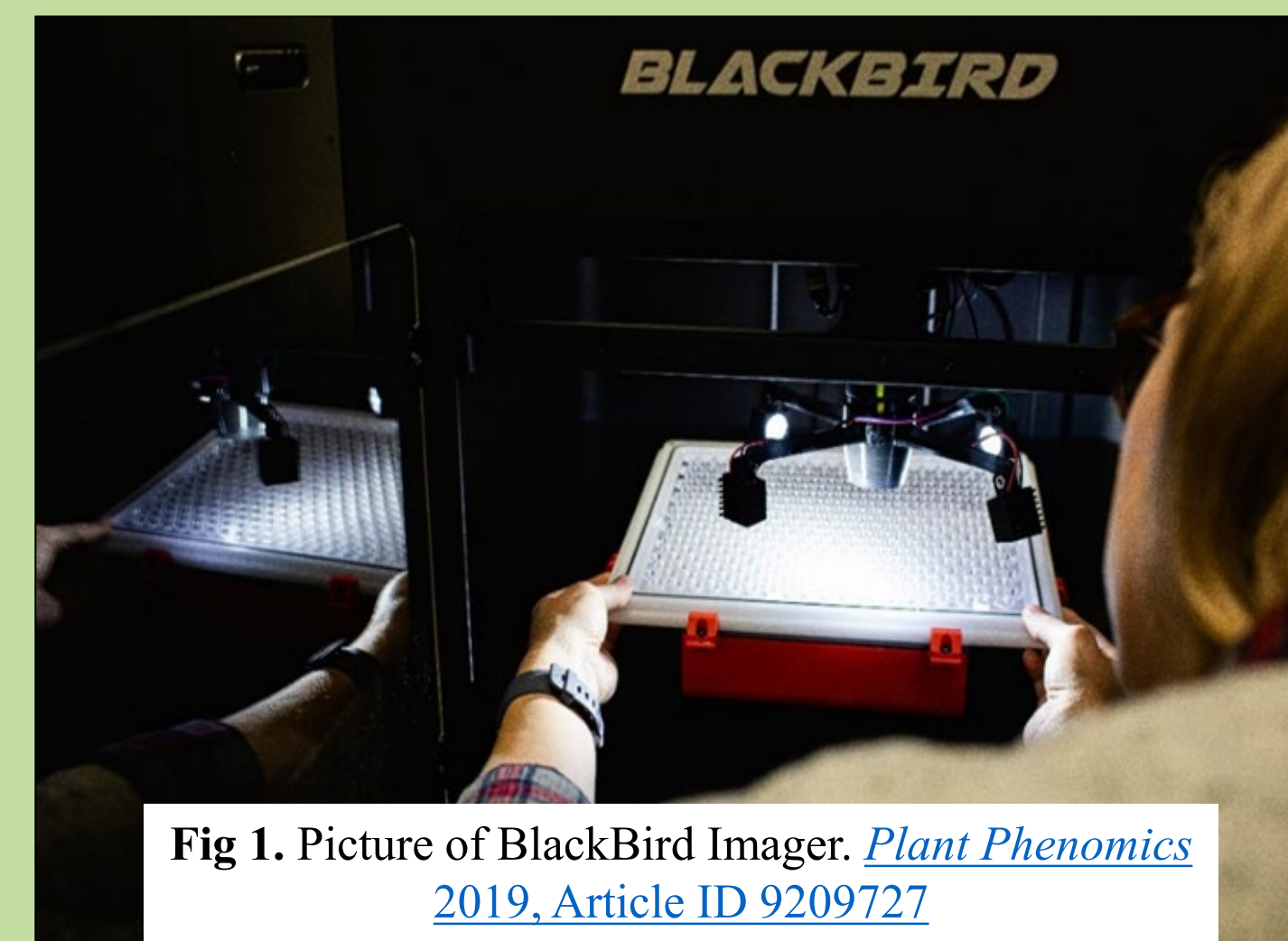


Fig 1. Picture of BlackBird Imager. [Plant Phenomics 2019, Article ID 9209727](#)

Methods

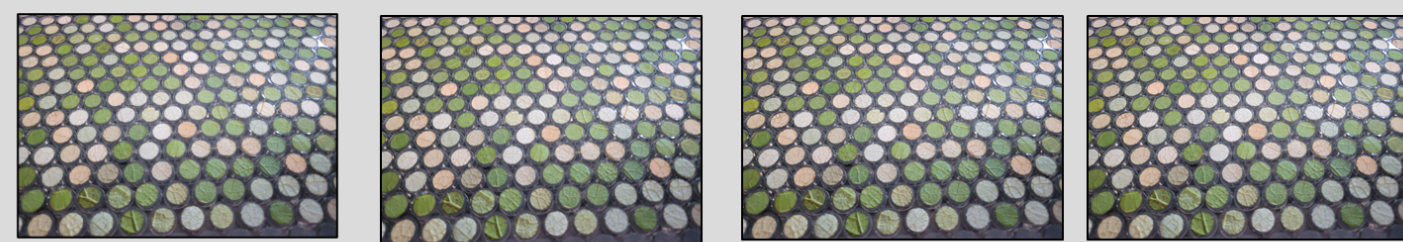
Collect 4 leaves from an accession
(young, shiny = susceptible)



Set up the assay and inoculate!

- 16 replicate leaf discs per accession across 2 experiments, conducted on different dates
- 944 accessions screened in total
- 3 to 5 timepoints (3 to 7 days post-inoculation)
- 60,416 photographed observations

One Experiment, 4 trays, 2 discs per tray, imaged over time



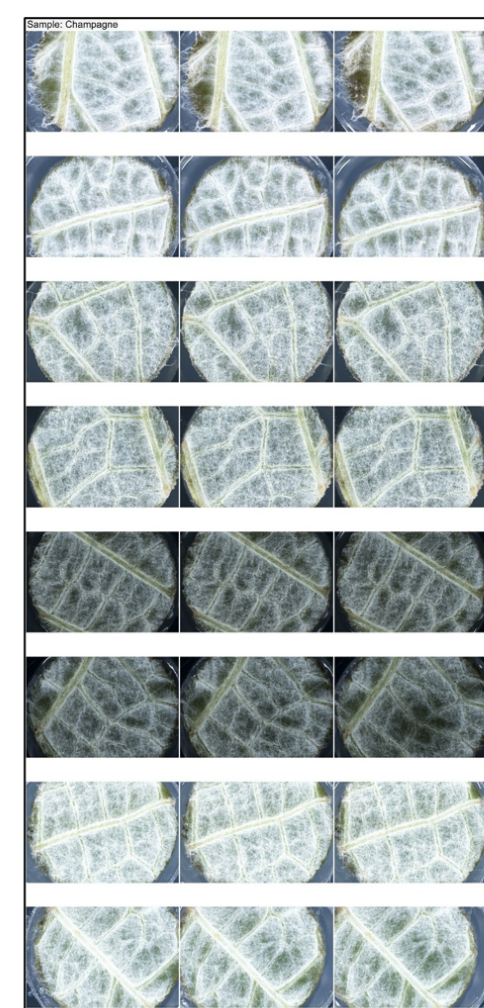
Disease Progress Using AI Image Analysis



- Each pixel = 1.2 μm
- RGB live imaging
- Artificial Intelligence Analysis
- More accurate than manual microscopy

Slide from L. Cadle-Davidson

Validate Data!



Mosaics used to observe characteristics, check leaves are same accession, ensure it's the bottom of the leaf, & check if downy mildew is present.

Python script for flagging disease severity that starts high and drops over time.

Significant Drop: $x > 5\%$ ▼
Small Drop: $0 < x < 5\%$ ▼
All Zeros
No Data: NA
Normal Values: Any ▲

Results

Data analysis red flagged approx. 9% of the samples as not following the expected disease development over time. It was found that leaf hairiness was the predominant driver of red-flagged samples (Fig. 2), substantially obstructing the model's ability to detect downy mildew symptoms on the underside of the leaf surface (Fig. 3).

Fig 2. Categories of image issues found for red-flagged samples. 1,811 replicates were reviewed and some had multiple issues flagged.

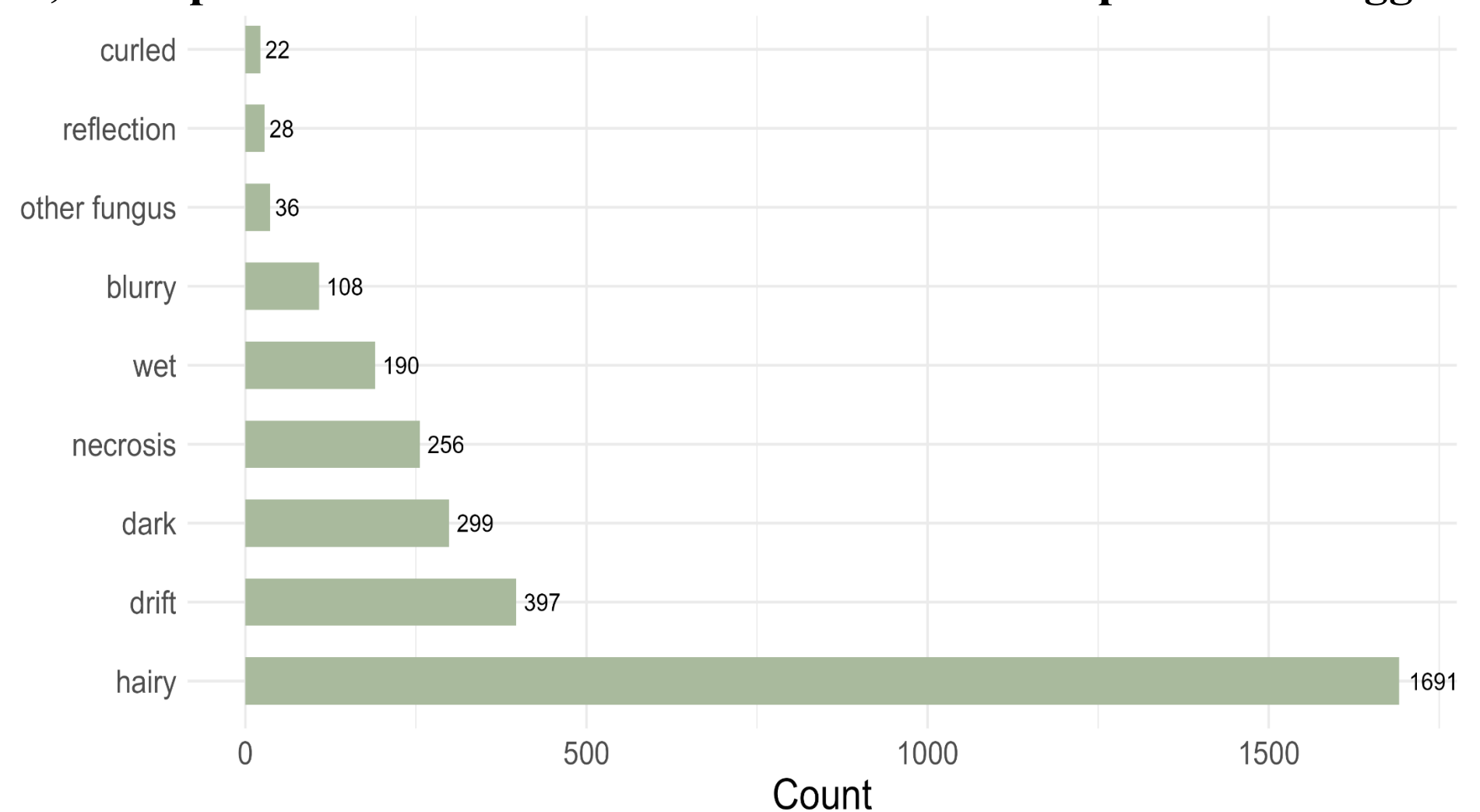


Fig 3. Examples of hairs on the underside of grapevine leaves. *Can you find the downy mildew?*

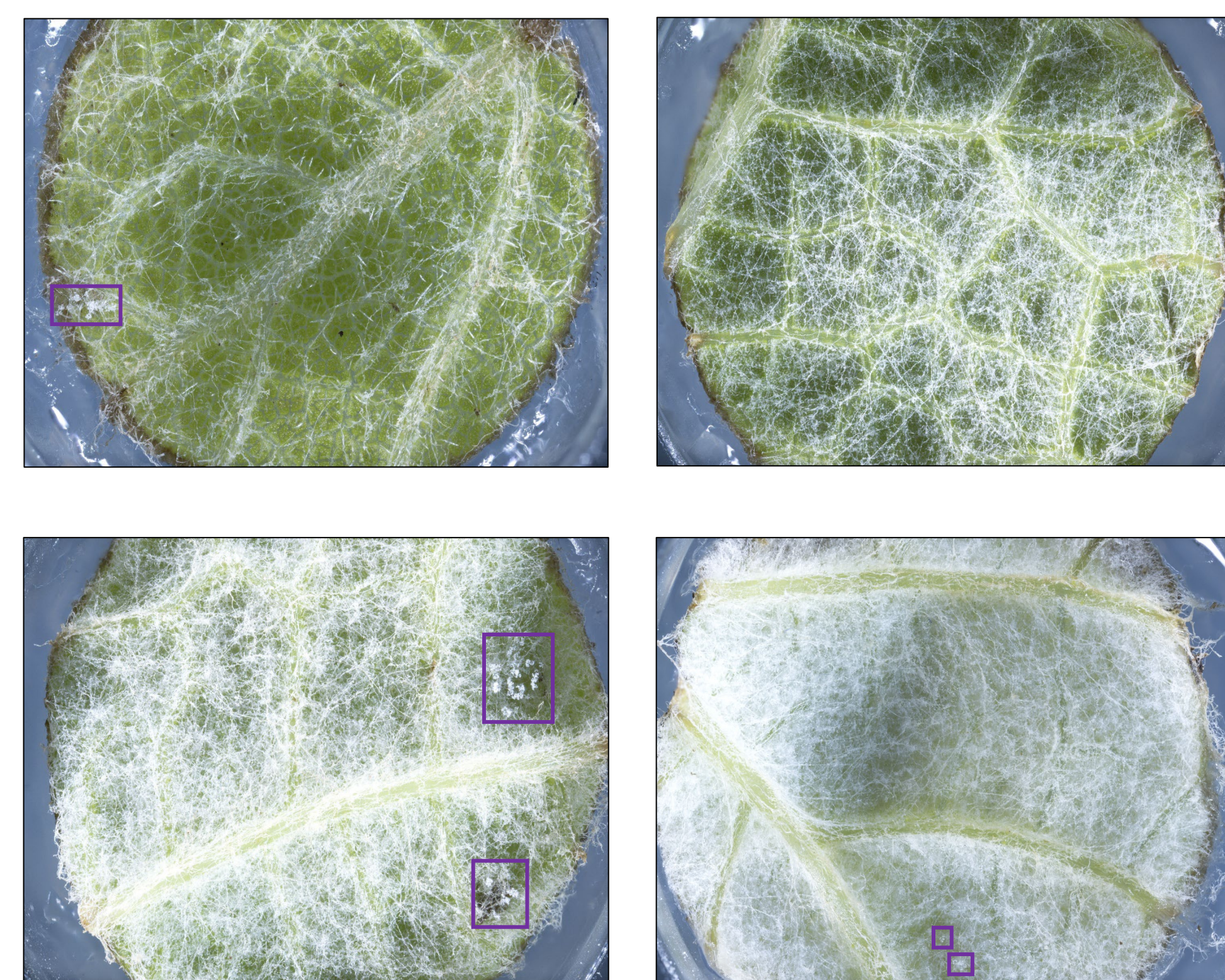
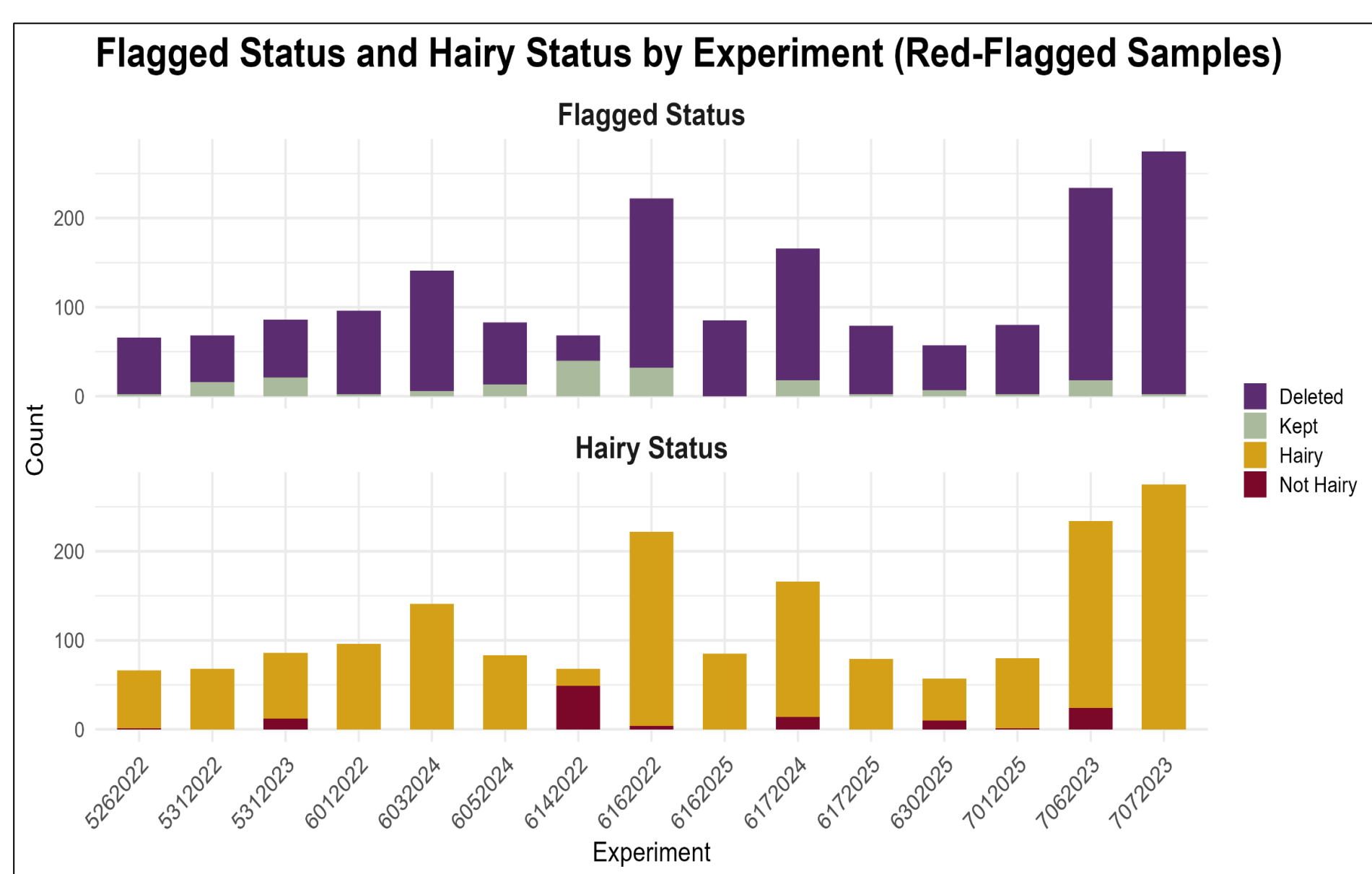


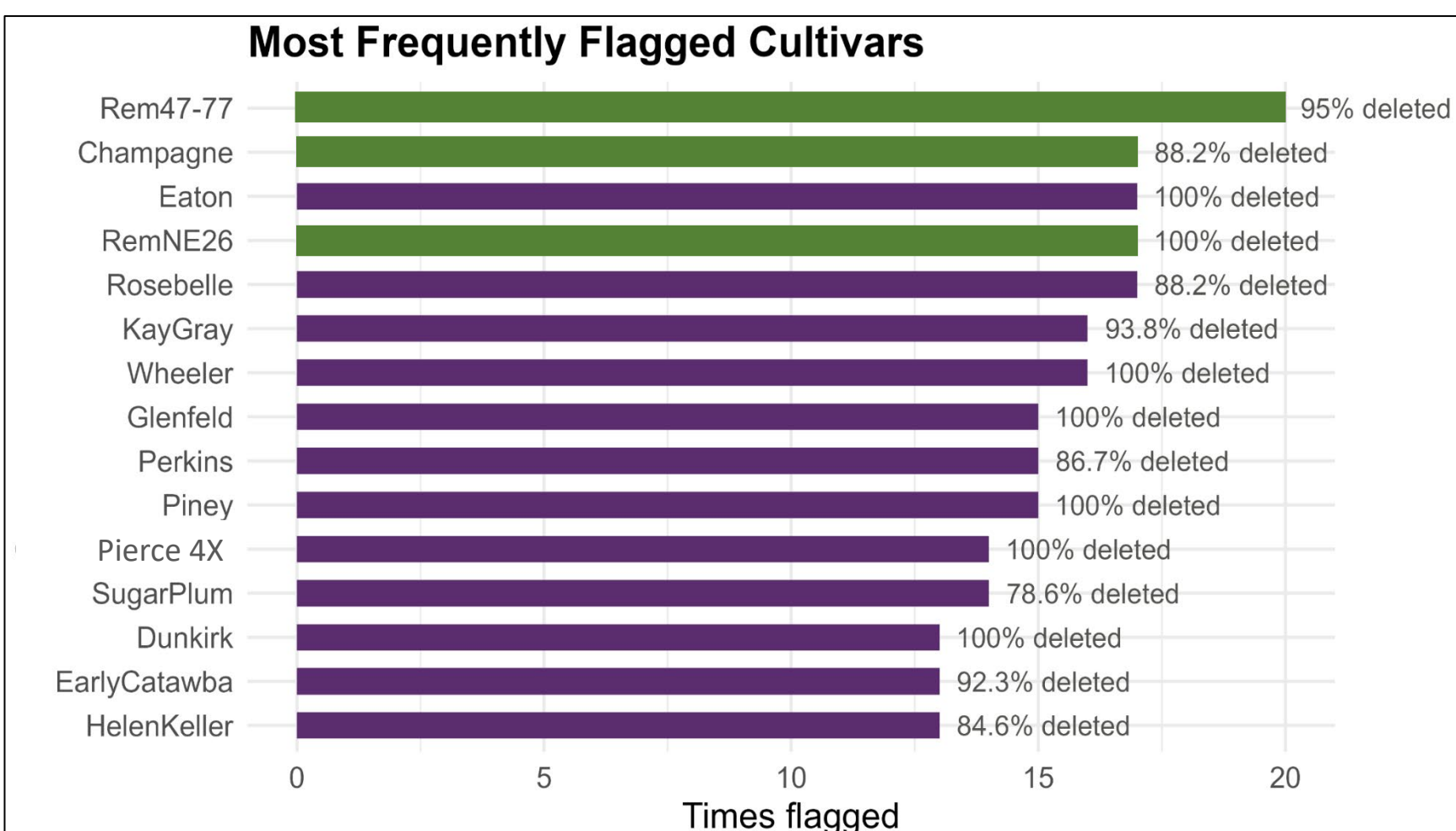
Fig 4. The count of red flagged samples by experiment date and the hairy vs non-hairy categorization.



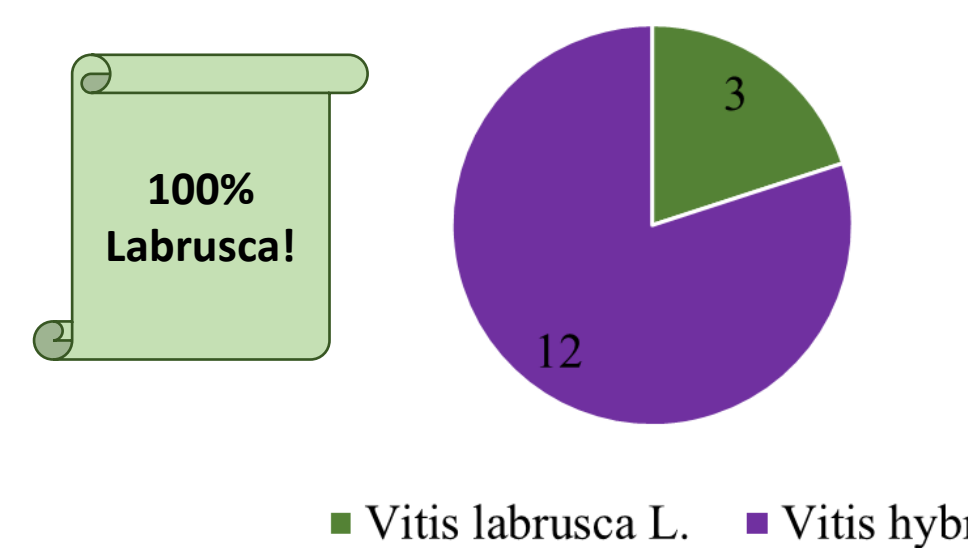
Of all red flagged accessions, 93.6% were identified as hairy. Among the hairy samples, only 2.6% had observable downy mildew present, and their severity measurements were “deleted” and are now recorded as disease incidence (present/absent) rather than as a severity measurement (Fig. 4).

Of the 15 most frequently flagged accessions, it was determined that 3 were *Vitis labrusca* species type, and the other 12 accessions had at least 50% *V. labrusca* in their pedigrees (Fig. 5).

Fig 5.



Species of Top 15 Most Deleted Cultivars



Discussion

Takeaways

- Red-flagged disease severity measurements were mostly from leaf hairs.
- This manual review has improved the accuracy and reliability of the dataset by eliminating many false-positives (the leaf disc was not infected).
- V. labrusca* types may not be amendable to the current imaging and AI-modeling of disease severity of Downy Mildew, and other similarly hairy leaves may need adjustment.

This experiment screened the majority of the Geneva Grapevine Repository, a diverse collection of genotypes and phenotypes. These findings highlight the importance of reviewing automated image analysis when being broadly applied, and this thorough quality control review can be used for developing additional AI models. Utilizing the BlackBird imaging system allowed for over 90% of tested accessions to have accurate, repeatable, and reliable disease severity data for Grapevine Downy Mildew, allowing for a substantial phenotype database for breeding against this disease.

References and Acknowledgements

"Grapes." *Cornell CALS: Cornell AgriTech*, Cornell University, <https://cals.cornell.edu/cornell-agritech/products-we-research/grapes>. Accessed 22 July 2026.
Leroy, Pascal, et al. "A bioeconomic model of downy mildew damage on grapevines for evaluation of control strategies." *Phytopathology*, vol. 115, no. 7, 2025, pp. 1357–1367. *American Phytopathological Society*, <https://doi.org/10.1094/PHYTO-01-25-0033-R>.
Sapkota, Surya, et al. "A Device for Computer Vision Analysis of Fungal Features Outperforms Quantitative Manual Microscopy by Experts in Discerning a Host Resistance Locus." *Phytopathology*, vol. 115, no. 7, 2025, pp. 1357–1367. *American Phytopathological Society*, <https://doi.org/10.1094/PHYTO-01-25-0033-R>.

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