NYWGF RESEARCH - FINAL REPORT TEMPLATE

Please fill in by typing over the red directions in each section and change font to black.

Funding for fiscal year: 2023

SECTION 1:

Project title: Determining bud mortality via thermal & multispectral imaging

Principal Investigator with contact info:
Justine Vanden Heuvel
Professor
Horticulture Section, School of Integrative Plant Science
Cornell University
Work: 315 945 7022
Email: justine@cornell.edu

Co-PI Collaborators with contact info:
Yu Jiang
Assistant Professor
Horticulture Section, School of Integrative Plant Science
Cornell AgriTech, Cornell University
Work: 315 787 2220
Email: yujiang@cornell.edu

New Research ☐ **Continued Research** ☒ (CHECK APPROPRIATE BOX)

Amount Funded **$** 22,040

SECTION 2: (This section should be in depth and akin to an academic report)

Project Summary Impact Statement:
Our previous findings suggest that 1) thermal imaging can detect grape buds without color information, which can reduce the cost of a sensing system; 2) thermal imaging can determine bud mortality, which can be used for a selective grapevine pruning system. We have developed a thermal stimulation method for this system in the lab but have been unable to find a successful thermal stimulation method for the field that works in cold and windy conditions. We have developed a portable active thermography system that can be transported around the region which can quickly image sampled canes and report the proportion of live vs. dead buds. We will soon trial this system with more cultivars grown in the Finger Lakes and Western NY for Year 4 of the project.

Objectives: Our primary objective in Year 4 was to conduct a large-scale experiment including more representative cultivars grown in the Finger Lakes and Western NY and damage status to build machine learning models that can be released to the NY growers for adoption in the future.

Materials & Methods:

We have developed new features for the existing data acquisition program and two new computer programs for data quality check and annotation and onsite analysis (Figure 1 and Figure 2). The previously developed data acquisition program functions properly to collect active-thermographic data of grape buds. Based on feedback from pilot users, we have added new features to enhance the user experiences when collecting large-scale datasets (e.g., sample size at thousands level). The first feature is to have a sound alert to remind the operator that a data acquisition session is finished. The operator can accordingly change the sample and start a new session without losing attention. The second feature is to automatically generate filenames based on predefined file prefix, suffix, and timestamp. This will allow the operator to focus on sample preparation and data acquisition and facilitate data management.

It is paramount to check the data quality after collecting a large-scale of thermal videos and annotate them for model training and validation. This will help the operator to quickly go through collected data to ensure their integrity for successive analysis and provide ground-truth labels. A key advantage is that all ground-truth labels are associated with each video file automatically without manual conversion of written notes or excel files that may misalign with video files, which may result in significant performance variation of trained machine learning models.

Additionally, from the production perspective, analysis tools are expected to be executable in the vineyard, so information can be readily accessed by vineyard owners or managers for timely decision-making. To this end, we have developed a new computer program that can load a collected video for analysis on the same laptop computer for analysis. In particular, the operator will directly see visual cues and thermal dynamic response curves of grape buds analyzed.

Results/Outcomes/Next Steps:

We are collecting large-scale datasets using the newly developed software with the thermal imaging system. After the data acquisition, machine learning models will be trained and tested to reveal new findings and/or suggestions related to bud mortality-based grapevine pruning strategy for precision vineyard management.

Technology Transfer Plan: We have developed new computer programs with graphic user interface that can support easy data quality check, class annotation for model training and validation, and onsite data analysis (Figure 1 and Figure 2). The developed computer programs have been fully integrated into the previously developed thermal imaging system for operation. The team is collecting a large-scale dataset that include representative cultivars from the Finger Lakes and Western NY throughout the wintertime from 2023-2024, so that we can use these developed system and analysis methods for revealing new findings in grape bud cold damage.

Attachments:

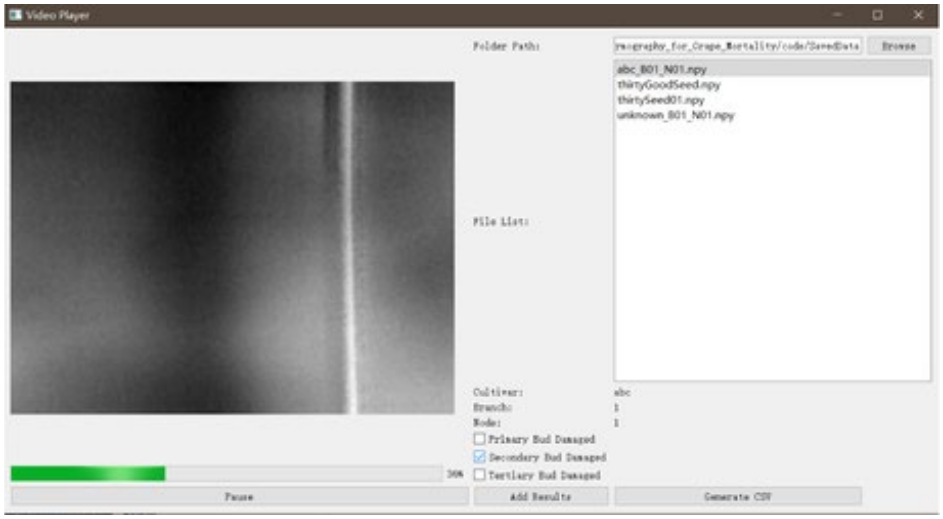

Figure 1: Graphic user interface of the data quality check tool. Users can use this tool to replay collected thermal videos and label the video class for model training and validation.

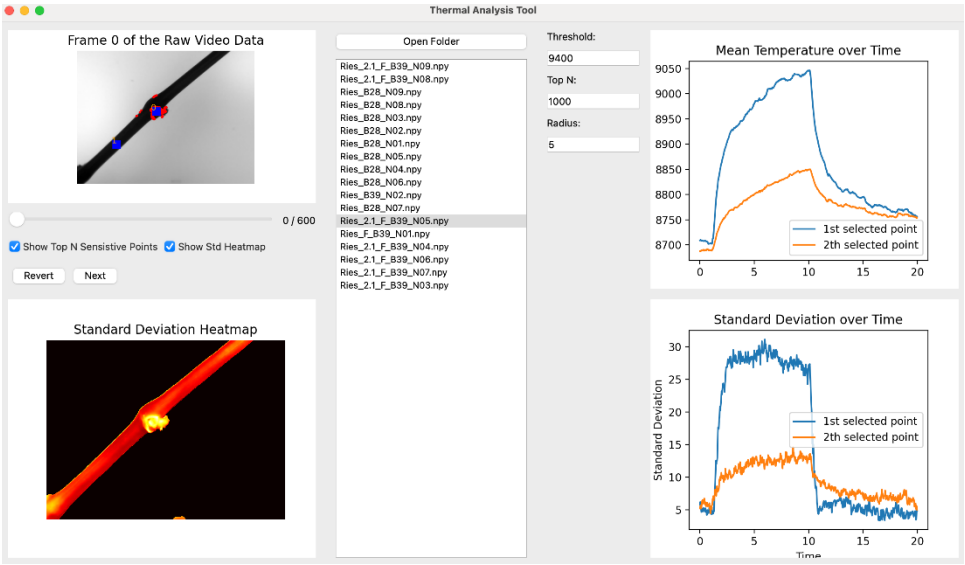

Figure 2: Graphic user interface of the data analysis tool. Users can use this tool to analyze collected thermal videos to determine if a video contains a damaged or healthy grape bud. The displayed grape bud shows distinctive thermal responses indicating its healthy status.

SECTION 3: (The goal of this research is to benefit growers and producers across New York State. Result summaries will be shared on the NYWGF website and via email newsletters. To that end, this section should be brief and written in terms understandable for the average grower and producer, as well as consumers and trade interested in our industry.)

Project summary and objectives: The overarching goal of this project was to develop a system using inexpensive thermal imaging to allow grape growers to easily quantify the number of live and/or dead buds in a vineyard block to better guide pruning practices. We have proven that thermal imaging can be used to differentiate live vs. dead primary buds and now have a useable imaging system so that growers can quickly and easily assess bud death on sampled canes. The system is portable but needs to be placed on a tabletop for

data collection. We are currently extending the use of this system to grape growers in the Finger Lakes and Western NY.
(5 Sentence Max)

Importance of research to the NY wine industry: Cold damage is a recurrent and major economic issue in the Northeastern U.S. winegrowing regions. Primary buds – and sometimes secondary and tertiary buds – are often damaged by fluctuating temperatures in the winter and early spring, resulting in deacclimation of vines and a subsequent loss of cold hardiness. When the cold temperatures return rapidly, bud loss can be significant. In the Finger Lakes region of New York, primary bud damage on many vinifera cultivars including Cabernet Franc reached as high as 80% in the spring of 2014. The use of non-destructive methods to evaluate the grape bud mortality accurately and rapidly will help growers to gather needed information for precision pruning decision-making for an optimal pruning strategy given potential cold damages.
(5 Sentence Max)

Project Results/next steps: We are collecting additional datasets including major cultivars in the Finger Lakes and Western NY using the developed thermal imaging system. The collected images will be used to train various machine learning models that can provide accurate classification of grape bud mortality status. These trained models are expected to be publicly accessible for growers who plan to adopt the developed thermal imaging system for production management in the future.

Supporting attachments: (Choose a maximum of 1 supporting figure or table to demonstrate results if desired)

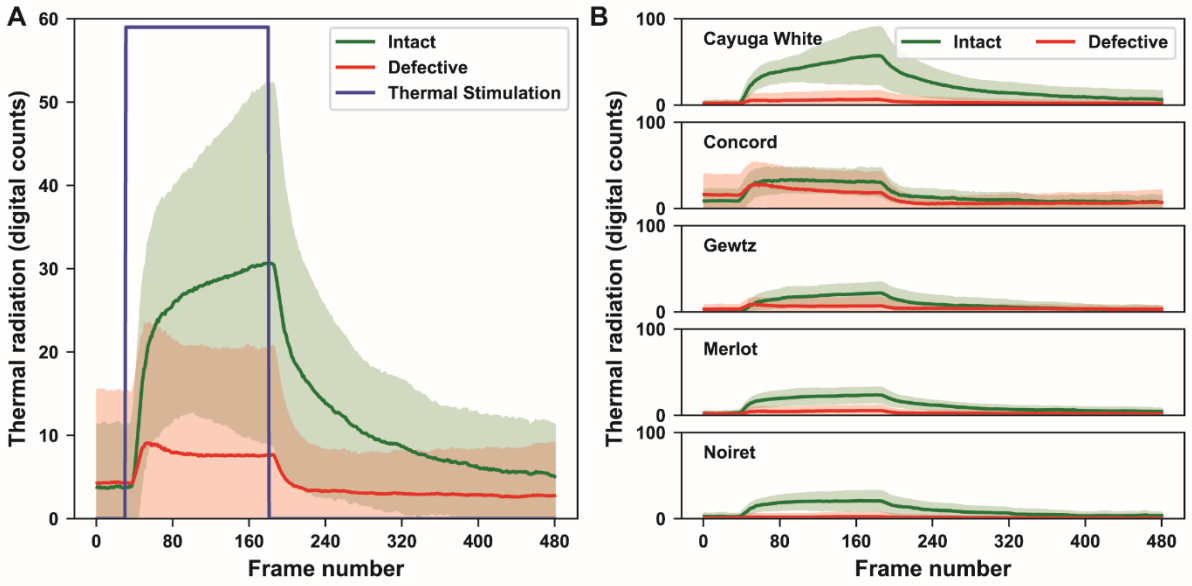

Figure 3: (A) Mean thermal responsive curves (solid lines) with standard deviation (shaded regions) of all samples with extracted thermal images for damaged (red line) and healthy (green) samples along with the thermal stimulation pulse curve (blue line); **(B)** Mean thermal responsive curves with standard deviation of samples of each cultivar for damaged and healthy samples.