Project title: Determining bud mortality via thermal & multispectral imaging

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New Research ☐ **Continued Research** ☒

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Project Summary Impact Statement: An active thermograph imaging system has been developed and tested for the determination of grape bud mortality in the lab and field. Our experiments showed that living buds could absorbed more heat and yield a higher surface temperature than dead buds with external thermal stimulations. This demonstrated the potential of using active thermograph for rapid and accurate differentiation of bud mortality status nondestructively.

Objectives:
1. Develop an optimal thermal stimulation method for buds in the vineyard
2. Characterize thermal properties of grape buds with different mortality status

Materials & Methods:
Objective 1: Develop an optimal thermal stimulation method for buds in the vineyard
We have developed active thermograph imaging systems for both laboratory and field use (Figure 1). The lab system contains a thermal camera (FLIR A700, Teledyne FLIR LLC), two 375-Watt heat lamps (Sunlite 375-Watt R40, Sunshine Lighting), a USB power relay, a sample holder, and a laptop computer. The USB relay was connected with the heat lamps to control the heating stimulation on and off during the data collection. A custom computer program was developed and deployed on the laptop computer for thermal video collection. In each video, heat lamps were turned on for the first 15 seconds to stimulate heating effects and then off to record the cooling response. For the field system, the heat lamps and thermal camera were installed on a portable mounting structure that can be flexibly attached to various mobile platforms (e.g., pickup trucks, ATV/UTVs, etc.) and/or used manually. A power generator was needed to power the imaging system and laptop computer. While cooling could be used as an alternative thermal stimulation, it was not a feasible option for field uses especially during the winter time in NYS. Thus, we did not incorporate the cooling stimulation approach in the final systems.

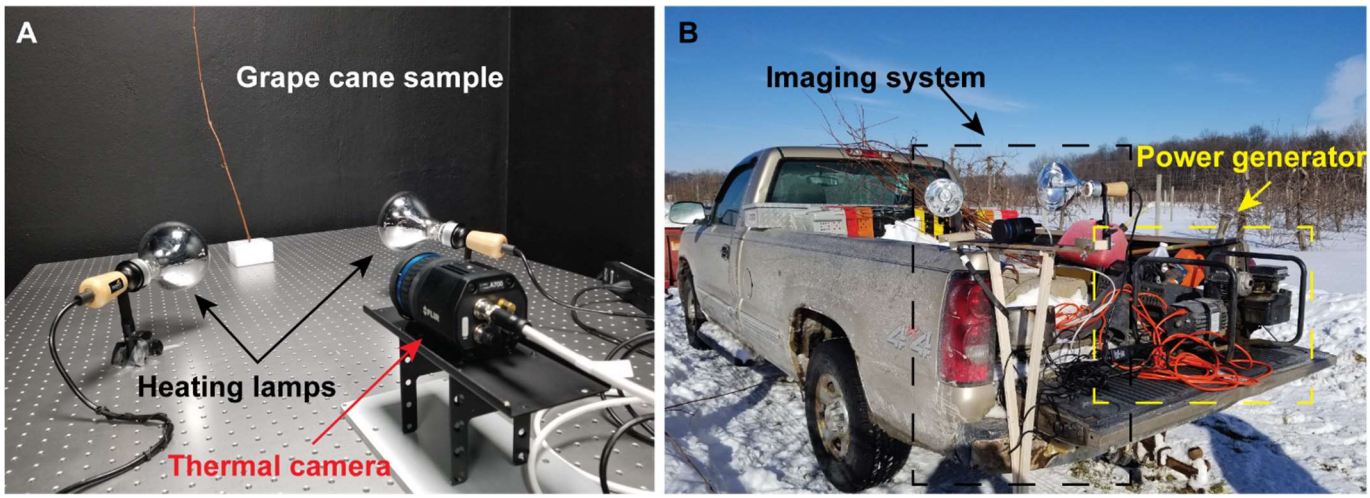

Figure 1. Active thermograph imaging systems developed for laboratory (A) and field (B) uses.

Objective 2: Characterize thermal properties of grape buds with different mortality status
We have collected 20 canes each of the Concord and Riesling cultivars from the vineyard with natural cold damages. Thermal videos were collected for the middle bud of each cane with the heating stimulation. After data collection, the middle bud was manually sliced and

evaluate to determine the bud mortality. In each thermal video, thermal responsive curves (i.e., temperature over the time) were measured at three points: the center point of the middle grape bud, the center point of the cane segment between the middle bud and the bud above it, and the center point of the cane segment between the middle bud and the bud below it. The difference between maximal and initial temperatures (T_{mi}) was extracted from the thermal curves as the feature to be used differentiate the bud mortality.

Results/Outcomes/Next Steps:
Laboratory experiments showed that the heating stimulation induced different thermal responses between living and dead grape buds (Figure 2). At the beginning, all samples were about 21 °C (or 70 °F) because they were stored inside for over 24 hours. After the heating stimulation was applied, all tissues (including both buds and canes) showed an increasing trend of surface temperature and reached to the maximal surface temperature once the stimulation was off. Subsequently, the tissues lost thermal energies and cooled off. Living grape buds showed a considerably higher maximal temperature than the dead ones, resulting in over 3 °C (or 5.4 °F) difference of Tmi. Additionally, living buds showed a higher maximal temperature than surrounding canes, whereas dead ones had the opposite effect. These could be used together as features for the differentiation of grape bud mortality.

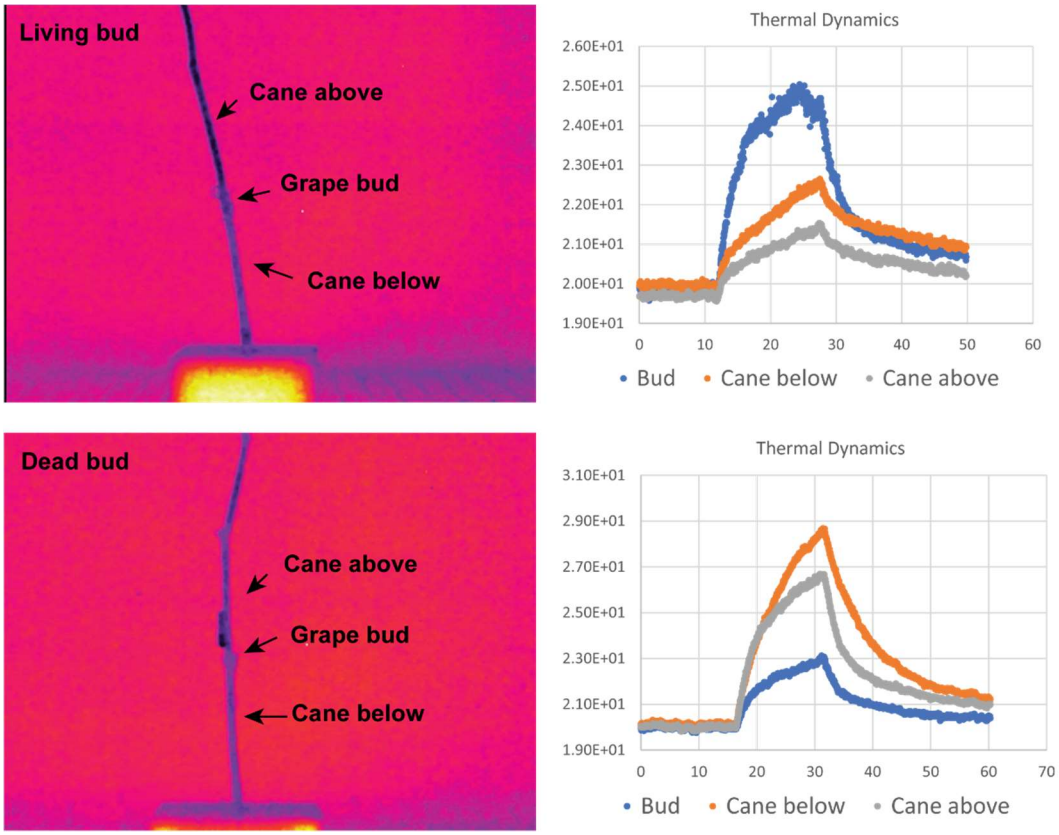

Figure 2. Representative examples of thermal response curves for living and dead grape buds from the thermal videos.

On the other hand, thermal videos collected in the vineyard did not show any thermal differences between buds with different mortality or even buds and canes. This was primary due to the insufficient heating stimulation in the field during the winter time. Although two 375-Watt heat lamps are powerful in the lab, the generated heat could be dissipated quickly

in the field and won't reach out to the grapevine tissues. Therefore, it is important for us to explore alternative solutions for stimulating the grapevine tissues in the vineyard in the future. There are two potential ways to address this issue. First, we could put the heat lamps closer to reduce the heat dissipation, but this may lead to a substantial challenge in designing the heat lamp mounting. Second, we could use a laser-induced stimulation so that a much higher energy can be delivered to grape buds. Both require further investigation.

Technology Transfer Plan:
The laboratory experiments have demonstrated the efficacy of using the active thermograph system for the determination of grape bud mortality, but we've been challenged in the field by providing the heat flash to the buds given the cold temperatures that occur during NY winters. To ensure useful technology transfer by the end of this project, we plan to further refine our lab system by improving the system stability, portability, and user interface so that at minimum we could set up the system in a barn in the vineyard and quickly examine the bud mortality from subsampled canes without manual slicing. This would still provide useful information to guide pruning practices while saving grower labor. More on-farm tests will be necessary to validate this potential plan.

Attachments: included in the report.