PennState
College of Agricultural Sciences

PROPOSAL TRANSMITTAL

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Title: Demonstrating and Evaluating the Cyclone Vacuum Apple Harvester

Submitted to: Patti Keller

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Program: SHAP Extension Advisory Committee Grant

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Proposed Project **4/1/2019 - 3/31/2020** **Total Project Request: $4,370**

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Title: Demonstrating and Evaluating the Cyclone Vacuum Apple Harvester

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Support:	David Slaybaugh	Mt. Ridge Farms, Biglerville, PA.
	Leighton Rice	Rice Fruit Company, Gardners, PA.

Duration of Project: One year (April 1, 2019 – March 31, 2020) new project.

Justification

This project addresses the SHAP Extension Priorities of *Mechanical Assisted Harvest*, and *Orchard Practices to Increase Precision Management and Work Force Efficiency.* The outcomes produced by this project should answer the following questions: 1) What quantitative impact does the Cyclone have on profitability? 2) Is the quality of the fruit delivered to the packing house quantitatively consistent and comparable to (or superior to) fruit harvested using existing practices? 3) What qualitative operational parameters are to be expected with this platform with respect to worker training, ease of use, system maintenance, and operational costs? 4) Does the Cyclone increase the labor efficiency of workers?

Description of Problem

Labor requirements associated with agricultural operations have long been recognized as the primary restricting factor with respect to profitability (Ricardo, 1821), especially when practices involve significant manual labor such as moving ladders and manually transporting fruit to bins. To address this problem and to maximize fruit production per acre, apple breeders and physiologists developed dwarfing rootstocks and training systems to reduce plant height, to increase planting density and yield per acre, and to make fruit more accessible for harvest (Robinson, 2003). While these developments have significantly increased worker productivity and overall yield, harvest efficiency is still constrained by human factors: the ability to access fruit in the canopy and the time and effort necessary to deliver fruit from the tree to the collection bin.

Recent engineering innovations have improved worker efficiency through the elimination or reduction of activities not directly related to the picking and transport of the fruit. Most notably, the use of mobile picking platforms such as the Brownie Quad have largely eliminating the need to reposition ladders to reach fruit high in the canopy (T. Baugher et al., 2009; Courtney, 2018). Bin carriers such as the Bin Bandit reduce the time necessary to collect multiple bins and deliver them storage or for further transport (Mason, 2018).

The last remaining significant bottleneck to maximizing harvest rates come from inefficiencies associated with human labor. Physiological limitations restrict the number of pieces of fruit that can reasonably be picked per hour, the number of pieces that can reasonably be carried in bags to the nearest bin, and the number of hours worked in a day. While robotic techniques promise to eliminate

the human element entirely, robotic harvesters are under development and have yet to achieve a reasonable fraction of the picking rate achieved by trained humans (Stuntz, 2018).

Alternatively, engineers have turned their attention toward developing platforms to assist manual laborers by reducing physical effort. The Phil Brown/DBR system (PB/DBR) utilizes a vacuum system to transport individual pieces of fruit directly from the hands of the picker to the bin (Lehnert, 2014). While harvesting, pickers never need to leave the PB/DBR platform to empty bags, nor have to bear the burden of full bags throughout the day.

The Cyclone system marries the PB/DBR vacuum-assisted harvest system with the Bin Bandit bin management platform. Because the Bin Bandit manages multiple bins simultaneously, harvest of fruit directly deposited into bins can continue as one long, coordinated sequence uninterrupted by the need to reposition ladders or walk among bins to deposit collected fruit. By drastically reducing labor requirements and eliminating unprofitable activities associated with fruit transport, the Cyclone has the potential to reduce significantly labor overhead and improve profitability.

Objectives

There are two primary objectives associated with this proposal: 1) to demonstrate the performance of the Cyclone vacuum-assisted harvest platform in a typical southeastern Pennsylvania apple orchard trained using high-density trellised systems, and 2) to collect data about the efficiency and efficacy of the platform for delivering undamaged fruit to the collection bin.

This demonstration project and research trial builds upon similar research concerning early-generation harvest-assist platforms conducted by Penn State (T. A. Baugher, 2012; T. Baugher et al., 2009; Schupp, Baugher, Winzeler, & Schupp, 2011), and trials of the PB/DBR system conducted by Washington State University in 2012 (Luo, Lewis, Zhang, & Wang, 2012).

Procedures

Demonstration

Demonstrating the system in a Pennsylvania orchard is the top priority. Because the Cyclone is relatively new (the PB/DBR and Bin Bandit systems were mated into a single product in 2017), there is yet little experience with it outside of Washington State. While several New York producers have agreed to purchase a Cyclone platform, as of this writing no Pennsylvania producers have operational experience with it (Cornwell, 2019; Rasch, 2018).

Penn State Extension will host a two-day (minimum) production demonstration of the Cyclone. Growers would have an opportunity to observe the system in operation, discuss operational concerns with Automated Ag representatives, and receive immediate feedback from their own workers. This event will be advertised throughout the state via Penn State Extension's website, newsletters such as *Fruit Times* and *Fruit News*, press releases to agricultural news agencies such as *Morning Ag Clips* and *Lancaster Farmer*, and through targeted mailings to SHAP's membership list.

Quantitative and Qualitative Platform Evaluation

The experimental design to evaluate the suitability of the platform is relatively straightforward. A minimum of six rows of a variety ready for harvest at the time of platform availability will be used as a test block. Two treatments will be applied: half of the rows will be harvested using the Cyclone system and half will be harvested using practices currently in effect in the orchard.

Individuals currently employed by the host will be selected by the host for this trial. The same team of workers who will pick fruit using the Cyclone will pick using the prevailing operational practices at that orchard. The purpose of keeping the number of workers constant and utilizing the same workers in both trials is to ensure consistency in the quality of fruit selected or discarded prior to binning and to reduce variability associated with the physical capabilities of the individuals.

Data collected will include the time taken to complete the harvest of a full row and the time necessary to configure the equipment for harvest of a row. From this data it will be possible to estimate the manhours required to harvest a row or a single bin of fruit, the wages spent per row or per bin, and the downtime necessary to prepare a row for harvest.

Additionally, the time required to train individuals to achieve sufficient mastery of technique for operational readiness will be measured. A survey of worker experiences and average time to proficiency will provide an estimate of the difficulty in adapting to an unfamiliar system.

At least one apple variety will be the subject of this trial. Preferably this will be a thin-skinned variety or one prone to bruising such as 'Premier Honeycrisp'. By selecting a variety that requires special attention during normal operations, problems associated with mechanized harvest will be more readily apparent.

Bins from each experimental replicate will be analyzed using the Compac sorting system at Rice Fruit Company. The *Spectrim* visible spectrum computer vision system will identify surface defects (Compac, 2018b) while the near-infrared spectroscopy system and computer vision software package *Inspectra²* will identify internal damage (Compac, 2018a). Individual pieces of fruit with surface or internal damage can be culled, resulting in an extremely accurate estimation of the mean damage cull rate per row. Since the hypothesis of this experiment is that damage caused by the Cyclone is not significantly different from damaged caused by standard practices, any observed deviation from the mean cull rate may be attributable to a treatment.

Deliverables

A comprehensive evaluation of the Cyclone's performance and an analysis of its projected return on investment will be published online and through traditional educational venues such as *Fruit Times* and *Pennsylvania Fruit News*. The results will also be presented as a poster at the 2020 Mid-Atlantic Fruit and Vegetable Conference.

Expected outcomes of the analysis include: 1) projected profit or loss to a producer operating the system in a typical southeastern Pennsylvania orchard, including amortization estimates for different investment scenarios; 2) an estimation of per-person labor costs and per-person performance changes in harvest efficiency; 3) a critical evaluation of the training and operational requirements for the system; and, 4) an evaluation of the quality of fruit delivered to the packing house with a particular emphasis on measurable changes in bruising.

Conclusion

When combined with the harvest efficiency data, a clear picture of the viability of the Cyclone as a harvest platform for use in Pennsylvania should become clear. From the data collected as part of this experiment, it will be possible to assist growers in making decisions about the suitability of the Cyclone system as an investment for their operations.

Budget

Hourly Wages	$ 900	(Assistant for 60 hours at $15 per hour.)
Fringe Benefits	$ 70	
Supplies	$ 275	(Flagging tape, data recording, etc.)
Travel	$ 170	
Miscellaneous		
Purchased Services	$ 2,730	(LaGasse Orchards – freight charges)
Printing & Copying	$ 200	(Posters, mailings, fliers, etc.)
Postage	$ 25	
TOTAL	$ 4,370	

A complete budget justification statement describing each category in additional detail, including how fringe benefits were calculated, can be obtained from the College of Agricultural Sciences Grants and Contracts Office.

Other Support

There are no direct sources of funding associated with this project currently available or pending.

David Slaybaugh of Mt. Ridge Farms in Biglerville has committed to hosting the system and to work with Extension researchers and educators to collect the data necessary to make the financial and labor estimates. Leighton Rice of Rice Fruit Company has committed to assisting with the fruit analysis. Tim Cornwell of LaGasse Orchards has agreed to help minimize shipping expenses. Letters of support from these industry representatives can be obtained upon request.

Citations

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