FINAL PROJECT REPORT
WTFRC Project Number: TR-11-102

Project Title: DBR harvest assist equipment evaluation under Washington conditions

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Cooperators: Penn State, WA Orchard Companies, CPAAS and WTFRC internal staff

Other funding sources

Agency Name:	USDA Specialty Crop Research Initiative
Amt. requested/awarded:	$6.1M (plus $6.1M non federal match) $94,000 was allocated to this specific project
Notes:	Karen Lewis is a Co PI and the principles of DBR Conveyor Concepts are Co- investigators on the project Comprehensive Automation for Specialty Crops (CASC).

Total Project Funding: $60,000

Budget History:

Item	**2011/2012**
Equipment	60,000
Total	60,000

OBJECTIVES

The primary goal of this project is to finalize design and fabricate a harvest-augmentation system and to test the system under Washington State conditions.

We proposed to develop a harvest-augmentation system for the apple industry that handles the fruit from the time it is picked from the tree until it is placed in the bin.

Testing objectives are clustered into 2 major areas: 1) equipment performance and 2) human performance.

Specific objectives for the one-year project are as follows:

1) Design and build a harvest-augmentation system to Washington State specifications
2) Determine durability of equipment under WA conditions
3) Actively solicit grower and worker input on equipment design and function
4) Determine worker productivity and harvest efficiency in large scale harvest assist trials
5) Determine fruit damage by measuring degree and amount of bruising and identify where bruising occurs along the system
6) Identify ergonomic issues and develop strategy to address those that require equipment or use modifications
7) Determine worker fatigue in large scale harvest assist trials
8) Determine economic impact of harvest-augmentation under WA conditions when compared to equal tasks completed on ladders

SIGNIFICANT FINDINGS

- On arrival, bruising levels in Granny Smith, Ambrosia, Gala and Braeburn exceeded industry tolerances
- With a major redesign of decelerator mechanism, bruising decreased in Granny Smith , Gala and Fuji
- With current decelerator mechanism design and moderate changes to bin filler, Fuji bruising is within industry tolerance
- With above changes, the system can receive fruit at 4 apples per second / tube X 4 tubes for a total of 16 fruit per second. At arrival, the speed was 1 apple per second
- A small but randomized time trial resulted in a 20% efficiency increase when the DBR harvest was compared to a ladder and bag harvest
- Apples must be put in tubes one at a time
- Transport system, bin filler and people are best optimized in uniform tree structure and cropload
- The system is simple – easy to operate, debug and correct
- The tractor towing the system should have a “creep gear” kit installed to allow for smooth low speed, driverless operation
- Workers in general like working from the platform and like picking into tubes
- With the new decelerator mechanism design, repeated IRD tests indicate that the majority of apple to apple bruising is now occurring during the delivery to the elephant ear in the bin. and placement in the bin
- Need to have two work levels on the platform

- Minor design changes around position of platform levers, position / location of tube inlets, tractor noise and exhaust, and a few remaining metal pinch points need to be addressed

RESULTS AND DISCUSSION

The harvest assist system did not perform as anticipated upon arrival in terms of bruise levels and ability to handle fruit treated with eclipse. In addition, we put the machine into a 13 ft middle vertical axe gala block and quickly determined that 13 foot centers in a cone shape architecture is not a good fit. Most of the efforts over the 5 weeks were focused on bruise reduction and machine design and function.

With the original decelerator design, bruising was recorded as high as 50% in under mature Granny Smith and 65% in Ambrosia. After redesign of decelerator mechanism and modifications to bin filler– bruising was recorded at levels of 25% in 'Gala', 30% in 'Granny Smith', 20% in 'Braeburn and 23% in 'Jazz'.

With a modification to the mechanism redesign– a small run of 'Fuji' resulted in 5.2% bruising with a minimum of 4.8% downgrade. Over mature 11-12# 'Gala' in two tests resulted in 14% and 11% bruising.

The redesign of the decelerator mechanism resulted in increased volume capacity and decreased apple to apple bruising. Modifications to bin filler have reduced – but not eliminated, apple to apple bruising in the bin.

The efficiency of the DBR system was evaluated in a single randomized time trial. We used the same crew, in the same block and timed bin filling using the DBR system and the ladder and bag system. Harvest using the DBR system resulted in a 20% increase in bin filling time.

Executive Summary

The funding from this project co-financed the design and fabrication of a 2011 DBR Conveyor Concepts harvest assist prototype. Additional funds of $94,000 were allocated through the SCRI CASC project. Total costs for design and fabrication were $154,000. Costs associated with delivery, setup and field validation were provided through the WSU CASC sub award. Because of crew demands and damaged fruit, substantial costs were incurred by project collaborators McDougall & Sons, Allred Farms and Allan Brothers. DBR traveled to Washington State 3 times during the 5 week harvest period. DBR principles have been innovative, proactive, responsive and successful with the redesigns and modifications.

The objective of this one year project was to design, fabricate and field test the DBR harvest assist system in Washington State. The system arrived September 19, allowing 5 weeks of in-field testing. The harvest assist system did not perform as anticipated upon arrival in terms of bruise levels, capacity and ability to handle fruit treated with eclipse. Most of the efforts over the 5 weeks were focused on bruise reduction and machine design and function. We tested the system in Granny Smith, Gala, Ambrosia, Jazz, Braeburn, and Fuji. We worked in several different orchard architectures and in blocks that required stem clipping and color picking. We worked with both internal and commercial crews and worked with 4 on the platform and 2 on the ground and 2 on the platform.

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Impact Recording Device (IRD) trials indicate that the majority of impacts occur in the transport tubes but that only .11% are above the threshold of a 10% chance that the impact will result in a bruise. The 3 major locations of high g-level impacts are: both ends of tubes, joints between tubes and decelerator, and where the tube inflects or bends.

The DBR system was shipped back to MI for modifications and upgrades. Modifications include but are not limited to, installation of lighting system for nighttime operations, auto steer kit for Kubota,

upgraded electric eye, elephant ear redesign and repositioning of tube inlet for platform work. Self leveling for the bin filler will be installed.

In collaboration with the CA Canning Peach Association and UC Davis, the system will be evaluated in CA peaches and pears during the month of August. During this time, extensive ergonomic, engineering and efficiency studies will be conducted by UC Engineering and UC Extension. The system will be evaluated in WA state apples in September and October.