

Title: Development and Evaluation of a Portable Mechanical Shaker for Blueberry

Progress Report

Grant Code: SRSFC Project # 2011-17

Research Proposal

Name, Mailing and Email Address of Principal Investigator(s):

Principal Investigator:

Anish Malladi
1121 Miller Plant Sciences,
Department of Horticulture,
University of Georgia,
Athens, GA 30602
Email: malladi@uga.edu
Phone: 706-542-0783

Co-Principal Investigator:

Scott NeSmith
1109 Experiment Street,
Department of Horticulture,
University of Georgia,
Griffin, GA 30223-1797
Email: snesmith@uga.edu
Phone: 770-228-7358

Objectives:

- 1) To develop a portable device for mechanical shaking
- 2) To evaluate the device for mechanical shaking of blueberry plants

Justification and Description:

The blueberry industry in the south-eastern US has witnessed remarkable growth in the past few years (Krewer and NeSmith, 2000). In Georgia, over 12,000 acres are currently under blueberry cultivation with the crop value exceeding \$100 million, justifying its ranking among the top fruit crops in the state. Sustained profitability of blueberry production in Georgia and other south-eastern states is dependent on the mitigation of factors which reduce blueberry production efficiency. Harvesting is typically one of the most expensive aspects of blueberry production as a majority of it is currently performed manually. Labor shortage and associated issues further

augment this situation. Over the past few years, there has been an increased interest in the use of mechanical harvesting to reduce production costs and to address issues with the availability of labor. Blueberry breeding programs such as that of the Co-PI are placing greater emphasis on the development of genotypes better suited for mechanical harvesting (NeSmith, 2009). Also, the abscission research program in the PI's laboratory focuses on the development and evaluation of plant growth regulators/abscission agents to enhance fruit detachment and to increase the efficiency of mechanical harvesting.

Evaluating and understanding fruit detachment is critical for improving the efficiency of mechanical harvesting. During the selection of new genotypes in breeding programs, evaluation of fruit detachment can provide important information on the suitability of the genotype for mechanical harvesting. However, such evaluation is often performed manually as use of mechanical harvesters is not feasible owing to small plot size. Similarly, evaluation of fruit detachment is an important component in the assessment of abscission agents. The PI's laboratory routinely utilizes a portable force gauge to determine the force required for fruit detachment in these studies (described in Malladi and NeSmith, 2010). While this tool is effective in determining the fruit detachment force on an individual fruit basis, it does not indicate fruit detachment responses at the whole plant level. A device that can allow the estimation of fruit detachment responses on the scale of an individual bush or on single branches would greatly benefit the above efforts. Such a device would be of tremendous use in breeding programs for the selection of genotypes better suited for mechanical harvesting, and would also be of immense utility in the evaluation of abscission agents for enhancing mechanical harvesting efficiency.

Devices that can induce mechanical shaking of individual branches of a blueberry bush can result in fruit detachment. While it may not directly simulate mechanical harvesting, mechanical shaking of branches can provide valuable information on the fruit detachment responses among blueberry genotypes. Also, it can potentially provide information on the applicability of abscission agents for inducing fruit detachment. Previously, mechanical shakers have been used to induce fruit detachment in blueberry. However, these instruments were cumbersome and are no longer commercially available. In this study, we propose the development and evaluation of a portable device that can facilitate mechanical shaking of individual branches in blueberry.

Methodologies

Development and Optimization of a Portable Mechanical Shaker

Extensive consultations on the selection of a suitable tool for mechanical shaking were performed with the Instrument shop at the University of Georgia. A portable reciprocating saw (DeWalt) powered by a lithium battery was selected for development as a mechanical shaker for fruit removal in blueberry. Two such units were modified as described below to allow for its use in mechanical shaking. An adapter with a padded notch at the end to clamp on to blueberry branches was developed and fitted to the instrument. A resistor was mounted on the instrument

to help control the rpm. This modification was essential to maintain consistency across units. The rpm was measured using a tachometer and subsequently set at a level determined after preliminary blueberry shaking trials.

Optimization of the portable mechanical shaker was achieved in initial trials using cultivars such as Powderblue and Premier. Tests of mechanical shaking were conducted on mature blueberry bushes grown and maintained according to standard cultivation practices at the University of Georgia, Horticulture Farm, Watkinsville, GA. Trials were performed when greater than 50% of the berries within the cluster on the branch were mature (blue-black in color). The branch was held with the clamp of the portable mechanical shaker above the cluster and subjected to mechanical shaking. Multiple rpm settings and different shaking durations were evaluated. Together, these preliminary studies allowed the determination of the rpm and optimum duration of shaking required for inducing consistent fruit detachment using the portable mechanical shaker.

Evaluation of Fruit Detachment by the Portable Mechanical Shaker across Blueberry Genotypes

Fruit detachment using the portable mechanical shaker was evaluated across three rabbiteye cultivars, Climax, Premier and Briteblue. Mature bushes grown and maintained according to standard blueberry cultivation practices at the University of Georgia, Horticulture Farm, Watkinsville, GA were used for this study. Four replicates of each genotype were evaluated. For inducing fruit detachment, a branch of the plant was mechanically shaken using the portable device. Speed settings (rpm) for mechanical shaking were determined from the above preliminary trials (800 rpm). The total number of fruit on the cluster prior to and after shaking was counted to determine the extent of fruit detachment. Detached fruit were captured in a catching frame placed below the cluster. The proportion of mature (blue-black) and green fruit in the detached fruit population was determined. The proportion of stemmy fruit was determined.

Evaluation of Fruit Detachment with the Portable Mechanical Shaker in Response to Abscission Agent Treatments

Fruit detachment in response to abscission agent applications was evaluated in the rabbiteye cultivar, Briteblue. Mature rabbiteye blueberry plants maintained according to standard blueberry cultivation practices at the University of Georgia, Horticulture Farm, Watkinsville, GA were used for this study. Three replicates were used in this study. Methyl Jasmonate (MeJA; 20 mM) and ethephon (1000 ppm), along with a surfactant (0.15% Latron B-1952) were applied at 9 am. These treatments have been previously shown to be effective in inducing fruit abscission in blueberry (Malladi and others, *in preparation*). Control plants were treated with the surfactant only. At 24 h after treatment, branches with clusters were shaken using the portable mechanical shaker. Shaking was performed on clusters with 50 mature fruit. The time taken for the removal of these 50 fruit from the clusters was determined in this study. Detached fruit were collected in a catching frame and the point of fruit detachment was determined. Two clusters per replicate were analyzed ($n=3$).

Results

Development and Optimization of a Portable Mechanical Shaker

A portable reciprocating saw from DeWalt was modified as described in the ‘Methodologies’ section. Two such units were developed in this study. Consistency in rpm across the units was achieved through the addition of a resistor. Lithium batteries helped in maintaining a consistent power supply to sustain the required rpm during mechanical shaking. The figure below shows the instrument and its various parts (Fig. 1). The adapter was clamped on to the branch above the cluster using bands (Fig. 2). Preliminary trials indicated that a rpm setting of 800 rpm was sufficient to induce consistent fruit removal from the clusters across different cultivars of rabbiteye blueberry. Around 5s was found to be sufficient for fruit removal from clusters containing mostly mature fruit.

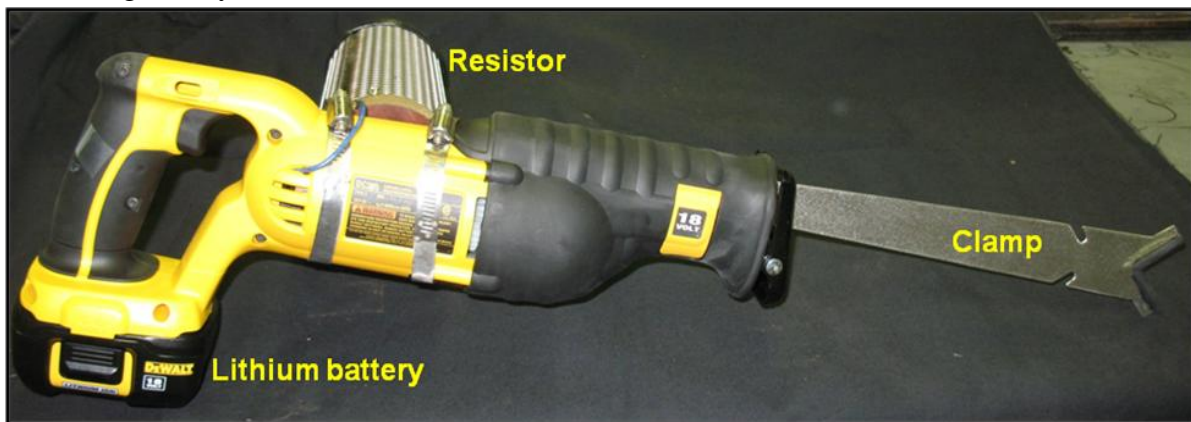


Figure 1: Mechanical shaker for fruit removal in blueberry. A reciprocating saw was modified by attaching a clamp and by addition of a resistor to enable fruit removal in blueberry.



Figure 2: The mechanical shaker in use for fruit removal in blueberry. The clamp part of the shaker was attached to the branch above the cluster and shaken at 800 rpm. Fruit detachment can be observed in the image. Detached fruit were collected in a catch frame.

Evaluation of Fruit Detachment by the Portable Mechanical Shaker across Blueberry Genotypes

Fruit detachment using the mechanical shaker was evaluated across three rabbiteye blueberry genotypes. Mechanical shaking resulted in the effective removal of fruit from the clusters. An average of 87%, 93% and 76% of fruit were removed from the cluster in 5s in the cultivars, Climax, Premier and Briteblue, respectively (Fig. 3). No significant difference in the extent of fruit removal was observed across the three cultivars tested. The vast majority of detached fruit were mature fruit (blue/black). The point of fruit detachment was evaluated by determining the proportion of stemmy fruit (Fig. 3). The majority of the fruit detached at the point of attachment of the berry and the pedicel (berry/pedicel junction) as a result of mechanical shaking. Only a small proportion of the fruit retained the pedicel (8-14%). The proportion of fruit with the pedicel attached was not significantly different across the three cultivars. These results are consistent with observed effects on fruit removal by a mechanical harvester. These data indicate that the mechanical shaker developed here was effective in fruit removal and resulted in fruit detachment at the berry/pedicel junction.

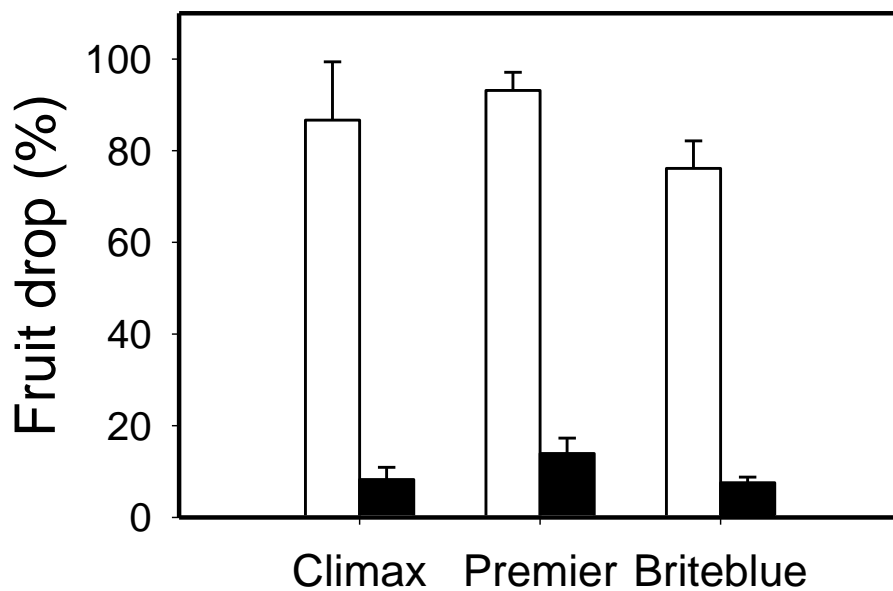


Figure 3: *Fruit detachment with a mechanical shaker in three rabbiteye blueberry cultivars. The mechanical shaker was used to remove fruit from clusters containing 50-60 fruit from each of three cultivars, Climax, Premier and Briteblue (n=4). The percent fruit drop is indicated by the open bars. The shaded bars indicate the percent fruit removal along with a pedicel attached (stemmy fruit).*

Evaluation of Fruit Detachment with the Portable Mechanical Shaker in Response to Abscission Agent Treatments

The abscission agents MeJA and Ethephon were used to induce fruit detachment in the rabbiteye blueberry cultivar, Briteblue. The mechanical shaker was used to evaluate fruit removal at 24 h

after treatment. In this study, the time taken for removal of all fruit (50) from the cluster was evaluated. In addition, the proportion of detached fruit which retained a pedicel (stemmy fruit) was also determined. MeJA and Ethephon treatments resulted in a shorter time of mechanical shaking required to remove fruit from the cluster, indicating that the abscission agents were effective in enhancing fruit detachment (Fig. 4). MeJA and Ethephon treatments resulted in >75% reduction in the time required for fruit detachment (Fig. 4). MeJA resulted in a majority of the fruit being detached with the pedicel still attached (83%), indicating that this agent resulted in abscission at the pedicel/peduncle junction (Fig. 5). While ethephon also resulted in a significant amount of fruit detachment at the pedicel/peduncle junction, the proportion was lesser than that in the MeJA treatment (Fig. 5). The control had only a small proportion of fruit detachment at the pedicel/peduncle junction (6%). The above data demonstrate that abscission agents result in a reduction in the time required for fruit detachment by mechanical shaking. However, the data also indicate that these agents increase the proportion of stemmy fruit.

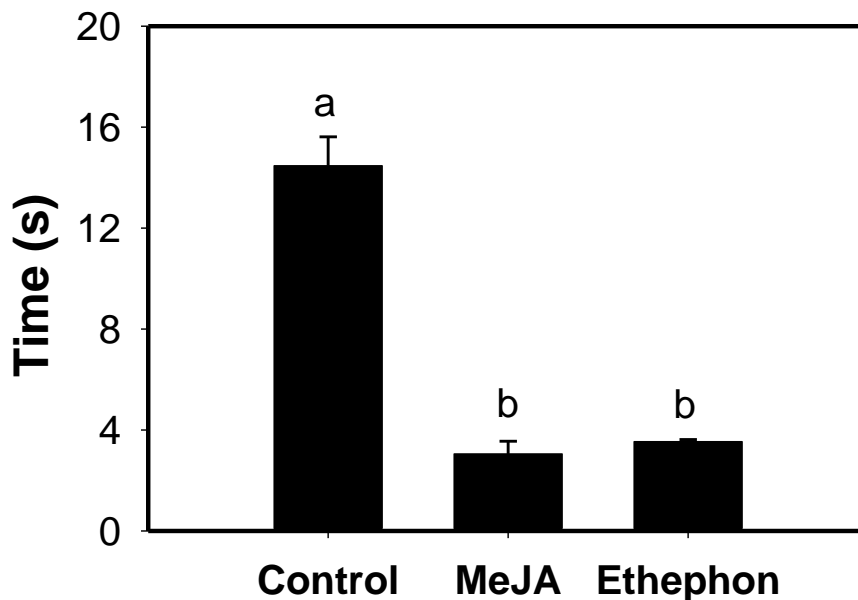


Figure 4: Fruit detachment by a mechanical shaker in response to abscission agent application. MeJA (20 mM) and Ethephon (1000 ppm) were applied and fruit detachment with a mechanical shaker was evaluated at 24 h after treatment. The time taken for removal of all the 50 fruit from a cluster is shown here. Error bars represent the S.E of the mean (n=3). Different letters above the bars indicate significant difference among means (Tukey's HSD). An outlier was removed from the Ethephon treatment.

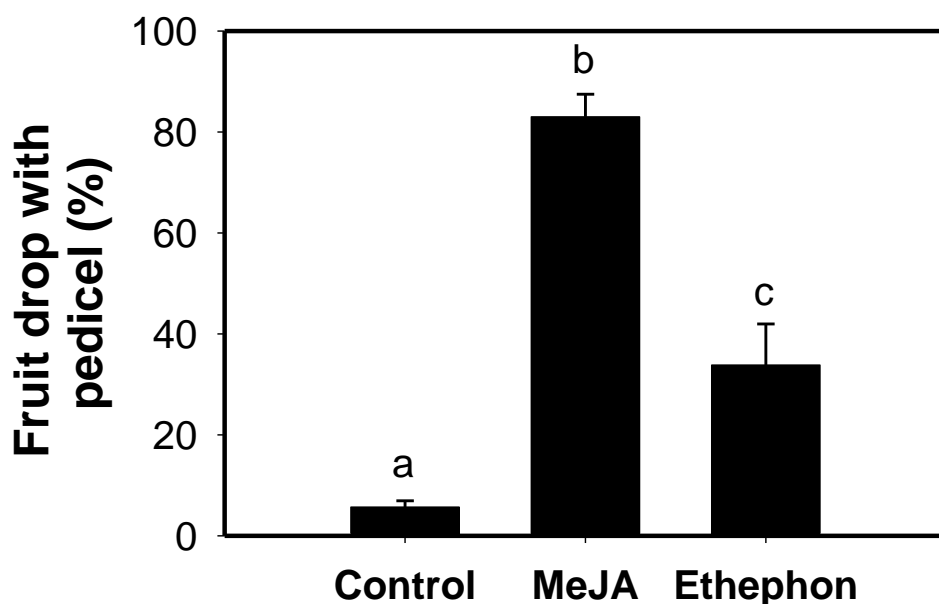


Figure 5: Percent fruit with pedicel in response to abscission agent application and mechanical shaking. MeJA (20 mM) and Ethephon (1000 ppm) were applied and fruit detachment with a mechanical shaker was evaluated at 24 h after treatment. The proportion of detached fruit with a pedicel is shown. Error bars represent the S.E of the mean (n=3). Different letters above the bars indicate significant difference among means (Tukey's HSD). An outlier was removed from the Ethephon treatment.

Conclusions

A portable mechanical shaker capable of consistent and effective fruit removal from blueberry was developed in this study. Effective rpm settings and a time for fruit removal was determined. The mechanical shaker was effective in fruit removal across cultivars. Fruit removal by the shaker was mainly at the berry/pedicel junction similar to that observed during mechanical harvesting. Further analysis will be performed across other cultivars and advanced selections (Co-PI's breeding program) in the following season. Abscission agent application resulted in a sharp reduction in the time required for mechanical shaking. However, the abscission agents, especially MeJA, resulted in a greater proportion of stemmy fruit.

Impact Statement

This study resulted in the development of a portable device for mechanical shaking in blueberry. As this tool may be utilized on individual branches, it is expected to offer a convenient, consistent and objective method for analysis of fruit detachment. The tool may be used by breeders to evaluate genotype suitability for mechanical harvesting. Additionally, this tool would be of immense utility in the evaluation of abscission agents for enhancing fruit detachment, as has been demonstrated here.

Citations: No publications have yet been developed from this study.

References

Krewer G., NeSmith D. S. 2000. Blueberry cultivars for Georgia. University of Georgia Fruit Publication 00-2.

NeSmith D. S. 2009. Blueberry cultivar development at the University of Georgia. A progress report for 2009. <http://www.smallfruits.org/Blueberries/production/alap09rep.pdf>

Malladi, A., and NeSmith D. S. 2010. Evaluation of rabbiteye blueberry cultivars and selections for fruit abscission characteristics. Final project report to the Southern Region Small Fruits Consortium.