FINAL PROJECT REPORT

Project Title: Implementation and evaluation of apple pollen tube growth models

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Tory Schmidt, Washington Tree Fruit Research Commission, Wenatchee, WA

Other funding sources: None

Total Project Funding: **$263,014.00**

Budget History:
Notes: **Virginia Tech and Washington State University submitted separate budgets as collaborative institutions.**

Budget 1
Organization Name: Virginia Polytechnic Institute and State University (Va. Tech)

Item	**2012**	**2013**	**2014**
Salaries*	35,762	37,192	38,680
Benefits	10,282	10,693	11,121
Equipment (laptop-field work)	1,500		
Supplies (lab &field)	1,500	1,500	1,500
Travel (to Wash. St. orchards)	5,000	6,000	6,500
Contractual services & repairs	1,250	1,250	1,250
Total	**$55,294**	**$56,635**	**$59,051**

***Note:** Salary for Research Specialist Leon Combs.

Budget 2
Organization Name: Washington State University ARC

Item	2012	2013	2014
Salaries	24,699	16,674	17,341
Benefits	9,490	6,534	6,796
Wages			
Benefits			
Equipment			
Supplies	1,000	1,000	1,000
Travel	2,500	2,500	2,500
Miscellaneous			
Total	**$37,689**	**$26,708**	**$27,637**

Footnotes: Partial salary support for Research Associate (Dr. Melba Salazar) and for Application Development Programmer (Mr. Sean Hill).

RECAP ORIGINAL OBJECTIVES

Our overall goal for 2012-14 was to collaborate with Washington State University and Washington Tree Fruit Research Commission to validate and implement pollen tube growth models for the most important commercial apple cultivars and to have those models generated in real-time through the AgWeatherNet portal (www.weather.wsu.edu). The specific objectives included:

1) Complete model parameters for Red Delicious, Honeycrisp, and Granny Smith (in 2013).
2) Guide collaborative effort to validate the models in commercial orchards and to incorporate the models into the AgWeatherNet website (Gerrit Hoogenboom, Melba Salazar, and Sean Hill).
3) Provide training to commercial apple growers on how to determine the desirable amount of king bloom open before "starting the model clock" (Combs, Virginia Tech).
4) Continue beta-testing of models for Gala, Fuji, Golden Delicious and Cripps Pink and begin beta-testing on Red Delicious and Honeycrisp (Combs, Virginia Tech).
5) Add plantings of Aztec and September Wonder Fuji and other new cultivars and strains for temperature testing (Combs, Virginia Tech).
6) Further develop reliable techniques for the study of a range of constant and variable temperatures and light conditions on pollen germination and pollen tube growth (Virginia Tech).

SIGNIFICANT FINDINGS

- Using real-time weather data we showed the pollen tube growth models to be a robust tool that can assist Washington apple growers in making more reliable bloom thinning decisions.
- Cultivar-specific models for Gala, Fuji, Golden Delicious and Cripps Pink were developed for pollen tube growth and were added to the AgWeatherNet website.
- The AgWeatherNet interface and output was found to be intuitive by the beta-test participants.
- Site-specific temperature data from AgWeatherNet's large network of weather stations allowed the model to be tested in many different microclimates.
- Integrating 48-hours of forecasted hourly temperature data into the pollen tube growth model algorithms allowed growers to schedule bloom-thinning sprays in advance.
- Validation of the models included sampling flowers from the field to determine the percent of flowers that had been fertilized.
- When compared with lab measurements, beta-test participants were very capable of measuring style length in the field.
- Comparisons between field evaluations of desired bins per acre and the actual harvested bins per acre showed that beta-test participants often achieved their targeted crop load. The beta-testers also reported to have improved return bloom the following year.
- Comparing the desired yield with the actual harvested yield demonstrated that the beta-test participants were able to understand the principles of the model, as well as access the models through the AgWeatherNet website.
- Comparisons between temperature sensors in commercial orchards and the nearest AgWeatherNet weather station showed nominal variation in model outputs, thus giving a high level of confidence in using the AgWeatherNet systems with the pollen tube growth model.

RESULTS AND DISCUSSION

In 2012, the Excel spreadsheets (Figure 1) that were previously used for tracking pollen tube growth, were incorporated into the WSU's AgWeatherNet website (Figure 2). To date, we have developed models for Gala, Golden Delicious, Fuji and Cripps Pink (Pink Lady). The AgWeatherNet interface was presented to industry representatives and beta-testers through a series of training sessions held in Naches, WA and Chelan, WA in early April 2012. Approximately 60 orchards amounting to several hundred acres of apples were used as beta-test field sites in 2012. In addition to the implementation of the pollen tube growth models on the AgWeatherNet, field testing continued to validate and expand the effectiveness of the modeling program. Validation included checking whether flower samples collected in Washington orchards were fertilized after thinning chemicals were applied by comparing model-predicted pollen tube growth versus actual growth in flowers (visualized with the use of florescence microscopy). In addition, yield data was recorded for the 2012 season (Figure 3).

Through growth chamber work conducted at Virginia Tech's Alson H. Smith, Jr. AREC (Winchester, VA) new pollen tube growth models were developed. Our work in 2012 focused on Honeycrisp, Red Delicious, and Granny Smith. The Honeycrisp was beta-tested through the AgWeatherNet site by a select group of growers during the 2013 growing season, and then by a larger beta-test group in 2014. Growth chamber tests in 2013 on Granny Smith and Red Delicious allowed us to release those models to select beta-testers in 2014. In 2014, Gala, Golden Delicious, Fuji, and Cripps Pink models were available to all registered users of the AgWeatherNet website. In 2014, we also started beta-testing the Red Delicious and Granny Smith models in commercial orchards. We highly recommend another two years of beta-testing the Red Delicious and Granny Smith models before these models are publicly released.

Temperature data collected by weather stations in the AgWeatherNet system showed nominal variation for the pollen tube growth model compared with temperature data-loggers placed in commercial orchards (Figure 4). Field sample tests were conducted in orchards on hand-pollinated flowers that were harvested at mid growth range intervals (48 and 72 hours after pollination) and evaluated in the laboratory to track actual growth versus predicted model growth (Figure 5).

A total of 145 models beta-test sites were used for validation and verification of the pollen tube growth models in 2014. These test sites spanned Washington's apple growing regions and gave valuable data and feedback concerning model-predicted timing of bloom applications versus grower projected timing. As seen in Figures 6, 7, and 8, which show the average style lengths (determines the time point when the model recommends application of first bloom thinning), the actual application timing can be altered by the model user to adhere to more specific conditions in the field. The final decision for application timing always rests with the user in the field.

Grower/beta-tester feedback has been given throughout the development of the models. Surveys sent to beta-testers regarding models have been useful in identifying problem areas of understanding how and what to do to when setting up and maintaining grower model data sets. Retrievable historical model data will give growers access to previous years' model application timings for comparison to present day environments. Additionally at fall 2014 model evaluation meetings, beta-besters expressed concerns regarding pollen tube growth rates at lower temperatures and requested additional testing in that area be conducted. This feedback is vital to the development of modeling programs.

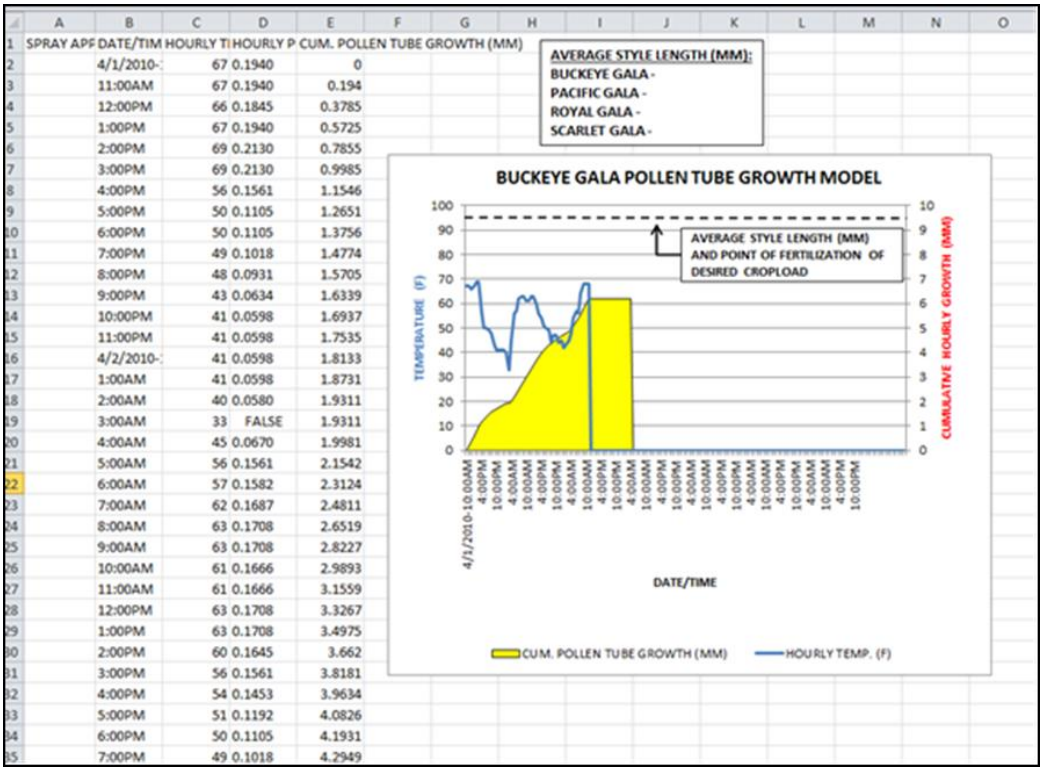

Figure 1. The pollen tube growth model in the Excel worksheet format.

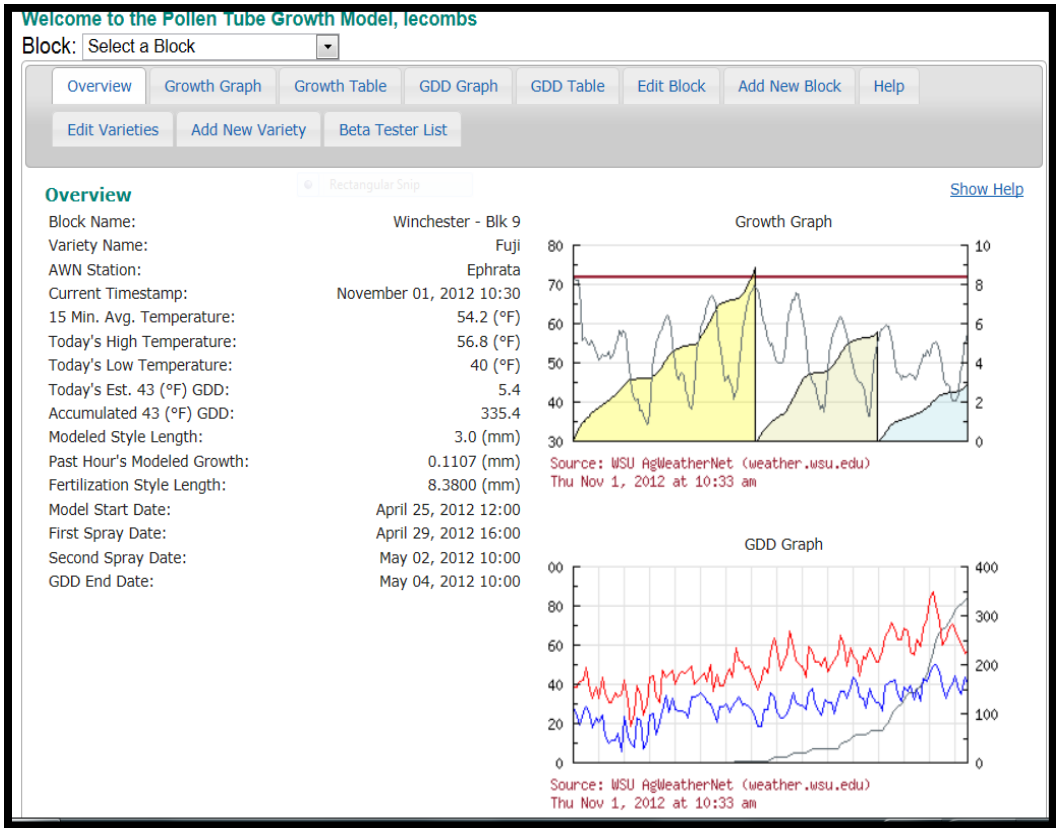

Figure 2. The pollen tube growth model in the WSU AgWeatherNet format.

POLLEN TUBE MODEL HARVEST DATA FOR BETA-TEST SITES IN QUINCY, WA (2012)			
CULTIVAR / STRAIN	**DESIRED YIELD (BINS / ACRE)**	**ACTUAL YIELD (BINS / ACRE)**	**% DESIRED YIELD (BINS / ACRE)**
Gala (Pacific)	**50**	**55.7**	**111**
Fuji (Nagafu 6)	**35**	**23.5**	**67**
G. Del. (Standard)	**55-60**	**61.8**	**103**
G. Del. (Standard)	**55-60**	**50.3**	**84**
Fuji (TAC114)	**35**	**27.4**	**78**
Fuji (TAC114)	**35**	**22.4**	**64**
FUJI (Early)	**40**	**38.7**	**97**
Cripps Pink Lady	**45**	**40.3**	**90**
Gala (Pacific)	**45**	**44.0**	**98**
G. Del. (Smoothie)	**55**	**32.1**	**58**

Figure 3. Harvest totals for 2012 comparing desired crop load versus actual harvest totals at beta-test sites in Quincy, WA.

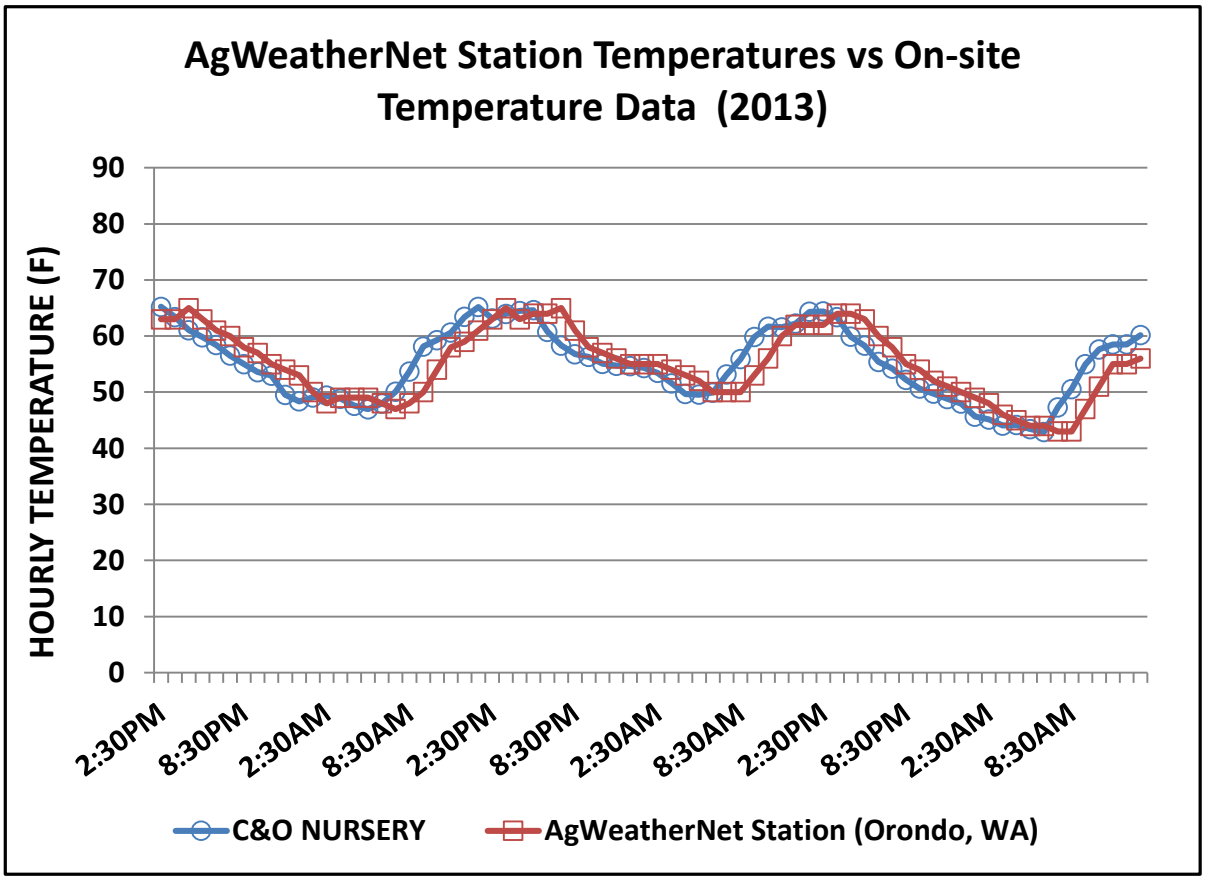

Figure 4. AgWeatherNet weather station data versus actual on-site temperature data-loggers.

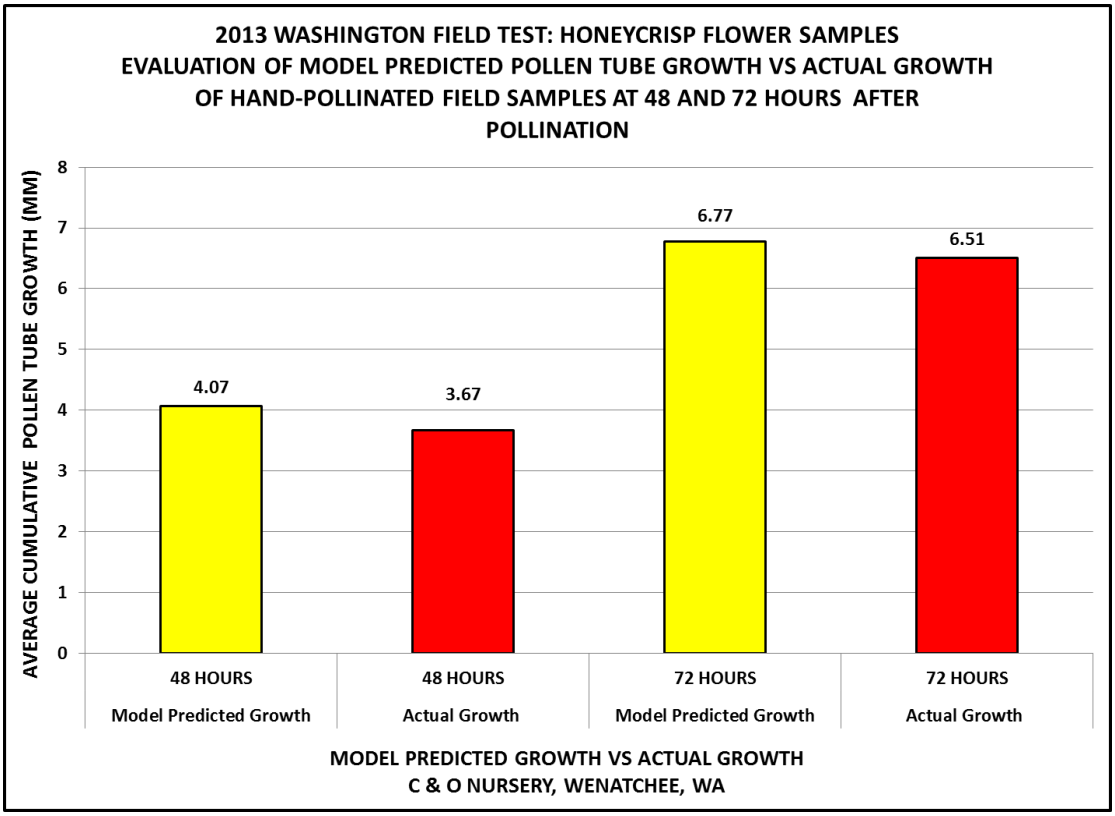

Figure 5. Model predicted growth versus actual growth.

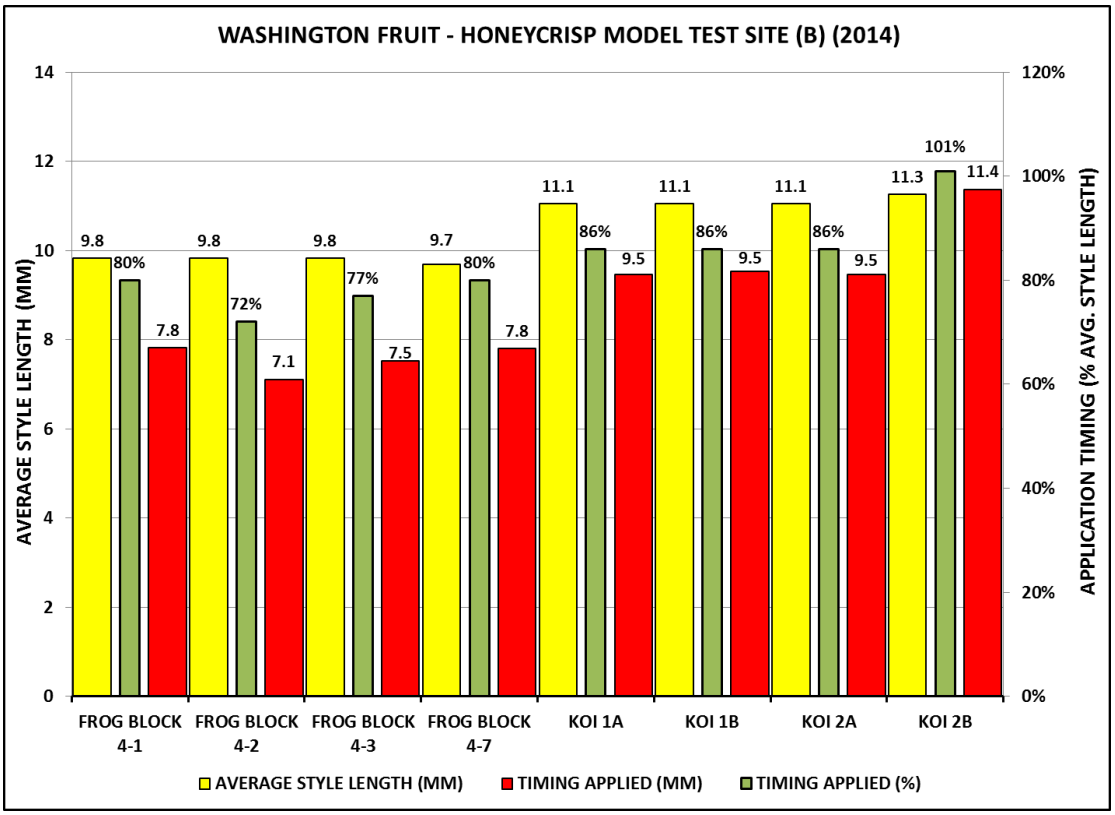

Figure 6. Model predicted timing versus actual application timing by grower.

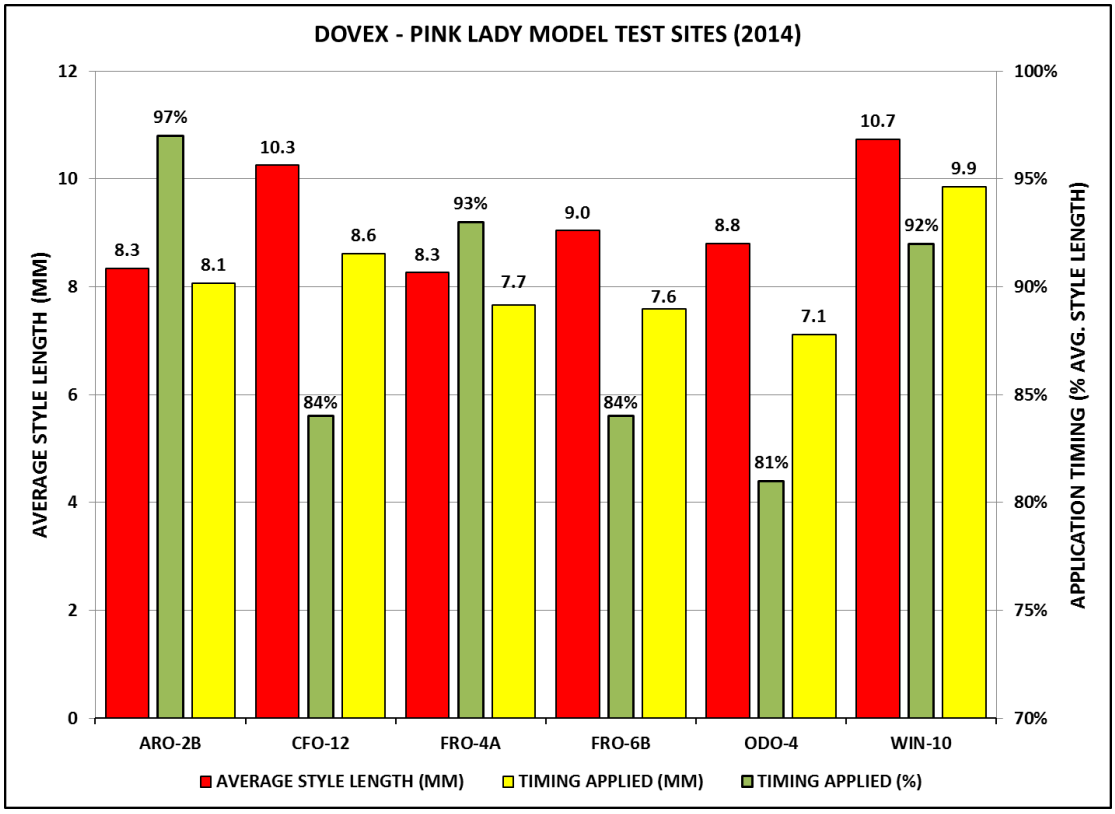

Figure 7. Model predicted timing versus actual application timing by grower.

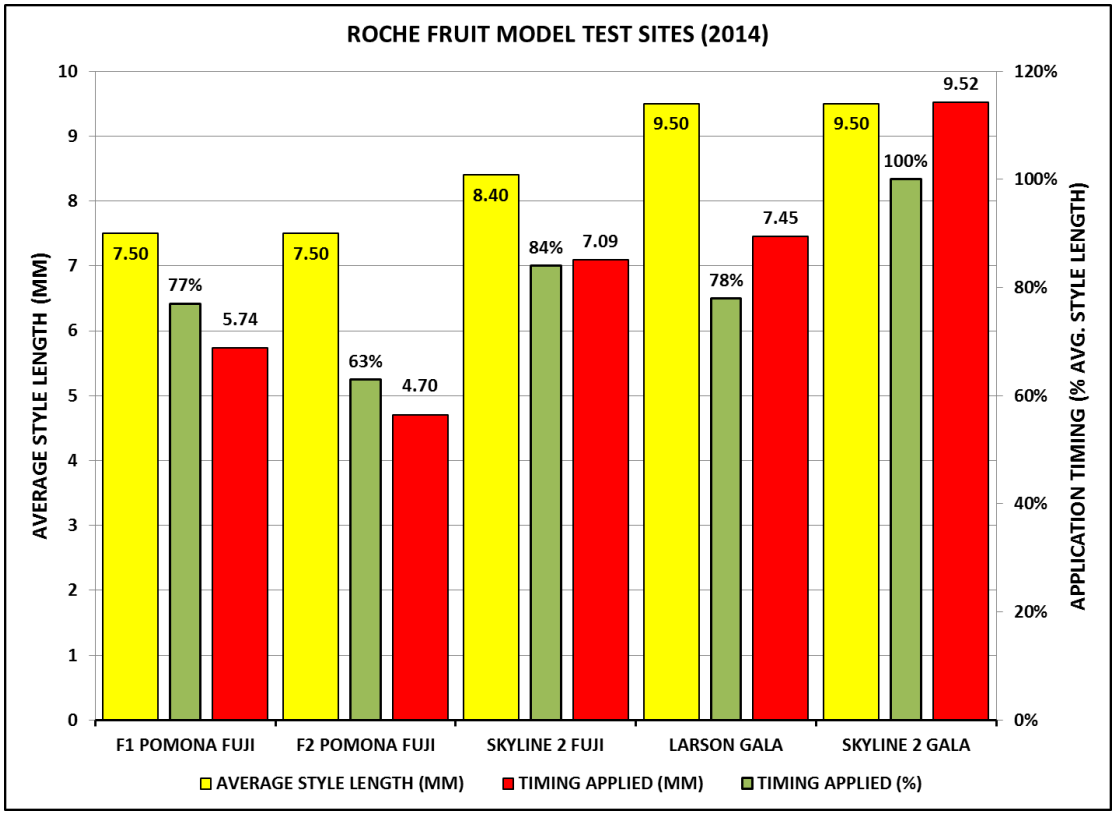

Figure 8. Model predicted timing versus actual application timing by grower.

EXECUTIVE SUMMARY

In apple (*Malus Xdomestica* Borkh.) production, crop thinning during bloom produces the largest fruit, the greatest return bloom in the following year, and reduces biennial bearing. The application timing for this spray has been subjective, and in the past was usually based upon the percent of full bloom open (e.g., applications at 20 and 80% full bloom). While this approach became a standard practice in some growing regions, more precise application timing can be achieved through modeling the fertilization of the desired percent of king bloom needed to achieve a full crop at the desired fruit size. When this target is achieved, a bloom thinner can be applied so that later blooming flowers are prevented from setting fruit. By measuring pollen tube growth rates under controlled atmospheric conditions using growth chambers, we have developed a model that calculates the time required to fertilize the king bloom after pollination.

Using real-time weather data we are evaluating the model as an important bloom-thinning tool for Washington apple growers and this allows them to make immediate bloom thinning decisions. Cultivar-specific equations that we have developed for pollen tube growth have been built into the AgWeatherNet website. The web-based interface makes these models straightforward to use and the output results easy to understand. The generated information allows growers to schedule bloom-thinning sprays in advance by using a 48 hour projected temperature feature.

Properly timed bloom-thinning gives the grower the optimum advantage for producing the best quality fruit. Understanding the progression of pollen tube growth after pollination is critical in applying bloom thinners at the proper time. In addition to optimal sizing benefits, crop loads not sufficiently thinned could result in trees being thrown into biennial bearing with little or no crop in the 'off' year. The primary focus is to evaluate the pollen tube growth model for the wide range of growing conditions in Washington. Real-time weather station data specific to that growing region will be downloaded to the AgWeatherNet model interface for program assimilation.

We thank the Washington Tree Fruit Research Commission for their continuing support of this project. We would also like to thank the following Washington growers who have supported this research project as beta-testers and/or allowed us access to their orchards to conduct research: Dovex Fruit, Stemilt Growers, Washington Fruit & Produce Co., Roche Fruit, Chelan Fruit Company, C & O Nursery, and Columbia Basin Nursery. In addition we would like to thank the support staff at Washington Tree Fruit Research Commission for their help with this project.