FINAL PROJECT REPORT

Project Title: Pollen tube growth model validation & utilization for flower thinning

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Total Budget for Virginia Tech:
Year 1: $43,591 Year 2: $43,591

Other funding sources: The Virginia Agricultural Experiment Station and the Hatch Program of the National Institute of Food and Agriculture, USDA, provide partial funding through salary support for Yoder and Peck, as well as the Virginia Tech facilities. Indirect support is also provided through the AgWeatherNet Program of Washington State University and its 177 automated weather stations.

BUDGET

Item	**2015**	**2016**
Salaries*	27,000	27,000
Benefits	13,298	13,298
Wages (4 wks, 20 hr/wk @ $15	1,200	1,200
Benefits	93	93
Equipment		
Supplies	1000	1,000
Travel	0	0
Contractual services & repairs	1,000	1,000
Plot Fees		
Total	$43,591	$43,591

***Note: Salary for Research Specialist Leon Combs; Wage person TBD.**

RECAP OF ORIGINAL OBJECTIVES:

Develop low-temperature pollen tube growth rates to allow for more precise pollen tube growth models for all seven varieties (Golden Delicious, Gala, Fuji, Pink Lady, Honeycrisp, Granny Smith and Red Delicious models) (Virginia Tech).

During our 2014 stakeholder meetings with the pollen tube growth model beta-testers, it became apparent that we needed to further explore the effects of low temperatures on the pollen tube growth model. In particular, the beta-testers felt that the model was underestimating the amount of pollen growth that occurs at temperatures below 55ºF. In developing the models, our earlier focus had been on temperatures that are more typical during bloom. When the model was brought into field situations, we extrapolated the empirically derived curves for the pollen tube growth that occurred below 55ºF. However, it is possible that the actual curve does not follow the predicted trajectory, and thus, empirical data is needed to develop more precise low-temperature pollen tube growth rates. These data will be extremely important in years when there are cooler than normal temperatures during bloom.

We will conduct these low-temperature tests on all of the cultivars for which we have developed pollen tube growth models, including Golden Delicious, Gala, Fuji, Pink Lady, Honeycrisp, Granny Smith, and Red Delicious. Better understanding of the effects of temperature on these processes and more attention to actual temperatures during the bloom period will improve the accuracy of post-fertilization application timing, thereby providing more reliable bloom thinning results. By comparing temperature data from various beta-test sites from across the Washington apple growing regions, we can better evaluate the effects of low temperatures on model parameters.

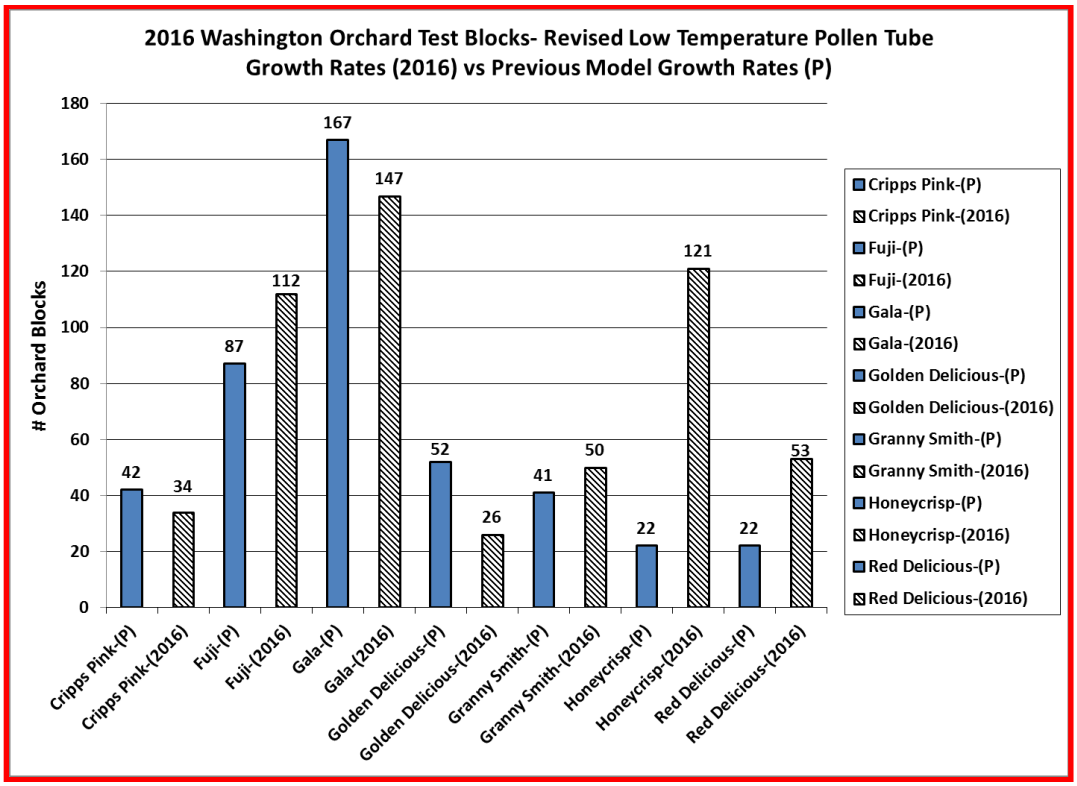


Figure 1. Number of test sites in 2016 using present model (P) vs Low temperature growth rate models (2016).

SIGNIFICANT FINDINGS

Low-temperature pollen tube growth rates from the first year of low temperature testing were compared to present model parameters on all models. The following graphics show hourly differences

between presently used models prediction of timing of first bloom spray vs predicted spray timing using the 1st year preliminary growth rate for each model. Also shown is the percent of hours that temperatures were below 55°F from start of model to application of first bloom thinning spray at each location in 2015. As shown in charts 1, 3, 5, 7, 9, and 11, hours below 55°F during bloom varied significantly across different growing regions and cultivars as shown above below from data taken during usage of pollen models at selected locations during the 2015 bloom thinning season.

Golden Delicious

- Percent of hours below 55°F from start of model fertilization period to first bloom thinning spray at four locations in 2015 ranged from 43% to 88% (Chart 1).
- Differences in application timing (hours) comparing present model versus first year low temperature test data ranged from 4 hours to 22 hours (Chart 2).
- First bloom thinning spray would have been applied earlier than present model predicted application timing if first year low temperature research testing parameters were used.

Chart 1

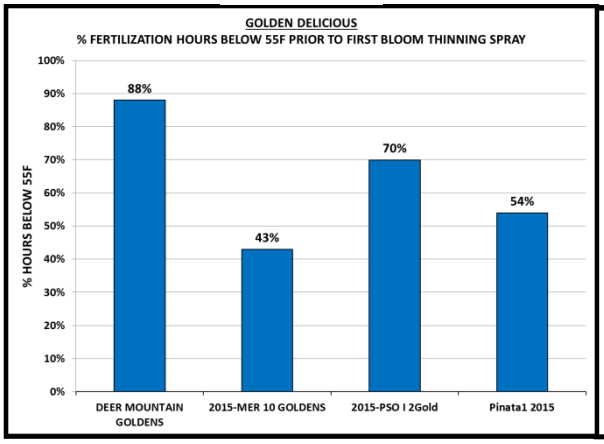
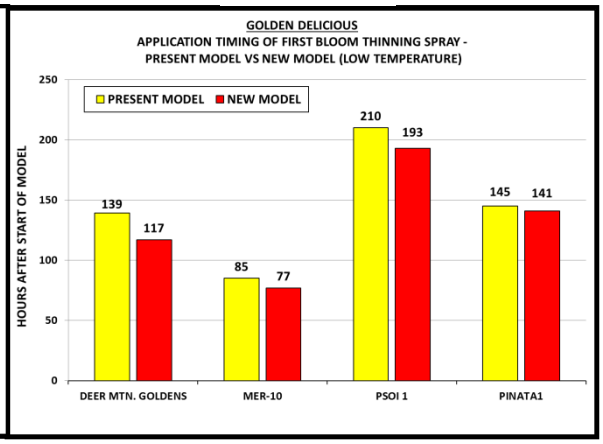


Chart 2



Gala

- Percent of hours below 55°F from start of model fertilization period to first bloom thinning spray at four locations in 2015 ranged from 30% to 88% (Chart 3).
- Differences in application timing (hours) comparing present model versus first year low temperature test data ranged from 3 hours to 18 hours (Chart 4).
- First bloom thinning spray would have been applied later than present model predicted application timing if first year low temperature research testing parameters were used.

Chart 3

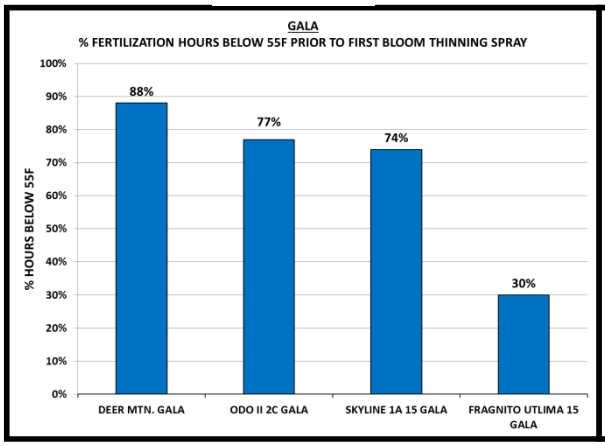
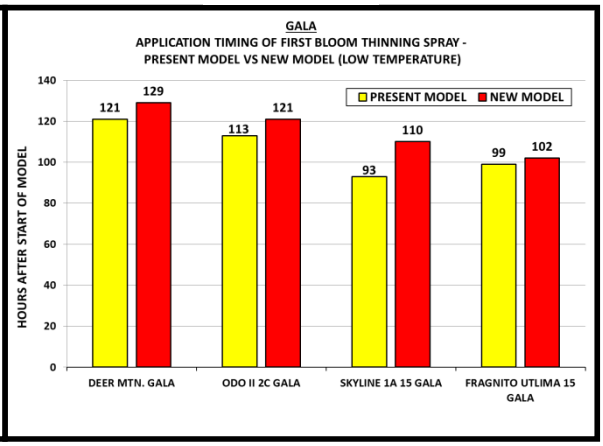


Chart 4



Fuji

- Percent of hours below 55°F from start of model fertilization period to first bloom thinning spray at four locations in 2015 ranged from 48% to 89% (Chart 5).
- Differences in application timing (hours) comparing present model versus first year low temperature test data ranged from 5 hours to 32 hours (Chart 6).
- First bloom thinning spray would have been applied earlier than present model predicted application timing if first year low temperature research testing parameters were used**.**

Chart 5

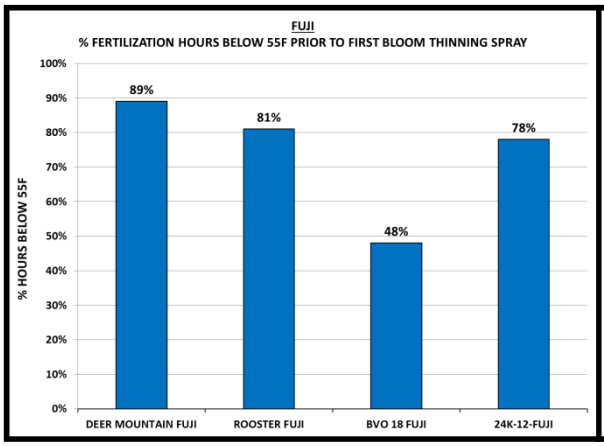
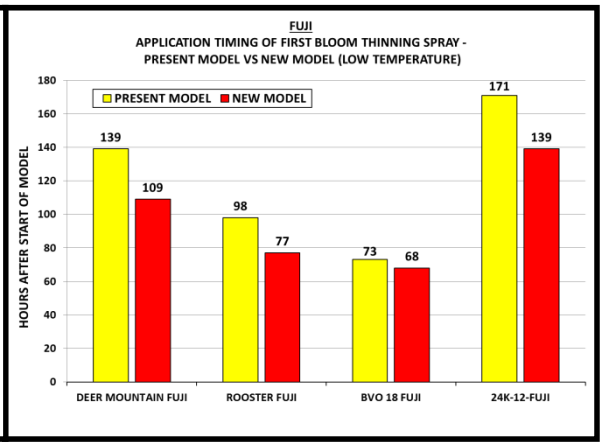


Chart 6



Cripps Pink

- Percent of hours below 55°F from start of model fertilization period to first bloom thinning spray at four locations in 2015 ranged from 68% to 78%.
- Differences in application timing (hours) comparing present model versus first year low temperature test data ranged from 18 hours to 25 hours.
- First bloom thinning spray would have been applied earlier than present model predicted application timing if first year low temperature research testing parameters were used.

Chart 7

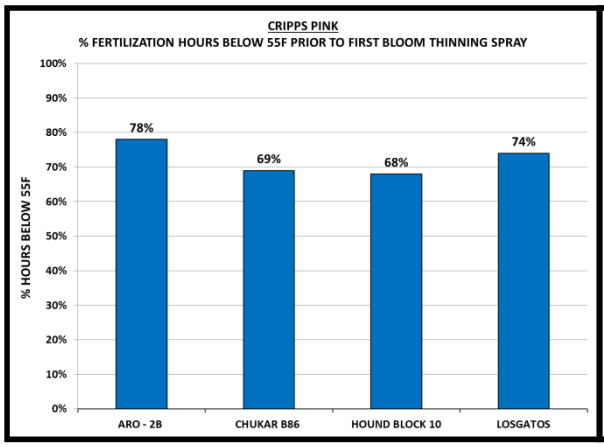
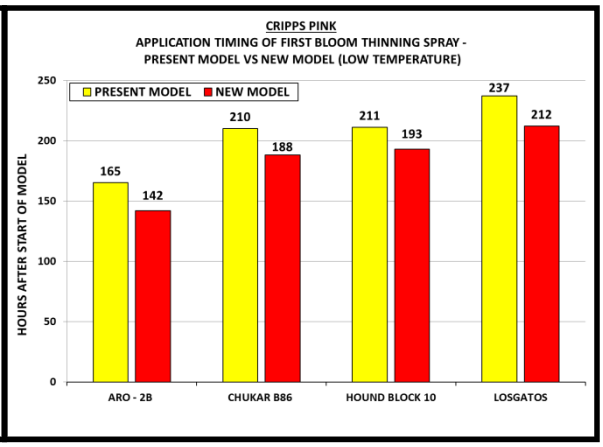


Chart 8



Honeycrisp

- Percent of hours below 55°F from start of model fertilization period to first bloom thinning spray at four locations in 2015 ranged from 37% to 64% (Chart 9).
- Differences in application timing (hours) comparing present model versus first year low temperature test data ranged from 1 hour to 30 hours (Chart 10).
- First bloom thinning spray would have been applied earlier than present model predicted application timing if first year low temperature research testing parameters were used**.**

Chart 9

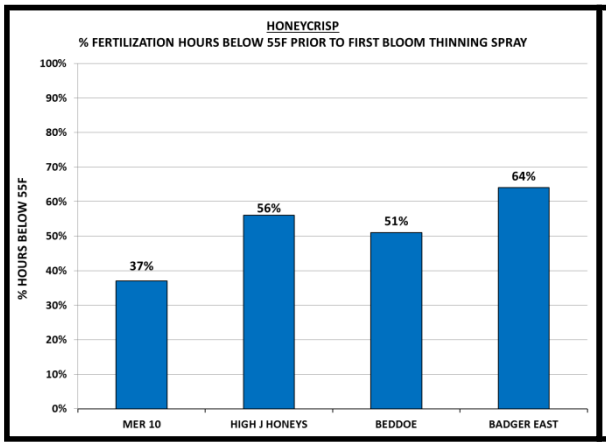
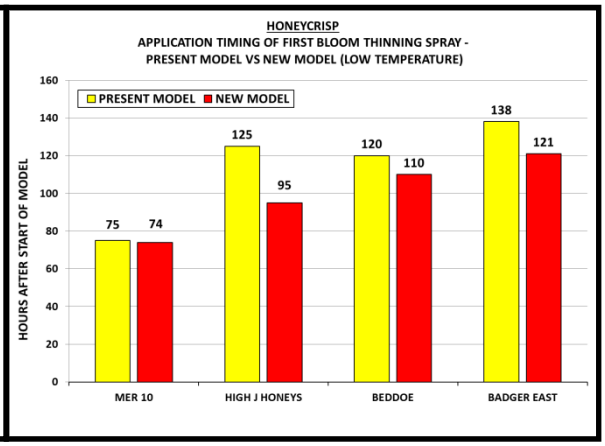


Chart 10



Granny Smith

- Percent of hours below 55°F from start of model fertilization period to first bloom thinning spray at four locations ranged from 37% to 74% (Chart 11).
- Differences in application timing (hours) comparing present model versus first year low temperature test data ranged from 2 hours to 53 hours (Chart 12).
- First bloom thinning spray would have been applied earlier than present model predicted application timing if first year low temperature research testing parameters were used.

Chart 11

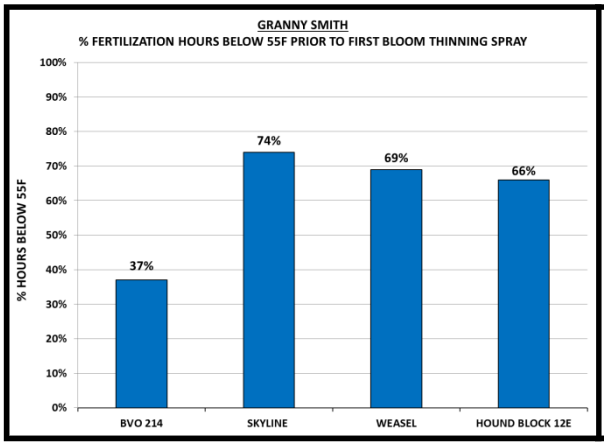
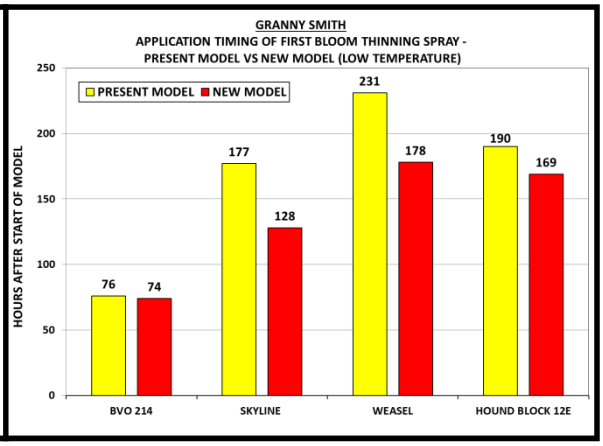


Chart 12



Red Delicious

- Percent of hours below 55°F from start of model fertilization period to first bloom thinning spray at four locations ranged from 78% to 81% (Chart 13).
- Differences in application timing (hours) comparing present model versus first year low temperature test data ranged from 6 hours to 22 hours (Chart 14).
- First bloom thinning spray would have been applied later than present model predicted application timing if first year low temperature research testing parameters were used.

CHART 13

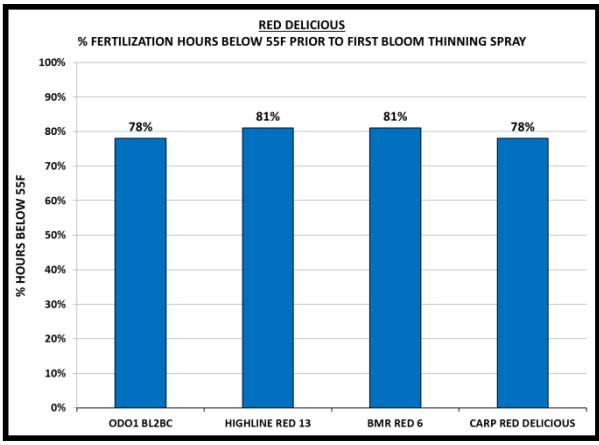
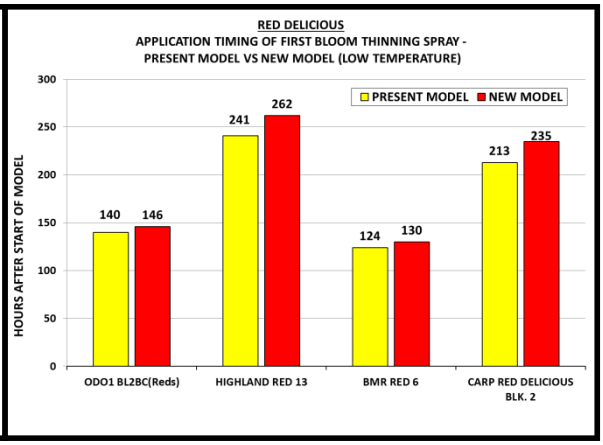


CHART 14



RESULTS AND DISCUSSION

The purpose of this research was to evaluate the effect of lower temperatures during bloom on the rate of pollen tube growth projected by the present pollen tube growth models presently available on the AgWeatherNet site. Prior to 2016, hourly growth rates for modeled pollen tube growth were extrapolated by using 35°F as base for zero hourly growth of pollen tube. Previous experimental growth chamber work had concentrated only on hourly growth rates starting at 55°F. Concerns raised at meetings with beta-testers, growers, and industry representatives prompted the WTFRC to request research covering the lower temperature growth rates from 55°F to 35°F.

As shown in Figure 2, by implementation of the new growth rates on the Honeycrisp pollen tube growth model, the first application of bloom thinning sprays would have been applied earlier than when using the 2015 model growth rates. In 2015 first year low temperature tests in Gala and Red Delicious dictated bloom thinning application timing would have been later than predicted application timings using presently available 2016 models. In all other cultivar models, bloom thinning application timing would have been earlier using first year low temperature tests data.

In reviewing the use of the models by beta-testers it has become apparent that as the growers get more comfortable with using the models the more they are adapting them to fit the individual needs of the specific blocks they are using the models on. As we have emphasized at our training sessions and in personal contact with growers that modifying the models to adjust on-site conditions is their decision to make. Figure 3 shows the high degree of variation in temperatures from year to year below 55°F. It also shows the high variation in overall temperature which occurs from season to season that makes tracking the pollen tube growth rates and proper application timing of king bloom thinners so challenging.

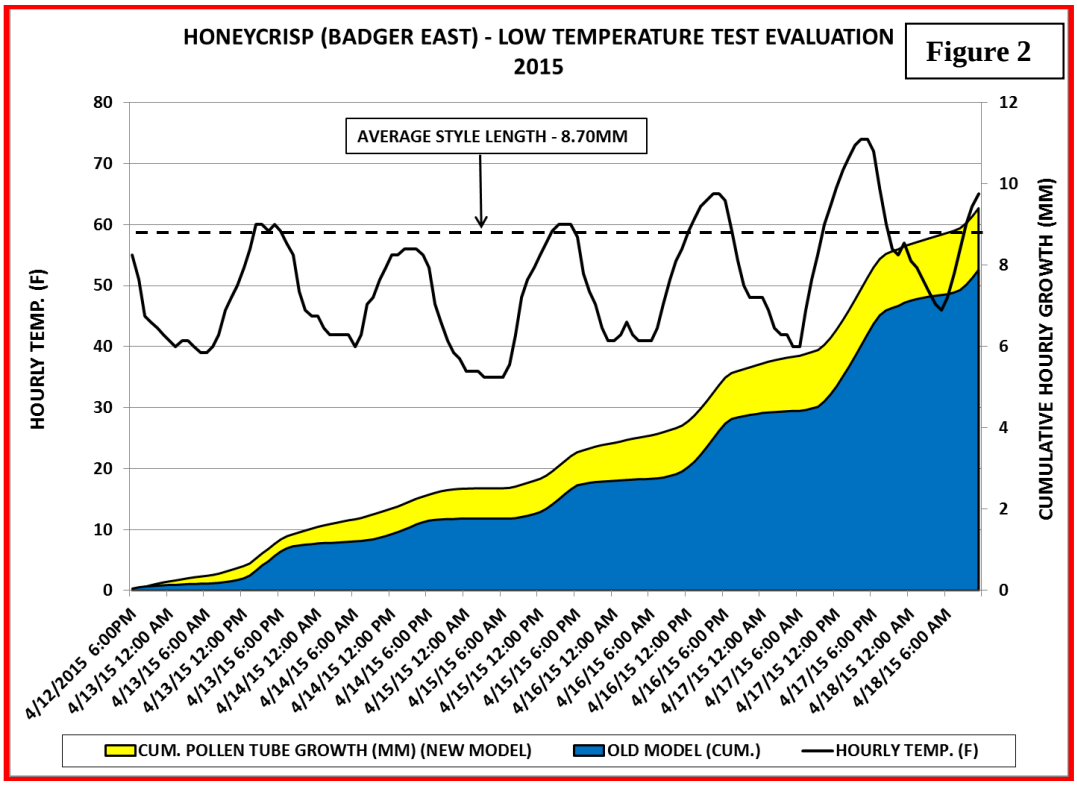


Figure 2. Comparison of effect of implementation of revised low temperature pollen tube growth rates vs previous model growth rates. The high amount of hours below 55°F shown in Figure 2 illustrates the need to re-consider the lower range of pollen tube growth below 55°F.

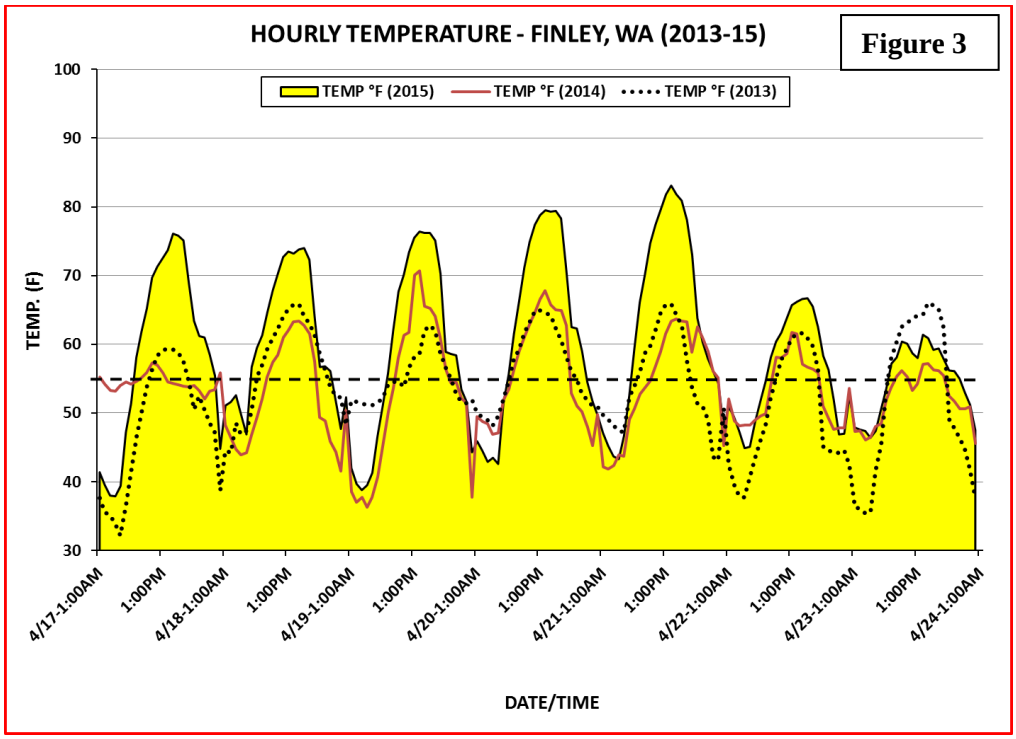


Figure 3. This graphic depicts the hourly temperature for Finley, WA for the same weekly period of April 17 to April 24 for 2013, 2014 and 2015.

EXECUTIVE SUMMARY

Temperature tests showed that in 2015 first bloom thinning application timing would have been later for Gala and Red Delicious than what is predicted by presently available 2016 models. In all other cultivar models, bloom thinning application timing would have been earlier using first year low temperature tests data.

As one beta-tester said when using the models "Don't assume anything". The most important part of using the models is to have as thorough an understanding of the specific block history as possible when preparing to use the model. The model can only tell you when it recommends applications to be applied. The information you input into the modeling program is the key to success or failure. Don't assume that just because you have an average style length of 10.5mm in Honeycrisp Block A (Adams Ridge) that Honeycrisp Block B (Pomona) will be the same. The more specific details you can input to the models, the more successful you will be at achieving the desired crop load goal. The primary goals of the models are to help reduce crop load, produce a volume of fruit that requires less hand thinning and also grows the desired fruit size for optimum pack-out. The model should also help to reduce biennial bearing the following year. The models enable the grower to schedule application timing in advance by using the 48 hour predicted growth and temperature data feature integrated into the model parameters.

These models are tools that can help the grower with crop load management, but they are only one tool and not a silver bullet that answers all the mysteries of bloom thinning. In talking with beta-testers, not all users follow all the steps laid out in the models' applications. How each user applies the models to their specific situation is up to their discretion. As was said earlier, the grower's knowledge of the block they are using the models on is the final deciding factor on how it will be used by them for applying bloom thinning applications at the proper time. The models cannot see what is happening at these locations, so final decisions rest with the people on the ground at the site. The decision of using these models in any form, or not using them at all, rests with the owners/growers, farm managers and field consultants.

We - suggest that training sessions should be conducted on how to use the models. In the past several years (2012-2015) we conducted training sessions at different locations throughout the Washington apple growing regions. As more new users sign up to access the models, repeated training sessions would be of great benefit to them in understanding the process of how to use the models properly. In working with the beta-testers, the one thing we have heard them say is, the more they use the models, the more comfortable they are with them. As for new users, we don't want them to try to use the models without proper training and then make a mistake that could have been avoided with better guidance. A bad experience using the models without proper training could result in new users doing a "one and done" test of the models and never using them again or having a negative opinion of the modeling program and passing that opinion on to others.