Apple Pollen Tube Growth Model

Adding some science to the art of chemical thinning

Virginia Tech
Invent the Future

Washington State University

Tory Schmidt, WTFRC  www.treefruitresearch.com
Apple pollen tube growth model

- Predicts how long it takes for flowers of different cultivars to be fertilized after they have been pollinated based on ambient temperature.
- This information can help inform crop load management decisions, especially timing of chemical bloom thinners (no more guesses like 20 & 80% bloom).
- *It’s a tool, not a silver bullet!*
What can the model do?

- Reduce risk of over- or under-thinning
- Help determine appropriate timings for chemical bloom thinning sprays
- Improve predictability of fruit set
- Facilitate logistical planning for spray crews during bloom
- Increase overall awareness of fruit set dynamics
What can’t the model do?

- Make up for previous management mistakes (pruning, nutrition, etc.)
- Prevent frost, hail, or equipment breakdowns
- Guarantee ideal spray conditions
- Directly inform postbloom thinning decisions
2002 – Ross Byers & Sue Wolf (VTU) funded by WTFRC to investigate pollination & potential thinning agents
2005 – Keith Yoder (VTU) joins project as PI
2008 – Rongcai Yuan (VTU) joins project; first year of field data collected in WA
2009 – First field validation by WA industry beta testers
2012 – Greg Peck (VTU), Gerrit Hoogenboom & Melba Salazar (WSU-AgWeatherNet) join project; beta testing hosted by AWN
How was the model developed?

• Dwarfed root-bagged trees are forced to bloom in a greenhouse

• Trees held dormant in cold room

• Pollen from selected pollinizers is harvested and stored

• Flowers are emasculated at full balloon stage, hand-pollinated, and tree is placed in growth chamber under predetermined climatic conditions
• Blossoms collected at planned intervals; pistils and ovules processed and stained to observe pollen tubes in the style.
• Fluorescence microscopy gives a view of germinating pollen grains and progression of pollen tubes down the style.
• This shows pollen tube growth over time at the selected temperature and indicates how soon fertilization would occur, based on style length.
• Fixed blossoms can be held for later analysis.
EXTENSIVE ON-SITE FIELD BETA-TESTING

WASHINGTON STATE

ALSEN H. SMITH JR., AREC
Grower inputs

1. Determine desired crop load
2. Count open flowers on 5-10 representative trees
3. Measure 25-50 style lengths gathered throughout the block
4. Check the model routinely during bloom
5. Use your head!
DIFFERENT GROWING SYSTEMS MAY REQUIRE A DIFFERENT APPROACH

• ON LARGE FREE STANDING BLOCKS COUNT TAGGED LIMBS OR VISUALLY ESTIMATE KING BLOOM OPEN

• ON TRELLIS BLOCKS WHOLE OR PART OF TREE MAY BE COUNTED OR VISUAL ESTIMATE MAY BE USED
STEP 1- ABCS OF DETERMINING KING BLOOM AVERAGE STYLE LENGTH
STEP 1- ABCS OF DETERMINING KING BLOOM AVERAGE STYLE LENGTH

A. KING BLOOM STYLE SAMPLES SHOULD BE TAKEN AS EARLY AS POSSIBLE TO ESTABLISH AVERAGE STYLE LENGTH OF VARIETY BEING TESTED.
STEP 1- ABCS OF DETERMINING KING BLOOM AVERAGE STYLE LENGTH

B. RANDOM FLOWER SAMPLING OF 25 – 50 FLOWERS ARE NEEDED TO ATTAIN AVERAGE STYLE LENGTH FOR TEST BLOCK AREA.
STEP 1- ABCS OF DETERMINING KING BLOOM AVERAGE STYLE LENGTH

C. MEASURE ONLY LONGEST STYLE FROM EACH FLOWER SAMPLED (SEE FOLLOWING SLIDES). AVERAGE LENGTH OF STYLES IS THEN USED AS BENCHMARK FOR FLOWER FERTILIZATION POINT FOR POLLEN TUBE GROWTH MODEL.
IN SOME VARIETIES (AS SHOWN ABOVE) STYLES MAY BE LONGER THAN ANTHERS WHILE IN OTHER ANTHERS MAY BE LONGER THAN STYLES.
MEASURE STYLES AS SHOWN FOR FLOWER STYLES MEASURED WITHOUT REMOVING FROM TREE
STYLES MAY BE REMOVED FOR MEASURING. CUT AT LOCATION SHOWN.
AFTER REMOVAL MEASURE ONLY LONGEST STYLE ON EACH FLOWER SAMPLED.
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Choose a username and enter your email address and a password so you can securely access the AgWeatherNet Data Portal.

Full Name: Sean E. Hill
Password: ************
Confirm Password: ************
Username: MyUserName
Password Requirements:
✓ At least 6 characters
✓ Contain only letters and numbers, no spaces

Email Address: sehill@wsu.edu
Confirm Email Address: sehill@wsu.edu

New User Information

Please provide the following information:

Organization: Washington State University AgWeatherNet
Address 1: 24106 N Bunn Road
Address 2: 
City: Prosser State: WA Zip Code: 99350
Create AWN Account

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Intention:
I plan on providing information products based on AgWeatherNet data to the public. My IP address is: 207.180.119.180 (pest20.proster.wsu.edu)
Registered!

Thank you MyUserName, your account has been created and you may now log in.
Add New Block

Welcome to the Pollen Tube Growth Model, MyUserName

Block: Select a Block  ☐  Current Season Only

Add New Block  Help

Add New Block

Block Name:  
Variety:  
Average Style Length (mm):  

AWN Station:  Select Station  
Model Start Date:  
Final Spray Date:  2014-07-01 00:00

Save New Block
Add New Block
Add New Block
Add New Block
Add New Block
Add New Block
Working With The Model
Working With The Model
Working With The Model
Working With The Model

Welcome to the Pollen Tube Growth Model, MyUserName

Block: West 40 □ Current Season Only

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## Working With The Model

Welcome to the Pollen Tube Growth Model, MyUserName

**Block:** West 40  
**Current Season Only:**

### Overview

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Forecast Temperature
Forecast Growth
Working With The Model

Welcome to the Pollen Tube Growth Model, MyUserName

Block: West 40  □  Current Season Only

Overview  Growth Graph  Growth Table  GDD Graph  GDD Table  Edit Block  Add New Block  Help

Base 43 (°F) Growing Degree Days Graph

Growing Degree Days
West 40; Gala; Chelan South, Chelan county
Jan 01, 2013 through May 04, 2013

Source: WSU AgWeatherNet (weather.usu.edu)
Fri Jan 10, 2014 at 8:28 am
Working With The Model

Select Different Block

Edit Model Inputs

Toggle On Screen Help

Edit Block

Block Name: West 40

This is the name of your block. Enter a descriptive name by which you refer to this block.

Variety: Gala

Select the variety of tree that you have planted in your block. If you do not find your variety listed here, please contact us for more information.

Average Style Length (mm): 10

This is the target style length for fertilization.

AWN Station: Chelan South

Select the nearest AgWeatherNet weather station.

Model Start Date: 2013-04-16 00:00

Select the date/time the model should start. This is the date and time where the estimated % or counted amount of king blooms are open for desired crop load.

1st Spray Date: 2013-04-20 09:00

Select the date/time of your first spray application.

2nd Spray Date: 2013-04-23 18:00

Select the date/time of your second spray application.

3rd Spray Date: 2013-04-27 09:00

Select the date/time of your third spray application.

4th Spray Date:

Select the date/time of your fourth spray application.

5th Spray Date:

Select the date/time of your fifth spray application.

Model End Date: 2013-04-29 00:00

Select the date/time the model should end.

Update Block
Hypothetical example

- Gala block where larger fruit is desired
- Spacing: 3’ x 12’ = 1210 trees/acre
- Desired yield: 60 bins peaking on 88s
- 60 bins x 24 boxes x 88 fruit = 126,720 fruit/acre or 105 fruit/tree
- As soon as typical trees have 105 flowers open, “start the clock” (activate pollen tube growth model)
Welcome to the Pollen Tube Growth Model, lecombs

Block: Select a Block

Add New Block
Block Name: WVU
Variety: Fuji
Average Style Length (mm): 8.15
GDD Base Temp (°F): 43

AWN Station: Pomona
Model Start Date: 2012-04-24 10:00
Final Spray Date: 2012-05-01 13:00

Save New Block
Welcome to the Pollen Tube Growth Model, lecombs

Overview

Block Name: WVU 1
Variety Name: Fuji
AWN Station: Pomona
Current Timestamp: February 28, 2013 07:15
15 Min. Avg. Temperature: 39.6 °F
Today's High Temperature: 0 °F
Today's Low Temperature: 0 °F
Today's Est. 43 °F GDD: 0.0
Accumulated 43 °F GDD: 0.0
Modeled Style Length: 0.3 (mm)
Past Hour's Modeled Growth: 0.1661 (mm)
Fertilization Style Length: 8.2500 (mm)
Model Start Date: April 24, 2012 10:00
First Spray Date: April 28, 2012 13:00
GDD End Date: April 28, 2012 13:00

Growth Graph

Source: WSU AgWeatherNet (weather.wsu.edu)
Thu Feb 28, 2013 at 7:17 am
## Pollen Tube Growth Model Table

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Welcome to the Pollen Tube Growth Model, lecombs
Block: WVU

Edit Block
Block Name: WVU
Variety: Fuji
Average Style Length (mm): 8.25
AWN Station: Pomona
GDD Base Temp (°F): 43

Model Start Date: 2012-04-24 10:00
1st Spray Date: 2012-04-28 13:00
2nd Spray Date:
3rd Spray Date:
4th Spray Date:
5th Spray Date:
Final Spray Date: 2012-04-30 15:00

FOR DETAILED EXPLANATION OF STEPS CLICK ON SHOW HELP LINK

STEP 1

STEP 2

CLICK ON UPDATE BLOCK

CLICK ON SHOW HELP LINK
Hypothetical example continued

- Apply first bloom thinning spray when model hits 100-110% of mean style length – the timing of this spray determines your fruit set.
- Entering spray timings reset the model to track tube growth in newly opened flowers.
- All subsequent sprays should be made when model is no more than 75% of style length to ensure no more fruit set.
- Strategy may be different in other scenarios (e.g. you want to set more lateral bloom).
SUBSEQUENT THINNING SPRAYS SHOULD BE APPLIED AS NEEDED BEFORE MODEL PREDICTED POLLEN TUBE GROWTH REACHES AVERAGE STYLE LENGTH
GOOSE RANCH - FINLEY, WASHINGTON
POLLEN TUBE GROWTH MODEL THINNING TEST
BUCKEYE GALA (2009)

TEMP. (F)

TEMP (F)

SPRAY #1-CUMULATIVE HOURLY GROWTH (MM)
SPRAY #2-CUMULATIVE HOURLY GROWTH (MM)
SPRAY #3-CUMULATIVE HOURLY GROWTH (MM)

AVERAGE STYLE LENGTH AND FLOWER FERTILIZATION POINT

ESTIMATED % KING BLOOM OPEN - 21 APR - 3:00PM
1ST BLOOM THINNING SPRAY - 25 APR - 7:00AM
2ND BLOOM THINNING SPRAY - 27 APR - 6:00PM
3RD BLOOM THINNING SPRAY - 1 MAY - 1:00PM

MODEL PREDICTED POLLEN TUBE GROWTH (MM)
Model limitations

- Assumes optimal bee activity and pollen availability/viability
- No models for secondary or niche varieties
- Unresolved questions about role of pollen source
- Normal use requires overly simplistic assumptions about efficacy of chemical thinners
“All models are wrong, but some are useful”
Suggestions for first uses

• Talk to a consultant or someone who has experience with the model
• Try it on with a small block
• Make a dry run – follow the model normally without spraying according to model timings
• Use the model to do a “post mortem” of your standard programs by entering those spray timings
• Play with it online before thinning season
Acknowledgments

• Virginia Tech
  – Leon Combs, Keith Yoder, Greg Peck, Ross Byers, Rongcai Yuan, Sue Wolf

• WSU AgWeatherNet
  – Sean Hill, Gerrit Hoogenboom, Melba Salazar

• WTFRC
  – Brandon Mulvaney, Mark Bell, Udel Mendoza, Ines Hanrahan, et al.

• Beta Testers
  – Kevin Larson, Harold Ostenson, Darin Case, Tom Butler, Harold Schell, et al.
THANKS!!

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www.treefruitresearch.com