Fruit Notes

Volume 80, Number 4: Fall, 2015

Fruit Notes

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Fruit Notes (ISSN 0427-6906) is published four times per year by the Stockbridge School of Agriculture, University of Massachusetts Amherst. **The cost of a 1-year hard-copy subscription is $40 for U.S. and $50 for non-U.S. addresses. The cost of a 1-year electronic subscription is $20.** Each 1-year subscription begins January 1 and ends December 31. Some back issues are available for $10 each. Payments via check must be in United States currency and should be payable to the **University of Massachusetts Amherst**. Payments by credit card must be made through our website: *http://extension.umass.edu/fruitadvisor/.*

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Tracking Fire Blight: Fighting Disease with Disease Forecasting

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While we can see insects, weeds and other kinds of pests, the microbes that cause disease usually can't be seen. We see the impact of diseases, symptoms such as cankers, rots, wilts and other damage, but that is long after the microbes have arrived and infected. To manage diseases effectively, we need to know when they will start to build up to dangerous levels before infection, then stop them. Using traps, pheromones or other insect pest management monitoring tools won't work for microbes. Instead we monitor those elements that drive pathogen growth and infection, particularly the weather. Weather data, particularly temperature, rain and humidity can be used to predict plant disease risk. To do this, weather data are entered into models that calculate risk. To get a good disease risk estimate, we need good weather data and a good model.

Fortunately, there are good fire blight models that can forecast pathogen growth and the risk of infection in apples. Knowing the risk of fire blight enables more accurate and effective spray decisions. Forecast models for streptomycin or other sprays are not the whole answer to fire blight management. Other tactics are required as described in "An Annual Fire Blight Management Program for Apples: An Update" in *Fruit Notes*, Spring 2015, but using a forecast model is a critical component. Fire blight models give growers a way to "watch" bacteria build up in an orchard without actually seeing them. Increasingly, pest management models, automated weather collection and weather forecasts, plus related treatment recommendations come bundled in computer-based decision support systems (DSSs).

In this article, we look at some common DSS options used for fire blight in the Northeast. These include NEWA (the Network for Environment and Weather Applications) managed by the New York State IPM Program, Ag-Radar managed by the University of Maine Extension, and the commercial product SkyBit (ZedX, Inc.). We will look at how each of these decision support systems work, and compare their performance at the University of Massachusetts Cold Spring Research and Education Center at Belchertown, MA in 2014.

Weather Data and Forecasts

There are basically two ways to collect weather data for a fire blight model: purchasing on-site equipment, or subscribing to a site-specific weather monitoring and forecast service that does not require an on-site weather station, so-called "virtual weather". While having a physical weather station on your property rather than using a virtual one may seem more reliable or accurate, this is not the case. Comparisons of virtual weather data to onsite weather stations used for disease forecasting indicate they perform equivalently (Gleason et al., 1997; Magarey et al, 2006; Cooley et al, 2011).

Weather station equipment. The most efficient weather station equipment is electronic and automated (Figure 1), recording data which is then routed to a computer that runs pest management models, such as a fire blight model. Alternatively, data may be downloaded to a computer manually, but it is more convenient to automate that process. Typically, weather data are collected at regular intervals and used in forecast model calculations.

There are several manufacturers of electronic weather stations, but stations need to be matched to the computer system and model that will process the weather data in a given DSS. NEWA is set up to accept data from Rainwise (Trenton, ME; http://www.rainwise.com) and Onset (Bourne, MA; http://www.onsetcomp.com/corporate) weather stations. NEWA also uses data from publically available stations at airports. Other weather stations, such as Davis (Hayward, CA; http://www.davisnet.com/weather/index.asp) and Spectrum Watchdog (Aurora, IL; http://www.specmeters.com/brands/watchdog/), cost less and are integrated with pest management software that can be run on individual personal computers, but we have not evaluated these

Figure 1. Electronic weather station.

DSSs.

The Rainwise and Onset stations used by NEWA generally cost from approximately $2,000, depending on the manufacturer and sensors purchased. Electronic weather stations require regular maintenance, need to be calibrated annually, and over time require repairs and sensor replacement. In our experience, parts costs for a station average $100 to $200 per year, though there is a wide range. Some stations function for several years with no replacement parts, others have required replacement parts within a year of being set up.

Weather stations should be calibrated annually, at least, to maintain data quality. Weather stations do not provide quality control; they simply report values. The accuracy of disease risk forecasts depends on the accuracy of weather data, so the level of quality control for weather data makes a difference to how good a disease forecast is. When a weather station fails, it may be immediately clear if the data are being monitored for quality. However if data are not being monitored, errors may go undetected for some time, leading to inaccurate risk forecasts.

In our experience, stations may break down for periods of a few hours to a week or more. NEWA automatically monitors weather stations, and if a weather station stops transmitting data the person in charge of the station is notified by email. However, detecting inaccurate data is more difficult. We have had cases where critical data such as temperature or the length of a wetting period has been inaccurately measured for long periods, leading to inaccurate disease forecasts. Maintaining continuous high-quality data from onsite weather stations requires significant effort and technical knowledge of the equipment.

Weather forecasts. On-site stations only provide weather observations. Weather forecasts are arguably more important for effective disease management, since chemical treatments generally are most effective if applied before infection. This is particularly true of fire blight management. While streptomycin is active within a 24-hour window after infection, it is most effective as a preventive treatment. In addition, post-infection chemical treatments are more likely to select for resistant strains of a pathogen than preventative treatments. In practice, users need to combine both past and forecast weather to evaluate risk and determine the need to spray.

DSSs that use on-site weather stations must also incorporate forecasts from some source. NEWA, for example, uses data from the National Digital Forecast Database, NDFD (http://www.nws.noaa.gov/ndfd/).

Site-specific virtual weather. Rather than setting up a weather station in an orchard, growers or consultants can subscribe to a service that generates virtual weather data for that orchard. Virtual data are created by combining different sources of actual weather observations (e.g. National Weather Service) with proprietary mathematical techniques which basically interpolate from the actual observations to estimate weather for locations distant from weather stations. In addition to being a substitute for station observations, site-specific virtual weather forecasts can be made.

Table 1. Risk level ranges for NEWA, Ag-Radar and SkyBit.

System	Risk Ratings
NEWA	**Low** - bactericides probably unnecessary. **Caution** - check the 5-day forecast, expect infection if warm weather continues (60°F or higher) and a wetting event occurs. **High** - expect infection if there is a wetting event, even a heavy dew. **Extreme** - the blossoms should be protected with streptomycin.
Ag-Radar Eastern Fire Blight Model	**No FB Infection** **Infection Risk** **Severe Infection Risk!**
Ag-Radar CougarBlight	**Low** **Caution** **High** **Extreme!** **Exceptional!**
SkyBit	**-** not active **++** infection

The most popular virtual weather subscription in the Northeast is SkyBit, which sells E-Weather service products. SkyBit offers an "AgWeather IPM Apple Disease Product" that includes virtual weather data and predictions of fire blight risk, as well as other diseases. Users can begin a subscription by calling in the geographic coordinates and elevation of an orchard and a starting date for the service. Alternatively, users can subscribe online (http://www.skybit.com/). Within one day, users will begin receiving weather and disease products via email or fax. Growers have the option of calling in a bloom date to improve the accuracy of the fire blight model used to make disease predictions, or may simply rely on the model's bloom estimate.

A subscription service can be activated only for those months when decisions will be made for pest control. Virtual stations require a subscription fee of approximately $200 to $400 for a growing season, depending on the length of time and types of products purchased. They come with quality control as part of the service.

Fire Blight Models

Models that analyze weather data to estimate fire blight risk follow generally understood relationships between the bacterial pathogen *E. amylovora*, the seasonal growth of apple hosts, and weather. As early as the 1950's, the plant pathologist William Mills at Cornell recognized a relationship between warm, humid weather and blossom blight, and suggested that streptomycin should be sprayed on blossoms when temperatures above 65° F and rain or high humidity were predicted. In the next 60 years, this basic approach has been significantly refined.

The primary focus for fire blight management is preventing blossom infections. Open flowers give *E. amylovora* a way to get into the tree where they produce toxins and destroy tissue (Figure 2). During the bloom

Figure 2. Pistils (green) and anthers (yellow) of an apple flower. Bacteria must be washed down the pistils to the base of the flower to infect (Photo: Penn State Univ. Extension)

Table 2. Comparison of different weather data sources for fire blight models.

System	Weather Record Source	Weather Forecast Source	Model
NEWA	On-site electronic weather station	Natl. Digital Forecast Database	CougarBlight
Ag-Radar Eastern Fire Blight Model	SkyBit virtual weather	SkyBit virtual forecast	MaryBlyt modification
Ag-Radar CougarBlight	SkyBit virtual weather	SkyBit virtual forecast	CougarBlight
SkyBit	SkyBit virtual weather	SkyBit virtual forecast	MaryBlyt modification

period, fire blight models estimate the reproduction of fire blight bacteria carried into open flowers, primarily by insects. Reproduction is driven by temperature, and heat unit accumulation is well correlated with fire blight infection potential. From 60º F to 70º F the bacteria grow slowly. They grow moderately between 70º F and 75º F, and rapidly between 75º F and 93º F. When temperatures are between 82º F and 90º F bacterial populations can explode, going from a few cells on each flower stigma to millions in a matter of hours. This rapid bacterial growth makes fire blight epidemics "appear out of nowhere".

Reflecting this explosive growth potential, fire blight models estimate bacterial populations based on degree **hours** or hourly heat units, NOT degree **days**. When sufficient heat has accumulated, the models estimate that there are enough bacteria in flowers to infect. A couple of days with temperatures in the 70's and 80's easily reach model thresholds. A single stigma in an apple blossom can support a million *E. amylovora* bacteria, far more than the minimum needed for infection.

Once the population of *E. amylovora* on pistils is high enough to cause infections, bacteria must be washed down to nectaries at the bottom of the flower, where they can move inside apple tissue. That requires water, such as rain. Other sources of moisture, such as heavy dew or the amount of water in a high volume orchard spray application may be sufficient to initiate infection, though this has not been definitively demonstrated.

CougarBlight and MaryBlyt. Two forecasting models or variants based on them are widely used in the Northeast: CougarBlight developed by Tim Smith in Washington state; and MaryBlyt originally developed by Paul Steiner in Missouri and Maryland, and modified by Alan Biggs in West Virginia. In addition to predicting blossom infections, MaryBlyt also predicts when the first appearance of different types of fire blight symptoms will occur, including blossom blight, shoot blight, canker blight and trauma blight. CougarBlight is a "blossom blight only" model. Both models require input on tree development, particularly open flowers, and environmental data, specifically temperature and rain. CougarBlight also asks for the history of fire blight in an area to adjust infection thresholds. If blight is in an area in the current growing season or was active the previous year, thresholds are lower than if there has been no blight in an area within

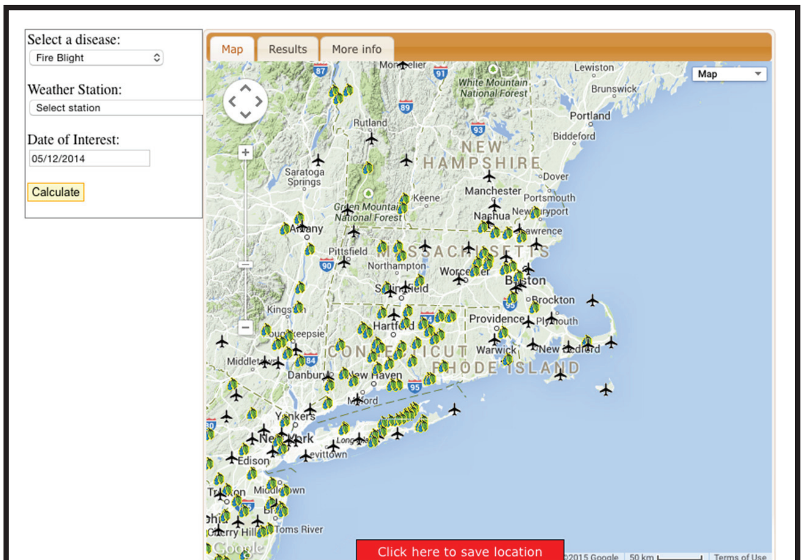

Figure 3. NEWA screen showing weather stations (leaf symbols) and airport weather (plane symbols) in New England and northeastern New York. A Belchertown, MA weather station is selected to run CougarBlight on May 12, 2014

Map | Results | More info

Fire Blight Risk Predictions for Belchertown

Blossom blight predictions using the Cougarblight model begin at first blossom open.

First blossom open date: 5/10/2014

First blossom open date above is estimated based on degree day accumulations or user input. Enter the actual date for blocks of interest and the model will calculate the protection period during bloom more accurately.

Orchard Blight History: Fire blight occurred in your neighborhood last year.

The orchard blight history above is the NEWA default. Select the actual blight history for your orchard and the model will recalculate recommendations.

Blossom Blight Summary - Cougarblight

	Past	Past	Current	Blossom Blight 5-Day Forecast (Forecast Details)				
Date	May 10	May 11	May 12	May 13	May 14	May 15	May 16	May 17
4-day DH	-	161*	457*	464*	540	491	276	313
Risk Level	-	Caution*	High*	High*	Extreme	High	Caution	High
Wetness Events								
Rain Amount	NA	0.04	0.00	0.09	0.00	0.00	0.65	1.11
Rain Prob (%) Night|Day ?			-|-	-|-	-|-	-|-	-|-	-|-
Dew ?	NA	Yes	No	No	Yes	Yes	Yes	No
Leaf Wetness (hours)	NA	6	0					

- *Low* - bactericides probably unnecessary, check the 5-day forecast for warm weather (60°F or higher) and wetting events.
- *Caution* - check the 5-day forecast, expect infection if warm weather continues (60°F or higher) and a wetting event occurs.
- *High* - expect infection if there is a wetting event, even a heavy dew.
- *Extreme* - the blossoms should be protected with streptomycin.

Figure 4. NEWA asks for the date of first bloom, and whether fire blight occurred last year, or is occurring in the current season. It then gives the risk of fire blight on each day. Here it shows "High" risk currently, and based on weather forecasts predicts risk will be High or Extreme for the next three days.

the past year.

These models can be run using daily high and low temperatures, and some simple tool such as a rain gauge to collect wetness data. For MaryBlyt, data may be entered into a personal computer on a day to day basis. CougarBlight does not require a computer, but simple calculations and a set of tables that indicate heat units and risk, though using a spreadsheet version of the model simplifies the process. Both MaryBlyt and CougarBlight are available on line. MaryBlyt 7.1 can be downloaded from West Virginia University's Kearneysville Tree Fruit Research and Education Center, http://www.caf.wvu.edu/kearneysville/Maryblyt/ . It runs only on the Windows OS. CougarBlight is available from the Washington State University Chelan-Douglas Extension site, where there are links to Excel spreadsheets in Fahrenheit and Celcius, http://county.wsu.edu/chelan-douglas/agriculture/treefruit/Pages/Cougar_Blight_2010.aspx . These sites also have excellent discussions of fire blight and its management, and instructions on use of the models.

It is easiest to use both models with automated weather data collection and forecasts. Both models have been adapted to different DSSs. In the Northeast, the most commonly used pest management DSSs that have fire blight models are NEWA, Ag-Radar and SkyBit.

NEWA. NEWA uses the CougarBlight model. Growers in Northeastern states can purchase a weather station and link to NEWA (http://newa.cornell.edu/). NEWA may also be used without a weather station in the orchard if there is a NEWA site nearby. But keep in mind, the further from an orchard a site is, the more difference there will be in weather and therefore in estimated fire blight risk. This difference can be the determining factor of whether or not conditions are met to allow blossom infection. (Figure 3)

Using NEWA to track fire blight risk is relatively easy. On the NEWA site, the orchard location, the crop and the disease of interest need to be identified through a series of selection steps. In the example here, a weather station at the UMass Cold Spring Orchard in Belchertown, MA has been selected to evaluate the risk of "Fire Blight" on Apples on May 12, 2014. NEWA automatically tracks weather data, so users do not need to enter it. Clicking the "Calculate" button will generate a table showing "Fire Blight Risk Predictions" for the location, in this case, Belchertown.

NEWA will ask you to enter the date of first bloom. This should always be the date that the first flowers of any variety in the orchard open. Since bloom is critical, and one day can make a big difference in fire blight risk, monitor trees closely for the beginning of bloom. (Figure 4) NEWA will also ask for "Orchard Blight History" as one of three options:

- No fire blight in your neighborhood last year.
- Fire blight occurred in your neighborhood last year.

Blossom Blight Summary - Cougarblight								
	Past	Past	Current	Blossom Blight 5-Day Forecast Forecast Details				
Date	May 10	May 11	May 12	May 13	May 14	May 15	May 16	May 17
4-day DH	-	161*	457*	-	75*	188*	269*	313
Risk Level	-	Caution*	High*	-	Low*	Caution*	Caution*	High
Wetness Events								
Rain Amount	NA	0.04	0.00	0.09	0.00	0.00	0.65	1.11
Rain Prob (%) Night|Day ?			-|-	-|-	-|-	-|-	-|-	-|-
Dew ?	NA	Yes	No	No	Yes	Yes	Yes	No
Leaf Wetness (hours)	NA	6	0					

Streptomycin Spray Date: 5/13/2014

Figure 5. The predicted impact on fire blight risk of a streptomycin spray applied on May 13 to the Belchertown orchard as estimated by NEWA.

- Fire blight is now active in your neighborhood.

This is a way of estimating inoculum levels. We recommend that growers be conservative and not use the lowest level, "no blight in the previous year".

The NEWA CougarBlight model shows past, current and forecast risk on one of four levels by day. In this example, risk is currently High. Based on the 5-day weather forecast for Belchertown, NEWA also predicts that fire blight risk will be High on May 13 and for the next 2 days. Based on this, this grower should apply a streptomycin spray as soon as possible.

NEWA also shows the effect of a streptomycin spray on fire blight risk (Figure 5). If streptomycin is applied on May 13 in the example, the forecast risk for the next 3 days ranges from Low to Caution, returning to High on May 17. A second streptomycin application may be needed at that time, depending on actual weather on May 13 through May 16.

The NEWA model can indicate when symptoms from a possible infection should first appear (Figure 6). In this example, to find out when symptoms from a May 12 infection should show up, lower down on the same page the "Infection Event Date" can be entered, and the first date of predicted symptom appearance will be calculated. In this example, symptoms from a May 12 infection should begin to show on May 25.

The same section of the NEWA screen also allows users to estimate when an infection occurred by entering a date when symptoms were first seen. In the example, suppose symptoms were seen on some trees for the first time on May 28. That date

Infection Event Date: 05/12/2014

Shoot Blight Infection for Belchertown

Fire blight symptoms on infected shoots show up when about 90 to 100 degree days base 55F have accumulated after an infection event.

Infection event:
May 12

Degree Days (base 55 BE) 5/12 through 5/25:
95

Check for symptoms starting on May 25

Symptom Occurrence Date: 05/28/2014

Shoot Blight Infection for Belchertown

Fire blight symptoms on infected shoots show up when about 90 to 100 degree days base 55F have accumulated after an infection event.

Symptom Occurrence Date:
May 28

Approximate Infection Date:
May 15

Degree Days (base 55 BE) 5/15 through 5/28:
94

Figure 6. NEWA predictions for first symptom appearance from a user-entered Infection Event Date (top), and estimate of the Approximate Infection Date from user-entered Symptom Occurrence Date (bottom).

```
E-WEATHER SERVICE                                    AGWEATHER IPM APPLE DISEASE PRODUCT
For: MA-BELCHERTOWN-HORTRESCENTER                                  Date: Tue May 13, 2014

                                     APPLE SCAB        FIRE BLIGHT       SOOTY BLOTCH
             WEATHER                   140414            140512             ------
      TMX TMN  PREC ARH LW          ASM AW TW  PW     ADH AW TW  PW      ALW      PW
Date  F   F     in   %  hr           %  hr  F         65F hr  F           hr
==== === === ===== === ==          ==== == === ==    ==== == === ==     =====    ==
BASED ON OBSERVATIONS
0501  65  44  1.01  88 24            2  50  47 ++      -   -   -  -        -       -
0502  63  47  0.00  56  8            2  58  48 ++      -   -   -  -        -       -
0503  64  44  0.00  58  0            3   0   -  +      -   -   -  -        -       -
0504  58  48  0.00  58  0            3   0   -  +      -   -   -  -        -       -
0505  61  47  0.00  56  0            4   0   -  +      -   -   -  -        -       -
0506  61  41  0.00  50  0            5   0   -  +      -   -   -  -        -       -
0507  65  36  0.00  45  0            6   0   -  +      -   -   -  -        -       -
0508  64  42  0.00  67  0            8   0   -  +      -   -   -  -        -       -
0509  58  53  0.11  87 23           10  23  56 ++      -   -   -  -        -       -
0510  78  58  0.55  78 20           14   8  65 ++      -   -   -  -        -       -
0511  77  54  0.00  39  5           19  13  63 ++      -   -   -  -        -       -
0512  83  50  0.00  47  0           26   0   -  +     170  0   -  -        -       -
BASED ON FORECASTS
0513  60  49  0.00  61  0           31   0   -  +     170  0   -  -        -       -
0514  69  46  0.00  68  0           37   0   -  +     188  0   -  -        -       -
0515  71  58  ----  79 10           46  10  64 ++     225 10  64 ++        -       -
0516  71  61  ----  83 22           55  22  66 ++     225 22  66 ++        -       -
0517  67  57  ----  86 24           63  46  64 ++     225 46  64 ++        -       -
0518  67  53  ----  74 24           70  70  62 ++     225 70  62 ++        -       -
0519  63  48  ----  70 11           75  81  61 ++     225 81  61  +        -       -
0520  63  47  ----  71  0           80   0   -  +     225  0   -  -        -       -
0521  65  47  ----  70  0           84   0   -  +     225  0   -  -        -       -
0522  66  48  ----  69  0           87   0   -  +     225  0   -  -        -       -
=========================================================================================
*********  IMPORTANT:  Check the dates at the top of each column.  *********
 Green Tip Date    - is used for Apple Scab
 Blossom Date      - is used for Fire Blight
 Petal Fall Date   - is used for Sooty Blotch

 ASM = Apple Scab Maturity Percentage
 ADH = Accumulated degree-hours from blossom date up to a max of 225.
 ALW = Accumulated leaf wetness hours from petal fall date.
 AW  = Accumulated wetness hours for the most severe event.
 TW  = Average temperature during the most severe event.
 PW  = Pest Wait/Watch/Warning:  - = not active
                                 + = active but no infection
                                ++ = possible infection & damage

******  ATTENTION: Please report your biofix dates (1-800-454-2266) ********
Please call 1-800-454-2266 to report your biofix dates for Green Tip,
Blossum, and Petal Fall. Your product will NOT be correct unless these
dates are reported accurately. Thank you.
```

Figure 7. SkyBit apple disease information for the UMass Cold Spring Orchard delivered on May 13, 2014.

is entered in "Symptom Occurrence Date", and NEWA estimates an approximate infection date of May 15.

SkyBit. As described above, SkyBit uses virtual weather stations to provide weather to its fire blight model, a modification of Mary-Blyt. In the example from Belchertown last year, we show the data received in an email for May 13 (Figure 7). Information is arranged in columns. The first column is the date. Columns 1 to 5 give weather information: maximum temperature (TMX F) and minimum temperature (TMN F), the amount of rainfall in inches (PREC in), relative humidity (ARH %), and the number of hours leaves were wet (LW hr).

The remaining columns give information for three apple diseases: apple scab, fire blight and sooty blotch. There are four columns of fire blight information. The number at the top of the column, 140512, is the blossom date, May 12, 2014. Growers need to supply the bloom date to SkyBit by calling a toll free number.

The first FIRE BLIGHT column shows accumulated degree hours over 65°F (ADH 65F), starting at bloom. The second FIRE BLIGHT column is the accumulated wet hours during the most severe infection event (AW hr). The third column shows the average temperature during the event (TW F). The fourth column indicates fire blight risk (pest wait/watch/warning, PW) as one of three levels:

- A minus symbol (-) meaning no risk or not active
- A single plus symbol (+) indicating blossoms are open and the minimum number of degree hours have been accumulated but infection has not occurred
- A double plus symbols (++) indicating risk of infection is high.

In the example, SkyBit indicates risk of infection on May 15. Based on this, an application of streptomycin would be recommended on May 14. SkyBit is relatively simple. It is not interactive, does

Range of open blossom dates for common apple cultivars	CougarBlight Heat Units, Inches Rain, & Leaf Wet Hours	I - No active FB within one mile this year or last two years	II - FB active within one mile of orchard within last two years, but not this year	III - FB active within one mile of orchard this year.	Dates blossom blight (& shoot blight) symptoms apparent if infection occurred
Early King Bloom Mon, May 12	307 HU, 0.0", 0 hrs	Low	Low	Low	
Tue, May 13	312 HU, 0.0", 0 hrs	Low	Low	Low	
Wed, May 14	340 HU, 0.0", 0 hrs	Low	Low	Low	
Thu, May 15	405 HU, 0.12", 9 hrs	Caution	EXTREME!	EXCEPTIONAL!	June 2, (June 12)
Fri, May 16	121 HU, 1.88", 24 hrs	Low	Caution	HIGH	June 3, (June 13)
Sat, May 17	139 HU, 0.0", 11 hrs	Low	Caution (if dew)	HIGH (if dew)	June 3, (June 14)
Sun, May 18	122 HU, 0.0", 0 hrs	Low	Low	Low	
Mon, May 19	68 HU, 0.0", 0 hrs	Low	Low	Low	
Tue, May 20	96 HU, 0.0", 0 hrs	Low	Low	Low	
Wed, May 21	126 HU, 0.0", 0 hrs	Low	Low	Low	

Figure 8. Ag-Radar output for the CougarBlight model at the UMass Cold Spring Orchard for mid-May, 2014.

If blossom infection occurred May 15, blossom blight would be noticeable by June 2, and shoot blight by June 12.

Range of open blossom dates for common cultivars.	FBP = Fire blight bacteria potential. 100% = minimum threshold level for infection. % FBP, Inches Rain, Leaf Wet Hours, & Avg. Temperature	In absence of rain, 3 or more hours of leaf wetness is counted as possible dew conditions for adequate wetting, which may overstate risk on such days. See Cougarblight model for additional comments. Eastern Fireblight Model Infection Requirements: 100% EIP (>=198 cumulative degree hours > 65F), + > 0" rain, or > 0.1 inch rain on previous day, + Average temp. on wetting day >= 60F
Early King Bloom Mon, May 12	86%, 0.0", 0 hrs., 68F	No FB infection
Tue, May 13	58%, 0.0", 0 hrs., 56F	No FB infection
Wed, May 14	70%, 0.0", 0 hrs., 58F	No FB infection
Thu, May 15	102%, 0.12", 9 hrs., 66F	INFECTION RISK
Fri, May 16	106%, 1.88", 24 hrs., 65F	INFECTION RISK
Sat, May 17	59%, 0.0", 11 hrs., 62F	No FB infection
Sun, May 18	48%, 0.0", 0 hrs., 57F	No FB infection
Mon, May 19	48%, 0.0", 0 hrs., 56F	No FB infection
Tue, May 20	45%, 0.0", 0 hrs., 61F	No FB infection
Wed, May 21	68%, 0.0", 0 hrs., 61F	No FB infection

Figure 9. Ag-Radar output for the Eastern Fire Blight model (MaryBlyt) at the UMass Cold Spring Orchard for mid-May, 2014.

not predict symptom development, or the impact of a streptomycin application.

Because NEWA and SkyBit use different sources of weather data, and different models, the output from the two systems may differ. In our example, NEWA predicted a high risk of infection on May 12 and 13, and extreme risk on May 14, while SkyBit did not predict any risk until May 15.

Ag-Radar. Ag-Radar (http://extension.umaine.edu/ipm/programs/apple/pestcasts/) currently uses virtual weather data purchased from SkyBit, but could use data from any source that provides automated delivery of quality-controlled data to run versions of both CougarBlight and MaryBlyt. (Ag-Radar calls its version of Maryblyt "The Eastern Fire Blight Model"). Ag-Radar works best when growers provide observed dates for first open bloom. These dates are then entered into the system to influence model estimates.

The Ag-Radar CougarBlight fire blight risk assessment for mid-May 2014 is similar to SkyBit's (Figure 8). Risk of infection is low until May 15, at which time it increases. Like NEWA, the Ag-Radar implementation of CougarBlight uses three levels to estimate the amount of initial inoculum though the prompts are different:

- No active fire blight within 1 mile of the orchard in last two years.
- Fire blight was present within 1 mile of the orchard within last 2 years, but not currently active in the area this year.
- Active fire blight cankers within 1 mile of the orchard this year.

Ag-Radar gives users the accumulated degree hours for the previous four days ("Heat Units"), inches of rain, and hours of leaf wetness. It also estimates dates for the first appearance of blossom symp-

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Inputs

Date	Phenology	Max Temp (F)	Min Temp (F)	Wetness (in)	Avg Temp (F)	EIP	BHWTR	BBS
5/9/2014	PK	57.6	53.5	0.03	55.6	-	-	-
5/10/2014	PK	79.0	58.3	0.38	68.6	-	-	-
5/11/2014	PK	76.6	53.5	0.04	65.0	-	-	-
5/12/2014	BL	85.2	54.5	0.00	69.8	97	+ - - + M	-
5/13/2014	BL	66.5	48.8	0.00	57.6	97	+ - - - L	-
5/14/2014	BL	72.4	45.5	0.00	59.0	121	+ + - - M	-
5/15/2014	BL	75.7	59.4	0.12	67.6	170	+ + + + I	-
5/16/2014	BL	66.7	62.4	0.05	64.6	73	+ - + + H	10 a
5/17/2014	BL	68.3	51.8	1.44	60.0	85	+ - + + H	16 a
5/18/2014	BL	67.3	43.1	0.00	55.2	61	+ - + - M	19 a
5/19/2014	BL	66.1	42.3	0.00	54.2	12	+ - - - L	22 a
5/20/2014	BL	73.8	48.5	0.00	61.2	36	+ - - + M	30 a
5/21/2014	BL	77.3	46.9	0.00	62.1	73	+ - - + M	39 a
5/22/2014	PF	61.9	52.8	0.53	57.4	-	-	42 a
5/23/2014	PF	65.6	51.8	0.49	58.7	-	-	46 a
5/24/2014	PF	64.8	50.8	0.05	57.8	-	-	50 a
5/25/2014	PF	72.8	47.5	0.02	60.2	-	-	56 a
5/26/2014	PB	78.1	52.9	0.06	65.5	-	-	67 a
5/27/2014	PB	79.3	49.7	0.05	64.5	-	-	77 a
5/28/2014	PB	51.5	46.6	0.02	49.0	-	-	77 a
5/29/2014	PB	69.9	40.2	0.00	55.0	-	-	82 a
5/30/2014	PB	72.6	48.5	0.07	60.6	-	-	88 a
5/31/2014	PB	66.3	49.0	0.00	57.6	-	-	92 a
6/1/2014	PB	76.2	43.2	0.00	59.7	-	-	100 a
6/2/2014	PB	81.2	53.2	0.00	67.2	-	-	-
6/3/2014	PB	86.7	55.9	0.04	71.3	-	-	-

Fiugre 10. MaryBlyt output using data from an on-site weather station at the UMass Cold Spring Orchard for mid-May to early June, 2014.

toms and the first shoot blight symptoms.

Ag-Radar also lets users choose the Eastern Fire Blight Model (EFB) based on MaryBlyt (Figure 9). In this example, the EFB infection risk estimate is similar to that of CougarBlight, with an "Infection Risk" on May 15 and 16. The model reports Fire Blight Bacteria Potential (FBP) as a percent of the minimum number of degree days needed for infection. In addition, inches of rain, leaf wetness hours and average temperature are given.

The Bottom Line

Any of these systems are useful in guiding growers in making a streptomycin applications and in some cases scouting for fire blight symptoms. To successfully manage fire blight, the important thing is to use one of them.

References

GLEASON, M. L., PARKER, S. K., PITBLADO, R. E., LATIN, R. X., SPERANZINI, D., HAZZARD, R. V., MALETTA, M. J., COWGILL, W. P. & BIEDERSTEDT, D. L. 1997. Validation of a commercial system for remote estimation of wetness duration. *Plant Disease,* 81**,** 825-829.

MAGAREY, R. D., SEEM, R. C. & RUSSO, J. M. 2006. Grape canopy surface wetness: Simulation versus visualization and measurement. *Agricultural And Forest Meteorology,* 139**,** 361-372.

COOLEY, D. R., ROSENBERGER, D. A., GLEASON, M. L., KOEHLER, G., COX, K., CLEMENTS, J. M., SUTTON, T. B., MADEIRAS, A. & HARTMAN, J. R. 2011. Variability among forecast models for the apple sooty botch/ flyspeck disease complex. *Plant Disease,* 95**,** 1179-1186.

Rutgers, The State University, Tree Fruit IPM State Report for 2015

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Rutgers Cooperative Extension IPM Program

Win Cowgill
New Jersey Agricultural Experiment Station

Tree phenology in 2015 started out late but by midsummer had returned to about normal. In North Jersey, Rutgers Sndyer Farm peach full bloom was 10 days later than 2014. Cropping was very good in both pome and stone fruit despite several cold nights in late April and a very short apple bloom in Northern NJ. At Snyder Farm apple bloom was very compressed moving from full bloom to petal fall in just four days due to warm temperatures.

In southern NJ, monthly temperatures s and rainfall were near normal for the year except for June The Office of the State Climatologist recorded a preliminary average of 8.29", more than 4" inches above the 4.02" normal rainfall. In June 2015 a farm in Gloucester County recorded 21 rain events totaling 10.4" for the month. Five of those rain events totaled an inch or more.

In Northern NJ we had a very dry April and May, running irrigation from late April to the last day of May. In June and early July rain was double normal rates. The balance of July, August and early September we went into a drought, at one point being 8 inches below normal. Peach and apple fruit quality were extremely high as a result with great brix.

Disease pressure is increasing in southern counties, primarily due to weather extremes. Fruit rots, especially Colletotrichum spp. (bitter rot in apples, anthracnose in peaches), are difficult to control in summers with frequent heavy rainfall. In apple, Empire appears highly susceptible. In peach, Klondike, White Lady, Sugar Giant, Harrow Beauty, PF Lucky 13, and PF 23 are among the varieties that frequently display anthracnose symptoms. Apple Scab is also becoming more difficult as DMI resistance is suspected in some orchards and QoI resistance has been confirmed in one Northern New Jersey Orchard in 2014. Fall or late winter applications of urea along with leaf chopping have helped to greatly reduce inoculum in infected orchards. We have also noted slight increases in brown rot and peach scab incidence in southern counties.

NEWA Fireblight forecasts, http://newa.cornell.edu/ for apple and pear were extreme for this season, more than double than in past years. The word got out to growers via newsletter and personal visits and much increased utilization of the NEWA website and forecasts. Many growers in Northern NJ made more than 5 Strep applications. Growers also did a good job of protection on young apple plantings using double applications of copper on newly planted apple and our recommended Apogee program on other blocks (2-3 applications of low rate Apogee). The several growers who failed to do this had extreme tree loss due to shoot blight fireblight. Brown marmorated stink bug populations, while still present at very low levels, have been trending lower during the past several years. The BMSB populations

Dogwood borer adult in pheromone trap May 31, 2015. Insecticide trunk sprays and/or mating disruption are indicated for control of dogwood borer, particularly in M.9 dwarf rootstock plantings were significantly reduced statewide as indicated by research and field observations. However populations of native stinkbug species were very high in 2015, and summer damage was significant in apple and some vegetable crops.

Spraying for BMSB in northern NJ was almost non-existent. **The question begs, what happened to the BMSB in Northern NJ?**

Internal worm damage in apple continues to be a challenge as more farms in southern counties experience significant damage. Again frequent heavy rainfall appeared to be a factor, making it difficult to maintain insecticide coverage. Codling moth populations and trap captures have increased on a number of farms. Two growers in northern counties had up to 5 percent fruit injury, but these orchards were not adequately treated. Populations on some other farms have still been problematic regardless of management practices. Growers have not widely adopted mating disruption for codling moth control because of high costs and lack of production blocks in adequate shapes and sizes. Mating disruption for oriental fruit moth (OFM) has been more widely adopted and has been very successful in orchards employing this technique. We have four generations of OFM in NJ. The first and forth generation flights are the highest, with the mid summer generations being the lowest due to management tactics. Under standard management practices we use a trap threshold of 6-8 moths per trap to initiate insecticide treatments. This rarely occurred during the summer months.

At the Rutgers Snyder Farm (14 Acres tree fruit plots), in Hunterdon County, NJ, mating disruption was used for CM, OFM, DWB and Peach Borers. All traps had complete shutdown, no damage of any of these species was observed. We also bated for female CM to check and see if any mated females came into the orchard, none were trapped. Due to the dry weather we had to make two insecticide applications for thrips on peaches. This was the first season in 20 years thrips were an issue on peach at Rutgers Snyder. Our only other insect that needed control was TABM.

Statewide, tufted apple budmoth (TABM) trap captures have been on the increase for several years. In many orchards pheromone trap captures exceeded 100 moths per trap per week. In most orchards treatments for TABM overlapped with CM or OFM treatments. Neither the seasonal observation nor postharvest fruit assessment revealed TABM injury in northern counties, but slight injury was noted this year in southern counties. Spotted tentiform leafminer (STLM) trap captures also increased this year and one southern county farm had significant injury. We have not seen this pest at these levels for many years. Biological control is still observed at high numbers so it is unclear what caused the outbreak. The return of these traditional pests raises questions about possible mortality of our biological control species and potential insecticide resistance. This is troubling due to the lack of effective alternatives.

About a third of our peach growers have been using mating disruption of peach tree borers in recent years. Most of them are following the scheme 2+1, or two consecutive years mating disruption with no mating disruption or using chemical control of the third year.

New Jersey Tree Phenology – 2015.

Pest Event or Growth Stage	Approximate Date	2015 Observed Date South Jersey	2015 Observed Date North Jersey
1/4" Green Tip Delicious	March 31 +/- 13 Days	April 14	McIntosh April 14
Tight Cluster Delicious	April 9 +/- 13 Days	April 19	McIntosh April 19
Pink Peach (Redhaven)	April 4 +/- 15 Days	April 19	April 21
Pink Apple (Delicious)	April 14 +/- 12 Days	April 22	McIntosh April 30
Full Bloom Peach (Redhaven)	April 9 +/- 14 Days	April 27	May 3
Full Bloom Apple (Delicious)	April 22 +/- 11 Days	April 30	May 5
Petal Fall (Redhaven)	April 22 +/- 10 Days	May 4	May 15
Petal Fall (Delicious)	April 27 +/- 14 Days	May 6	May 9
Shuck Split (Redhaven)	April 30+/- 11 Days	May 11	May 20
Pit Hardening - Peach	June 15 +/- 9 Days	June 13	June 20
Asian Pear Green Bud			April 10
Asian Pear Tight Cluster			April 14
Asian Pear white bud			April 18
Asian pear full bloom			April 22
Asian pear petal fall			May 5

This strategy works well because traditional postharvest chemical treatments of tree trunks and scaffold limbs are excluded from the program. Although MD is a little more expensive than chemical control, growers who use it prefer the practice compared to spraying, since it can be more effective, saves time during early September, and can help promote good public relations.
Growers will need to adopt mating disruption for peach tree borers completely in 2016, as EPA is proposing banning Loresban (Chlorpyrifos) by 2016, see http://www.growingproduce.com/vegetables/epa-proposes-to-ban-chlorpyrifos/

In 2015, Comstock Mealybug was observed in southern and central NJ infesting Asian pear and apple in in September. Injury was significant in Asian pears that were bagged. High levels of parasitism were observed in the field, however nymphs were able to enter the bags and feed on the stems. This is the first observation of this pest at economic injury levels in NJ.

Ambrosia beetle was a problem in one orchard in southern NJ again in 2015, although to a lesser extent than 2014. In 2015 the insect was found infesting peach, however damage was limited since peach does not appear to be a good host because of the tendency to exude thick sap in wounds. Growers in other regions of the state have reported damage from this pest after the outbreak last year. Prior to 2014 it was a long known pest of nursery stock but had not been identified as a significant pest in fruit production.

In pears, pear psylla populations were difficult to control in southern counties due to high populations of adults persisting into September. Heavy leaf feeding was observed through late summer, but overall growers treated aggressively and had reasonably clean fruit at harvest. High populations were also noted in northern counties but control was reported to be better.

In Northern NJ some growers had trouble with Pear Psylla. However pear psylla was non-existent on a ½ acre block of Asian Pears at Rutgers Snyder Farm. Two applications of Dormant Oil were made, the first a 3% solution at bud swell and one a 1% solution at tight cluster. No other insecticide treatment was necessary.

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University of Massachusetts Amherst Fruit IPM Report for 2015

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Most specific observations made at the UMass Cold Spring Orchard in Belchertown, MA.

Winter will be remembered for the amount of snow and length of sub-freezing temperatures. A low of -9 F. was recorded on 16-February. Low temperatures flirted with stone fruit bud damage, however, come spring bloom was OK. The deep snow allowed for more rodent (vole and rabbit) damage than usual. Pruning was slow and delayed, going well into the spring.

Spring was a bit late in arrival for the second year in a row, but progressed about on schedule. Apple green tip was 18-April, full bloom app. 10- May. McIntosh petals were off by 18-May. Pictures of bud stages are archived on the **UMass Fruit Advisor** (http://www.umassfruit.com). There was definitely some stone fruit bud damage, however, most growers ended up with a good peach crop. (Some mid-winter thinning of fruit buds is welcome.) No frost/freeze damage to apple flowers was reported. The April-early May period was on the dry side in many locations.

Apple fruit skin surface temperatures exceeding 112°F may result in sunburn. The problem is exacerbated as fruit approach harvest.

Summer temperatures were at first seasonal, with abundant sun and near average rainfall. Hail hit a few unfortunate orchards, with reports of up to 100,000 bushels damaged in the Sterling area. August into September became warm to hot and dry. September had near record heat for the month, and apple red color development was lacking during this time. In fact, a summer high temperature of 94 was recorded on 8-September.

The **peach** crop was generally very good, with some more cold-sensitive varieties on the light side. Quality was excellent. Similarly, the small sweet cherry harvest was one of the best in years.

Apple harvest started about right on schedule, but as previously mentioned, red color was wanton into late September. The crop was generally heavy, and everyone commented on how large in size individual apples were this year. September heat kept customer traffic on the lighter side, but picking up in October. The heavy crop meant there were still plenty of apples around come Columbus Day. If not for the loss of apples to hail, the apple crop would have been one of the largest in years. Little pre-harvest drop was reported (except in a few Honeycrisp blocks), and no particular quality problems have been reported. ReTain applications seem to have worked very well. The growing season ended 18-October with a hard freeze in most spots.

A dry spell from mid-April into early May resulted in a relatively easy **apple scab** control season. In some orchards there may have been as few as three scab infection periods, with most orchards likely having four to five infection periods. Virtually no scab come harvest time was seen.

Fire blight was largely a no-show despite several dire warnings from the models for high infection risk. This has been a little puzzling, but most growers applied streptomycin religiously in 2015 following the outbreak of 2014. That practice, combined with fairly dry conditions, are likely the major factors that resulted in virtually no fire blight. We collaborated with Quan Zeng from the CT Agricultural Experiment station by submitting fire blight strikes (where we could find them) for streptomycin resistance testing. All samples came back negative for streptomycin resistance.

The Massachusetts **NEWA** network (http://newa.cornell.edu) includes 21 on-site weather station/orchards (plus 23 airports, total 44 locations) providing fruit and vegetable growers with daily developmental models (including forecasts) to aid in decision-making for management of insect and disease pests. Some of these locations were centerpieces for providing Extension team-based IPM recommendations on diversified fruit & vegetable farms via the **Extension Implementation Program (EIP,** NIFA), which also provided training in monitoring and management of key pests to 10 mentor growers and 15 partner growers across Massachusetts. Mentor growers worked on 2-3 key IPM issues over the course of 5 months of farm visits and were involved with twilight meetings and project guidance. Partner growers were involved with one research/ extension project.

Overall **insect** pressure was average, with a few exceptions. One observed exception was significant pre-bloom and into bloom foliar and flower bud feeding injury from green fruit worms. This was reported to be the case throughout the Northeast.

The **UMass EIP** team, with the assistance of growers and independent scouts around the state, maintained and monitored fifteen **brown marmorated stink bug (BMSB)** traps. Small green/yellow/clear plastic rocket traps were placed in fruiting trees; large, free standing, black pyramid traps were placed at the bases of fruiting trees. In 2015 both of the pheromones (the more specific one from USDA and the more general one) were available commercially and were used together. Trapping began in late June and ended in mid-October. The first confirmed sighting was August 12, in Worcester County. Confirmed trap catches and observation of BMSB amounted to only 31 in 2015 compared to 27 in 2014 (MDAR numbers). While trap captures were not at all high, this pest remains of concern to growers in MA. We suspect there are small resident populations developing in and around farms and it's just a matter of time


Green fruitworm on apple foliage and frost damage to Honeycrisp apple


Hail damage to Honeycrisp apple and SWD on sound nectarine

before economic damage to fruit crops is documented. A dedicated BMSB information page was maintained on the UMass Fruit Advisor.

In 2015 the UMass Fruit Program set up a **Spotted Wing Drosophila (SWD)** monitoring network with 10 locations across the state. Each location was set up with paired traps with one trap using a standard Apple Cider Vinegar plus yeast and whole wheat dough bait/drowning solution combination and the second trap using a commercially available lure from Trece with a soapy water drowning solution. The first SWD capture occurred in Essex county with a single female caught in late June. This turned out to be somewhat of an anomaly as several weeks passed before any additional captures were recorded at that location and no other captures occurred in the state until mid-July. Numbers of captures varied between the two trap types so no consistent benefit was found to recommend one over the other based on efficacy. The main benefit of the commercial product was ease of use compared to the messy ACV+yeast+ww flour combination. SWD populations were somewhat slow to escalate but by late August pressure on commercial berry operations was very high. Late season blueberry varieties and primocane raspberries were the most severely affected. The impact of crop canopy management for open air flow and good sunlight/spray penetration was highlighted in several cases. Where canopies were open effective SWD suppression was maintained longer. Where canopies were dense, even rigorous spray programs were not enough to keep SWD under adequate control. Although not generally considered a problem in sound peach/nectarine orchards, SWD male and female activity (egg laying) was observed in a sound nectarine orchard in western Massachusetts in September. (And the grower reported significant infestation in some of their peach/nectarine blocks.) A dedicated SWD web page was maintained on the UMass Fruit Advisor.

A Northeast SARE-funded study, **Towards Sustainable Disease Management in Northeastern Apples using Risk Forecasts and Cultural Controls** is nearing completion at 19 commercial orchards in New England and University/extension research facilities in MA, NH, and ME. Collaborating scientists are William MacHardy, Cheryl Smith, and George Hamilton of NH and Glen Koehler and Renae Moran of ME. Scab sanitation strategies, advances in the delayed first scab spray strategy, PAD counts, and spring ascospore trapping and maturation are the foci of the study. Results are being summarized and reported.

The UMass Fruit Team participated in an SCRI-funded study, **Manipulating Host- and Mate-finding Behavior of Plum Curculio: Development of a Multi-Life Stage Management Strategy for a Key Fruit Pest**. We helped create a colony of PC from June-dropped apples and participated in a nematode biocontrol study. Tracy Leskey, USDA-ARS Kearneysville is the PI/project director.

There were approx. 30 research/data-collection/demonstration trials/plots conducted at the **UMass Cold Spring Orchard** in 2015. Research focused on: the use of plant growth regulators for crop load management, growth control, and stop-drop; using Decision Aid Systems for managing apple scab; apple and peach NC-140 rootstock plantings; apple, peach, cherry, Asian pear, and NE1020 cold climate wine grape variety and planting system evaluation; improving young apple tree growth and branching with fertigation and hormones; and managing Honeycrisp apple production problems with fertigation and hormones.

Seven growing season **Twilight Meetings** for commercial tree fruit growers were held in Massachusetts, Rhode Island (in cooperation with Rhode Island Fruit Growers' Assoc.), and New Hampshire (in cooperation with U. of New Hampshire) during April, May and June. **Healthy Fruit** (healthyfruit.info) was published 19 times from April-September with timely integrated pest management information for pome and stone fruit. **Berry Notes** (12 issues) and **IPM Berry Blast** (13 issues) were published providing information on pest alerts and other timely topics. The **Massachusetts Fruit Growers' Association** Summer Meeting was held at Red Apple Farm in Phillipston, MA. Guest speaker Quan Zeng from the CT Agricultural Experiment Station gave an update on the status of fire blight resistance to streptomycin in New England.

European apple sawfly damage on apple fruitlet May 24, 2015. Often a pre-bloom insecticide spray is the only effective control of this pest where it is prevalent.

Evaluation of Kasugamycin: Control of Bacterial Spot on Peach

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Infection of peach fruit by the bacterial spot pathogen *Xanthomonas arboricola* pv. *pruni* results in the formation of blackened, pitted lesions on the fruit epidermis. Infections that occur early in growing season result in larger, deeper pitted lesions, while those that occur in mid-to-late summer tend to be more numerous, but shallow. Infection of foliage, results in the formation of angular, black lesions that eventually shot-hole. If a sufficient number of lesions occur, the leaves become chlorotic and abscise. In disease favorable years, significant crop loss and defoliation can occur on susceptible cultivars.

Current management of peach bacterial spot is dependent on (i) planting of less susceptible cultivars; (ii) application of the antibiotic oxytetracycline (Mycoshield, FireLine); and (iii) application of copper-based bactericides (e.g., Kocide, Cueva, etc…). Unfortunately, residual activity for the oxytetracycline products is only a few days at best, and copper bactericides used during the growing season need to be applied at low rates since copper also causes phytotoxicity. These bactericide limitations often make control difficult, especially when environmental conditions are favorable for disease development.

A new antibiotic, kasugamycin, is now available for agricultural use in the United States. The product Kasumin 2L, which contains kasugamycin as its active ingredient, is currently registered for control of fire blight on pome fruit. Kasugamycin is a hexopyranosyl antibiotic, which is a different chemistry than either streptomycin (glucopyranosyl) or oxytetracycline (tetracycline). Thus, cross-resistance is not likely and the different antibiotics could be used together in a program. Furthermore, FRAC guidelines list kasugamycin as a 'medium risk" for resistance development, while the other two antibiotics are rated as having a "high risk" of resistance development.

The purpose of this study was to examine the ability of kasugamycin to manage bacterial spot on peach. Since the number of kasugamycin applications will be limited per season, treatments consisted of programs that integrated Kasumin with the current registered antibiotic, oxytetracycline. Programs that incorporated copper bactericide (Kocide) were also examined. In addition to providing full season coverage, the integration of these different bactericides also acts as a resistance management strategy. Finally, a full season program of Kasumin, applied with the non-ionic spreader-activator Regulaid, was included for determining the antibiotic's lone efficacy. Except for the Kasumin-only program, treatments followed a USDA / IR-4 protocol.

Materials & Methods

Orchard Site. The experiment was conducted in a highly susceptible O'Henry peach orchard, located at the Rutgers Agricultural Research and Extension Center, Bridgeton, during the spring and summer of the 2015 growing season.

Treatments. Bactericide treatments were replicated four times in a randomized complete block design. Due to low fruit set, two trees were used per plot. Treatment trees were surrounded on all sides by non-sprayed buffer trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.5 mph was used for applications. Insecticides and miticides were applied as needed using a commercial airblast sprayer. Bactericide treatment application dates were 11May (shuck-split), 21May (1C), 31May (2C), 11Jun (3C), 22Jun (4C), 2Jul (5C), 13Jul (6C), and 23Jul (7C). Except for a leaf curl application on 3 April, consisting of Ziram 76DF at 4 lb/A, no additional fungicides were applied during the course of the study.

Available water for spraying was acidic (pH=4.8). Thus, an alkaline buffer, potassium carbonate, was used to adjust pH of the water to 7.0 prior to mixing in the bactericides. This pH correction was performed only for those applications

Table 1. Bacterial Spot on Fruit (August 7).

Treatment	Rate / A	Timing	% Infected Fruit [2]	# Lesions / Fruit [2]	% Fruit in Category [1] Market Grade 1 [2]	Market Grades 1+2 [2]	Cull [2]
Non-treated control	--------	------	93 a	96.8 a	37 c	58 b	42 a
Kasumin Full Season							
Kasumin 2L [3]	64 fl oz	SS, 1C-7C	87 ab	64.4 a	45 c	74 ab	26 ab
Kasumin / Mycoshield Block Programs							
Kasumin 2L Mycoshield	64 fl oz 12 oz	SS, 1C-3C 4C-7C	90 a	86.0 a	50 abc	72 ab	28 ab
Mycoshield Kasumin 2L	12 oz 64 fl oz	SS, 1C-3C 4C-7C	87 ab	101.4 a	46 bc	64 b	36 a
Antibiotic + Copper Mixture / Alternation Programs							
Kasumin 2L + Kocide 3000 [4] Mycoshield Kocide 3000 [4]	64 fl oz + 8 oz 12 oz 8 oz	SS, 1C-3C 4C, 6C 5C, 7C	72 bc	28.2 b	67 ab	85 a	15 b
Mycoshield + Kocide 3000 [4] Kasumin 2L Kocide 3000 [4]	12 oz + 8 oz 64 fl oz 8 oz	SS, 1C-3C 4C, 6C 5C, 7C	61 c	34.4 b	70 a	86 a	14 b

[1] Market grade 1 = total lesion area no larger than 1/8” diameter; Market grade 2 = total lesion area no larger than 3/16” diameter and no single lesion larger than 1/8”; Cull = total lesion area larger than 3/16” and/or single lesion larger than 1/8”.

[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test ($\alpha=0.05$, $K=100$).

[3] Regulaid added to Kasumin full season treatment at rate of 1 pt / 100 gal.

[4] Spray water adjusted to pH=7.0 with potassium carbonate prior to addition of bactericides.

Table 2. Bacterial Spot on Foliage: Assessment #1 (June 25).

Treatment	Rate / A	Timing	% Infected Leaves [1, 2]	% Infected & Shot-holed Leaves [1, 2]	% Abscised Leaves [2]	Overall Shoot Rating [2, 3]
Non-treated control	--------	------	39.9 a	39.9 a	11.1 bc	3.5 ab
Kasumin Full Season						
Kasumin 2L [4]	64 fl oz	SS, 1C-7C	45.2 a	48.0 a	9.0 c	4.2 ab
Kasumin / Mycoshield Block Programs						
Kasumin 2L Mycoshield	64 fl oz 12 oz	SS, 1C-3C 4C-7C	30.9 a	36.3 a	5.9 c	3.8 ab
Mycoshield Kasumin 2L	12 oz 64 fl oz	SS, 1C-3C 4C-7C	32.7 a	32.7 a	3.9 c	3.4 b
Antibiotic + Copper Mixture / Alternation Programs						
Kasumin 2L + Kocide 3000 [5] Mycoshield Kocide 3000 [5]	64 fl oz + 8 oz 12 oz 8 oz	SS, 1C-3C 4C, 6C 5C, 7C	34.9 a	48.7 a	23.8 a	4.5 a
Mycoshield + Kocide 3000 [5] Kasumin 2L Kocide 3000 [5]	12 oz + 8 oz 64 fl oz 8 oz	SS, 1C-3C 4C, 6C 5C, 7C	42.1 a	54.0 a	17.7 ab	4.5 a

[1] Infected leaves = leaves with at least one lesion (can have shot-holes); Infected & Shot-holed = infected leaves + leaves with only shot-holes.

[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

[3] Overall shoot rating (OSR) = % leaf area infected or shot-holed (1=0%; 2=1-15%; 3=15-25%; 4=25-45%; 5>= 45%)

[4] Regulaid added to Kasumin full season treatment at rate of 1 pt / 100 gal.

[5] Spray water adjusted to pH=7.0 with potassium carbonate prior to addition of bactericides

Table 3. Bacterial Spot on Foliage: Assessment #2 (August 4).

Treatment	Rate / A	Timing	% Infected Leaves [1, 2]	% Infected & Shot-holed Leaves [1, 2]	% Abscised Leaves [2]	Overall Shoot Rating [2, 3]
Non-treated control	--------	------	93.3 a	99.7 a	32.8 bc	3.8 b
Kasumin Full Season						
Kasumin 2L [4]	64 fl oz	SS, 1C-7C	91.3 a	100.0 a	49.6 a	3.6 b
Kasumin / Mycoshield Block Programs						
Kasumin 2L Mycoshield	64 fl oz 12 oz	SS, 1C-3C 4C-7C	89.2 a	97.1 a	22.9 c	3.8 b
Mycoshield Kasumin 2L	12 oz 64 fl oz	SS, 1C-3C 4C-7C	91.5 a	96.5 a	37.7 abc	3.4 b
Antibiotic + Copper Mixture / Alternation Programs						
Kasumin 2L + Kocide 3000 [5] Mycoshield Kocide 3000 [5]	64 fl oz + 8 oz 12 oz 8 oz	SS, 1C-3C 4C, 6C 5C, 7C	72.3 b	97.2 a	44.4 ab	4.6 a
Mycoshield + Kocide 3000 [5] Kasumin 2L Kocide 3000 [5]	12 oz + 8 oz 64 fl oz 8 oz	SS, 1C-3C 4C, 6C 5C, 7C	65.8 b	96.7 a	51.4 a	4.7 a

[1] Infected leaves = leaves with at least one lesion (can have shot-holes); Infected & Shot-holed = infected leaves + leaves with only shot-holes.

[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan *K*-ratio t-test (α=0.05, *K*=100).

[3] Overall shoot rating (OSR) = % leaf area infected or shot-holed (1=0%; 2=1-15%; 3=15-25%; 4=25-45%; 5>= 45%)

[4] Regulaid added to Kasumin full season treatment at rate of 1 pt / 100 gal.

[5] Spray water adjusted to pH=7.0 with potassium carbonate prior to addition of bactericides

that included the copper compound, Kocide 3000.

Assessment. Disease incidence, severity (lesion numbers), and "marketable fruit" assessments were performed on 7 August. A total of 25 fruit were examined per plot during each assessment. For the marketable fruit assessment, fruit were graded based on the size of lesions and the area of fruit surface they covered. Definitions for the grades, developed in cooperation with NJ growers, are given in the data table footnotes.

Infection of leaves by *X. arboricola* pv. *pruni* results in the formation of leaf spots, shot-holing, and defoliation. Foliar assessments for all three of these symptoms were performed on 25 June and 4 August. During each assessment, the number of missing leaves and leaves with lesions and shot-holes were counted on each of five vegetative shoots per plot. Results were presented as % leaves infected, % leaves infected and shot-holed, and % leave abscised. An overall shoot rating (OSR) was also performed based on the percentage of leaf area infected and shot-holed.

Weather Data. Air temperatures and rainfall data were recorded by a Campbell Scientific 23X data logger located at the research station. This weather station is part of the Mesonet Network operated by the Office of the NJ State Climatologist. Observations were taken every two minutes and summarized every hour. Hourly temperature and rainfall data were averaged and summed, respectively, for each day of the growing season. Monthly temperature averages and rainfall accumulations were compared to the 30-year means or sums, respectively, for Bridgeton, NJ.

Results

Environment. During the four-month experimental period, air temperatures were near normal in April, June, and July but 5°F above average for May (67 vs 62°F). Rainfall in April was slightly below normal relative to the 30-year average (3.25" vs 3.58"), while precipitation in May was 2.8" below normal (1.27" vs 4.07"). However, frequent rains in June resulted in a total monthly accumulation that was more than three times the 30-year normal. A total of 11.7" rainfall occurred in June versus the normal 3.37 inches. Precipitation greater than 0.09" was recorded on 16 days – more than half the days in the month. Rainfall in July was also considerably higher than average, 7.15 inches versus the 30-year normal of 4.30 inches. However, unlike June, this above-average performance was due to a few heavy rains.

Fruit Infection. Disease pressure was quite high on highly susceptible O'Henry fruit. At the end of the study, 93% of non-treated fruit were infected with an average 97 lesions per fruit (Table 1). As a result of this high disease severity, only 58% of control fruit were marketable, with 37% at grade 1.

Disease incidence and severity levels were generally lower for the full season Kasumin and two block programs relative to the control, but the reductions were not statistically significant (Table 1). Similarly, these three treatments had higher percent of fruit in grade 1 and grades 1+2 compared to the control. For example, the Kasumin / Mycoshield block program yielded 72% marketable fruit, which was 14% higher than the control. However, this and other increases in saleable fruit were not statistically significant.

The addition of the copper bactericide Kocide 3000 to the antibiotic programs resulted in significant reductions in disease incidence and severity and significant increases in both grade 1 fruit and total saleable fruit (Table 1). Fruit disease incidence was reduced by 21 to 32% and lesion density by 64 to 71%. Marketable fruit was 85 to 86% of the total harvested, of which 67 to 70% was grade 1. Of course, these improvements resulted in significant reductions in culled fruit for the two treatments.

Foliar Infection. At the first assessment on 25June, about 40% of leaves on non-treated trees were infected and shot-holed with 11% defoliation (Table 2). By early August, almost 100% of the highly susceptible O'Henry leaves on control trees were infected and shot-holed with 33% defoliation (Table 3).

At both assessments, most of the treatment means were not significantly different from the non-treated control means (Tables 2 & 3). That is, the bactericide programs appeared to have little efficacy at controlling foliar infection on highly susceptible O'Henry. However, both programs with copper had significantly less infected leaves than the control, indicating that these programs were having some impact at reducing disease development on foliage. Unfortunately, the shot-holing and leaf drop caused by the copper tended to negate any reductions in disease levels.

Conclusions

Antibiotics. The antibiotic treatment programs examined in this study consisted of the two Kasumin / Mycoshield block programs and Kasumin full season program. On highly susceptible O'Henry peach, none of these programs provided any significant control of disease incidence and severity on fruit or leaf infection and defoliation on shoots. Although these three programs yielded higher levels of marketable fruit in grades 1 and grades 1+2 than the control, none of these increases were significant. For example, the Kasumin full season program yielded 74% marketable fruit versus 58% for the non-treated control. This amount of saleable fruit is "respectable" given the high susceptibility of the cultivar! Nevertheless, under the conditions of the study, this difference was not statistically significant.

Two factors are proposed as possible causes for the lack of efficacy by the antibiotics, particularly for the known standard Mycoshield. The treatment protocol for the study stipulated a 7 to 10 day spray interval with a maximum of eight applications per season. Thus, in order to equally cover the infectious period from shuck-split in early May through the end of July, sprays were applied at 10-day intervals. This agrees with the typical summer cover spray interval range of 10 to 14 days. However, this timing is primarily for fungicide applications, which provide reasonably long residual activity. The antibiotic programs would probably have benefited from shorter spray intervals given their shorter residual activity (2-3 days for Mycoshield; Kasumin unknown). But, of course, use of shorter intervals would have required additional applications beyond the protocol's specification. For example, a 7-day interval would have required 12 applications for the same time period.

A second factor that could explain the antibiotic programs' lack of efficacy was the unusually high amounts of rainfall that occurred, particularly throughout June and the first half of July. No doubt that the frequent and heavy rainfalls that occurred would have made the short residual activity of Mycoshield, and perhaps Kasumin (?) practically non-existent. And to make matters worse, temperatures during the rainy last three weeks of June and first two weeks of July were quite favorable for bacterial growth (optimum at 75-84°F). Thus, infection periods would have been occurring at a time when antibiotic activity was compromised. The applications probably lowered epiphytic bacterial populations temporarily, but the continuous, favorable conditions allowed rapid population rebounds.

No doubt frequent, unusually high rainfalls and long spray intervals were a deadly combination in the 2015 growing season, especially on highly susceptible O'Henry. Further testing is needed to better discern kasugmycin's efficacy, particularly under more typical rainfall conditions.

Copper. Given the inability of the three antibiotic-based programs to control bacterial spot under the conditions of the study, one can conclude that the efficacy of the antibiotic + copper programs was primarily due to the activity of the copper component. The fact that both these integrated programs resulted in very similar levels of fruit infection and proportions of marketable fruit was also evidence that the copper bactericide, in this case Kocide 3000, was the efficacious element of the programs.

The relatively high rate of Kocide 3000 used in the study may be responsible for the effective fruit disease control, especially with the longer spray interval and considerable amounts of rainfall. The recommended rate for Kocide 3000 30DF, when used for consecutive summer cover sprays on peach, is 1.65 oz per acre. This amount provides 0.5 oz metallic copper per acre (equivalent to the former standard Tenn-Cop 5E at 8 fl oz/A). The rate used in the study, 8 oz/A, is therefore 4.8 times more concentrated.

Given the high rate of copper used, the test trees no doubt suffered high levels of defoliation (nearly 50%), but the trade-off was a higher percentage of grade 1 and total saleable fruit. Perhaps this is acceptable since we don't eat the leaves! However, had 7-day spray intervals been used and/or more normal levels of rainfall encountered, much greater levels of defoliation would probably have occurred. In past studies examining a variety of copper bactericides (Kocide 3000, Badge X2, Nordox, Cueva), high rates at 7 to11 day intervals resulted in 74 to 80% defoliation by harvest time.

Fruit Notes

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