RIMpro Cloud Service info bulletin 2015-3
Zoelmond, April 16 2015

RIMpro-*Erwinia 2.0*

Fire blight flower infections occur when infection conditions are favourable AND bacterial inoculum is present. Where no fire blight inoculum is present in or near the orchard, no flower infections occur even when the weather conditions are favourable.

RIMpro-*Erwinia* calculates fire blight infections assuming there is inoculum available. The infection simulation follows all steps in the infection biology. The original RIMpro *Erwinia* model has been improved in close collaboration with Vincent Philion (IRDA Québec). Information on the algorithms implemented can be found in Philion and Trapman 2011. The model is still experimental. Extended validation is planned for 2015. It is highly recommended to keep the default simulation parameters for best results. But as RIMpro is an open shell, experts can change the parameters to their own experience.

1- Flowering period- The user has to set the date the first flower opens, and the date that last flower opens in the menu option “Local Parameters”. Please note that this refers to days on which new flowers open and not days on which older flowers are still present.
2- Daily fresh flowers- During the flowering period every day a new flower cohort opens.
3- Contamination: -The cohort of open flowers is considered contaminated with 10 CFU *Erwinia* bacteria on the first day that has 3 hours suitable for flower visits by insects (temperature over 15 °C)
4- Bacterial growth: - Growth of the bacterial population on the contaminated stigma is calculated in 30 minutes time steps using the growth curve published by Schouten (1987). As the Schouten curve overestimates the population growth under natural conditions an empirical correction factor of 0.55 is used. The epiphytic growth of the bacterial population on the stigma of the successive flower cohorts is shown in the bottom graph.
5- Critical population level: - Infection is possible after the bacterial population on the stigma exceeds 1×10^5CFU and a wetness event occurs.
6- Triggering wetness event: Free water in the flower allows movement of the bacterial population to the flower bottom, and dilutes the nectar that is protecting the flower for infection. The infecting bacterial population in the flower cup is set 10x lower than the stigma population.

7- Infection:- The potential infection incidence is dependant on flowerage and infecting bacterial population. The implemented algorithm is based on lab work by Pusey. (Philion & Trapman 2011). The potential infection incidence is shown in the middle graph.
8- Disease threshold:- The default threshold for the potential infection incidence that is regarded as a flower infection under field conditions is set to 0.2 based on preliminary validation of the model with field records.
9- Latency:- Incubation calculations are made for infection events that exceed the disease threshold. The entophytic bacterial growth is calculated using an algorithm published by Steinbrenner (1992). The growth of the entophytic *Erwinia* population is shown in the upper graph.
10- Disease expression:- When the endophytic bacterial population exceeds the level of 1 x 10^8CFU the plant tissue is ruptured by the pressure of the intercellular bacterial population and the fire blight symptoms get visible.

Interpretation and use of the model results

Calculated potential infection events only coincide with true infections when bacterial inoculum is present in the orchard at the time the model assumes contamination.

The use of the model to plan control strategies is dependant on the mode of action of the available control agents.

Resistance inducers like Aliette, phosphonate, BION and Vacciplant have to be applied before the infection occurs to reduce the susceptibility of the plant to bacterial infections. As these substances are mobile in the plant these products must be applied a few days before the infection.

Antagonists like BlossomProtect compete with the *Erwinia* population that is growing on the stigma and reduce pH. By limiting the maximum epiphytic population they reduce the risk flowers get infected by fire blight. To be effective these products have to reach the stigma in the open flowers. There can be no effect on flowers that are still closed. Some Blossom Protect is transported to newly open flowers by insects but this is not considered sufficient for disease control. To be effective on the flower cohort at risk, applications have to be made in the last 24-48 hours before the infection occurs.

Plant systemic curative materials like antibiotics (streptomycin, kasumin, oxytetracyclin) can still be used until 24 hours after the infection occurred to kill the *Erwinia* population that has infected the flower cup.

Preventative application of fire blight control agents is the basis of an integrated control strategy. Therewith the RIMpro infection forecast is crucial for the practical management of fire blight. The quality of the infection forecast is completely dependant on the accuracy of the weather prediction for the location. Generally if the *Erwinia* population on the stigma reach the critical level in flowers that are relatively young, infections will hit where wetness events occur.

Management
When epiphytic populations exceeding the critical level are forecasted, protective treatments with resistance inducers should be applied. When an infection is foreseen in the next 24-48 hours an antagonist should be applied. When inoculum is known to be present and an infection with a high potential infection incidence has been calculated, the immediate application of an antibiotic should be considered. Open flowers sprayed once remain protected for the whole life of these flowers. However, more than one application can be needed if new flower cohorts open after the initial spray become at risk.

Model validation
Preliminary validation using 47 cases (orchards * years) showed that years with only one day favourable for infection resulted in low disease incidence. Years with multiple infection days result in high infection in sites where inoculum was present.
Critical factors showed to be the correct period over which fresh flowers open, and the accurate determination of flower wetness events.
We are planning an extended validation in 2015. We are very interested to include more field cases in this validation. If you have observation series of fire blight over the past years along with accurate 30 or 60-minute resolution weather data that you are willing to share with use, please let us know.

Server link
Consultants can create an iframe on their website to embed the RIMpro-*Erwinia* graphics. The iframe should point to this link:
http://www.rimpro.eu/faces/erwinia.xhtml?id=*YourStationID*

Marc Trapman

Referred publications:
Philion, V. and Trapman, M. 2011. Description and preliminary validation of RIMpro-Erwinia , a new model for fireblight forecast. Acta Hort. (ISHS) 896:307-317

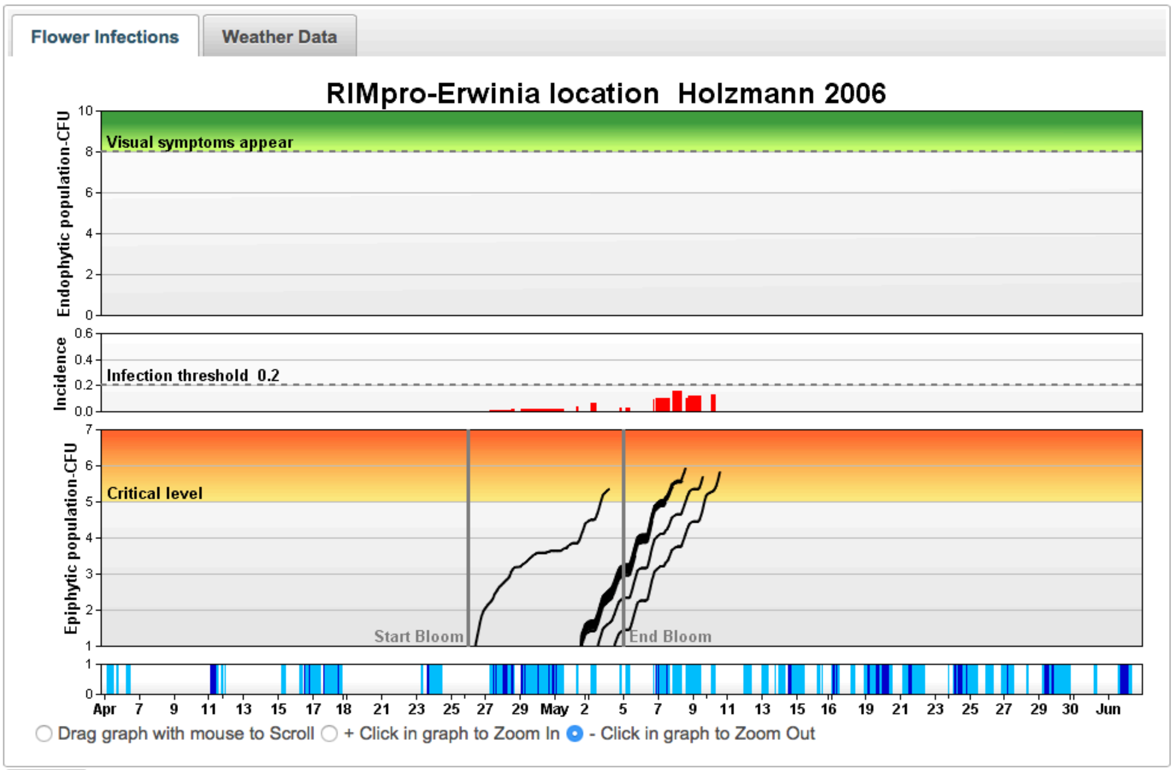
Schouten, H.J., 1987. A revision of Billing's potential doublings table for fire blight prediction. *European Journal of Plant Pathology*, 93(2), pp.55–60.

Steinbrenner, B., Lischke, H. & Zeller, W., 1992. A new approach to the forecast of fireblight (Erwinia amylovora)– prediction of disease outbreak by simulation of the population dynamics. *Acta Phytopathologica et Entomologica Hungarica*, 27(1), pp.587–591.

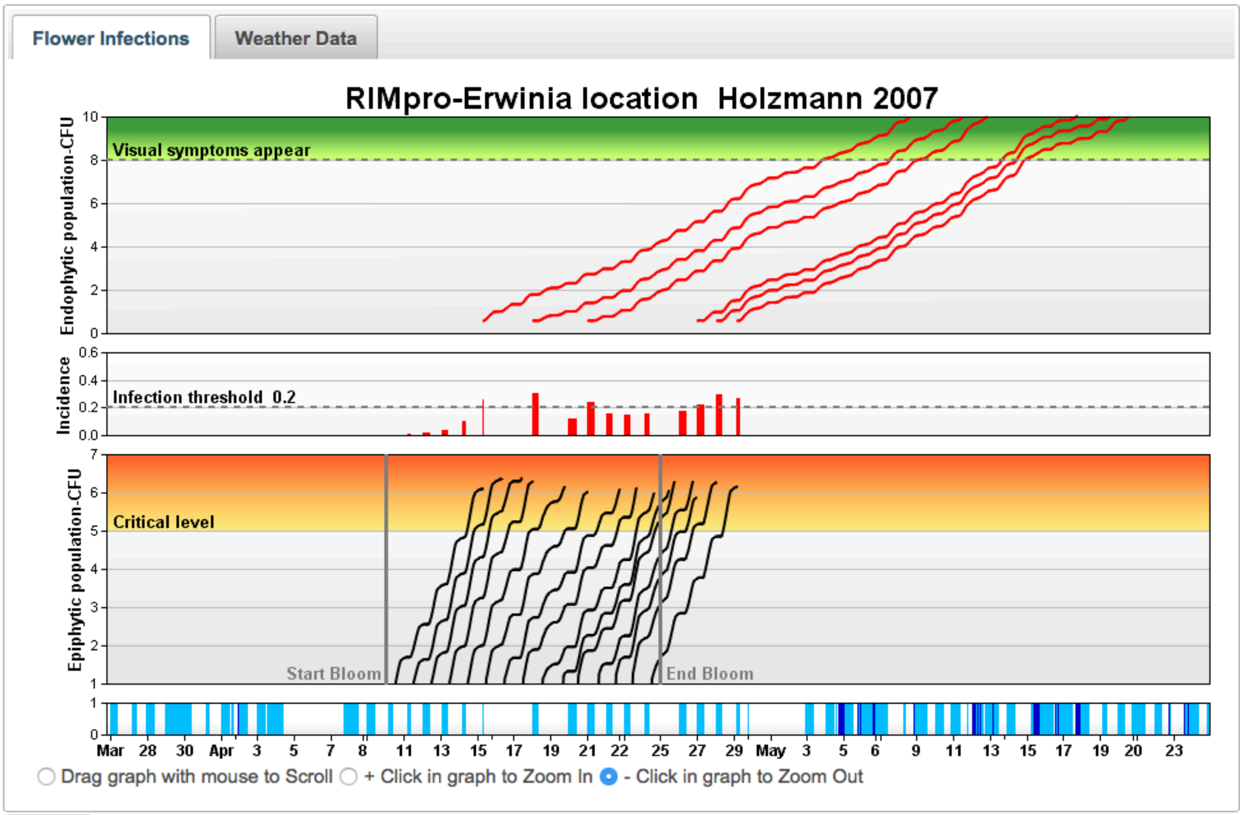
Examples
The graphs on the following pages show the simulation results in four successive years for an orchard in Styria (Austria):

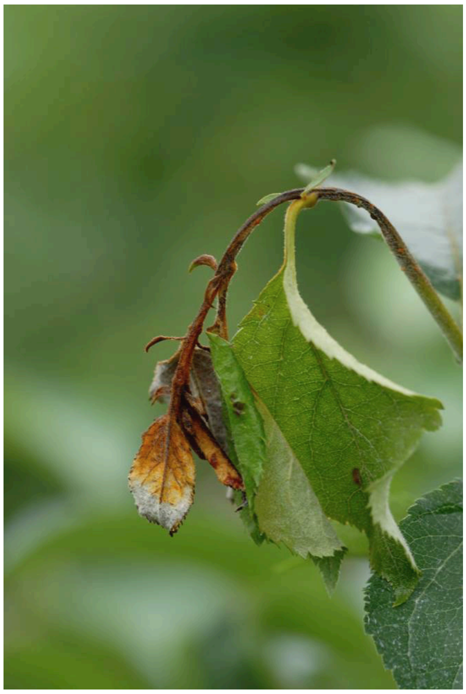
- The bar immediate above the date axis shows leaf wetness readings in light blue, and active rain in dark blue as registered by the on-farm weather station.
- The lower graph shows the growth of the *Erwinia* population on the stigma after contamination. Each black line stands for a new daily flower cohort.
- The middle graph shows the potential infection incidence as calculated from flower age and level of the infecting bacterial population.
- The upper graph shows the endophytic growth of the *Erwinia* population after infection. About the time this population reaches 1 x 10^8CFU the fire blight symptoms become visible.

2006 - During the main flowering period the weather was cold and rainy. Conditions for contamination of flower cohorts that open during these days were not met until the end of bloom. All already opened flowers got contaminated May 1st. No potential infection exceeded the threshold and in the field no fire blight symptoms have been observed.

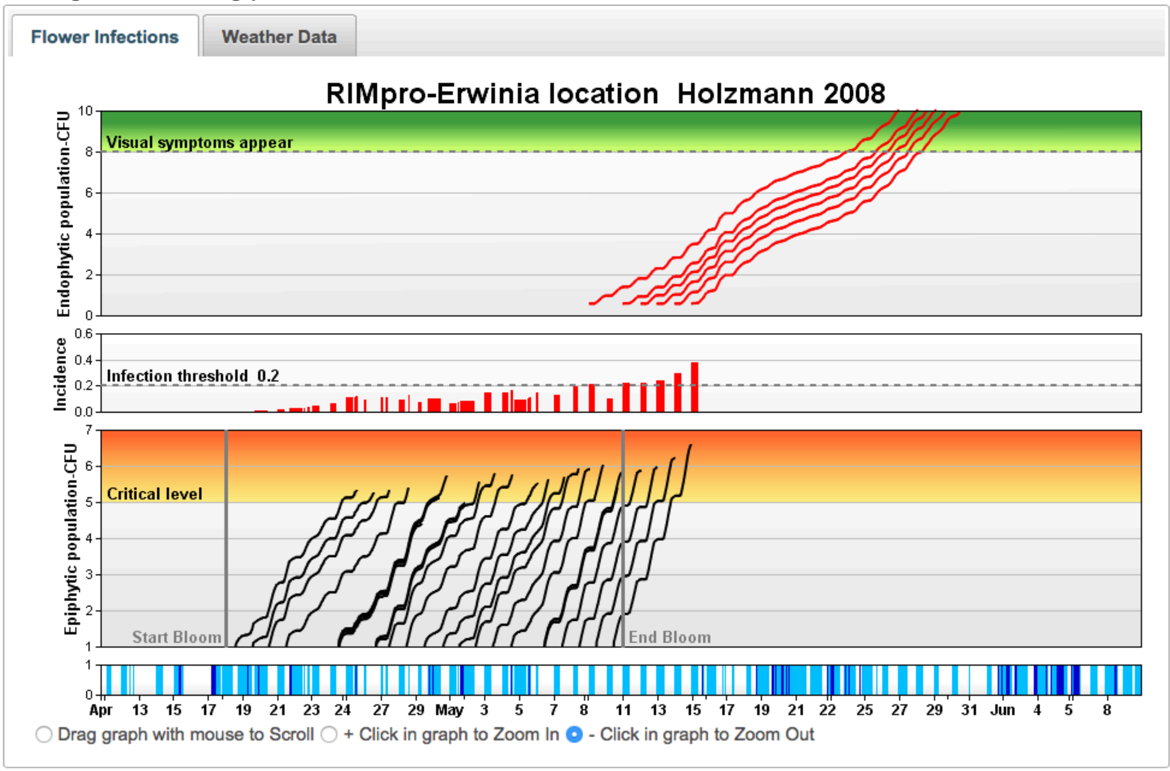


2007- The weather during bloom was very favourable for the development of high *Erwinia* population levels on the stigma. Six wetness events caused potential infection events. In the field the first fire blight symptoms where observed on May 12 indicating the first potential infection events probably did not lead to real infections.
2007 was a year with severe fire blight infections in this orchard and in other orchards in the region, as well as in other regions in mid Europe. Since the earliest infections rarely result in symptoms, sprays can be adjusted depending on individual risk management preferences. Nonetheless, at least 2 sprays were needed to adequately manage fire blight in 2007. The first spray in relation to the April 20th infection, and a second spray for flowers cohorts opened later and which lead to infection on April 25th to April 28th.





2008- No infections evens where calculated during the main blooming period (April 18 until May 4) and no fire blight symptoms were found on these flowers. Symptoms where only found May 18-May 30 on late flowers on 1-year old wood, and late flowering on newly planted trees. In the simulation parameters the blooming period is extended to cover these late flowers and the potential infection periods that caused these late fire blight outbreaks become visible. Blossom dates in the simulations must be adjusted for these special cases and these orchard blocks must be managed accordingly.



2009- No potential infection events exceeding the infection threshold have been calculated, and no fire blight symptoms have been found in the orchard this year.