RIMpro and Apple Scab in New England: Accuracy and Grower Adoption

Elizabeth W. Garofalo, Jon M. Clements and Daniel R. Cooley
Stockbridge School of Agriculture and UMass Extension, University of Massachusetts, Amherst

Keywords: Apple scab, RIMpro, New England, Apple

RIMpro (rimpro.eu) is a cloud-based decision support system that provides fruit growers with information useful in managing insects and diseases in apples, pears and grapes. The system uses either local weather station data or web-based commercial weather service data in models to simulate risk of damage from diseases and pests. Apple models include scab, fire blight, sooty blotch, codling moth, sawfly, Marssonina leaf blotch, and fruit thinning. Users can sign up for an individual account, currently for €220 per year (approximately $250 USD), and must arrange to provide their local weather station data in the proper format. So-called virtual weather data generated for any location via a web service is available for an extra €50. More details about RIMpro are explained in the article by Acimovic et al. in this edition of Fruit Quarterly.

"RIMpro decision support system for scab management was evaluated in New England in from 2012-2018. RIMpro made conservative estimates, recommending applications when perhaps none were needed, and often over predicting the end of primary scab season. In a couple of instances it failed to predict a scab infection. The best results were with an on-farm weather station rather than cloud based weather data. RIMpro provides a detailed picture of the infection process behind major apple diseases, particularly scab, and is a valuable tool. But we recommend other sources of information also be considered, particularly a grower's experience and knowledge, when making pest management decisions."

For several years, our lab at the University of Massachusetts Amherst has been evaluating the performance of different decision support systems, including RIMpro, to determine their accuracy, with a focus on managing apple scab. Observations at the UMass Cold Spring Orchard in Belchertown from 2012 through 2015 indicated that there were differences between systems and direct observations of ascospore maturity, as well as between each of the systems. Most importantly, there were differences in estimates of the length of primary scab season (Clements & Cooley 2013; Garofalo et al 2016). In 2016, we began a study looking at these differences in more detail, and in particular looking at how well the systems did when compared to observations of apple scab spores and infections of trees under orchard conditions. In this article we discuss how well RIMpro did relative to observed infections and spore development, and our experience with a group of New England apple growers who used RIMpro.

Field Studies with RIMpro and Apple Scab

During 2016, 2017 and 2018, we worked with RIMpro at different orchards in MA and CT, where we ran RIMpro and established a system to determine ascospore maturity and the timing of apple scab infections. In the fall preceding each year, we collected scab-infected leaves from unsprayed trees before they fell. We put them in a layer, protected by landscape fabric and overlaid with hardware cloth, at sites adjacent to the study orchards to overwinter. The following spring, approximately three weeks before estimated apple bud break, six random leaves were collected and brought back to the laboratory to determine ascospore maturity using a Petri-plate assay developed many years ago in Geneva, NY to determine whether the scab fungus was ready to release infectious spores. We continued to collect leaves and observe release from each site each year until we no longer saw any spores, usually in June.

To identify actual, real-world apple scab infections, we used potted McIntosh trees kept under cover in a plastic hoop house at the UMass Cold Spring Orchard. When buds broke at each orchard, weather forecasts were monitored, and before the first predicted rain four trees were taken from the hoop house and placed over the infected leaves at the test sites. After each potential infection period, these trees were collected, replaced with four new trees, and brought back to the hoop house. There they were observed for development of leaf scab infections. If a set of trees developed infections, it indicated that an infection period had, in fact, occurred.

We compared this information to RIMpro output. RIMpro provides data on the proportion of ascospores that have matured and are left to be released in a season, and the point at which no more ascospores are available. RIMpro, like all decision support systems, needs to know when ascospore development starts. The simplest starting point is 50% green-tip on the most common cultivar in an orchard. While RIMpro allows users to use more accurate information from actual ascospore observations, such as the Petri-plate assay, we assume most growers will use green-tip, and so used that date in our evaluation.

RIMpro also gives an estimate of the intensity of a given infection period. This is the Relative Infection Measure or RIM which gives the system its name, and it shows users the timing and severity of each primary scab infection. The RIM scale goes from 0 to 1200. In a relatively clean orchard, with no scab the previous year, a RIM of 100 or greater is considered large enough

Table 1. Comparison of RIMpro and laboratory observations of 100% ascospore maturity at orchards in Massachusetts and Connecticut.

			100% ascospore maturity	
Year	Site	Green-tip	RIMpro	Ascospore observations
2016	Belchertown MA	31 Mar	24 Jun	21 Jun
	Deerfield MA	30 Mar	21 Jun	24 Jun
2017	Belchertown MA	10 Apr	24 Jun	6 Jun
	Deerfield MA	10 Apr	24 Jun	30 May
	Amherst MA	10 Apr	30 Jun	6 Jun
2018	Belchertown MA	18 Apr	6 Jul	18 Jun
	Deerfield MA	18 Apr	6 Jul	18 Jun
	Amherst MA	18 Apr	10 Jul	4 Jun
	Southington CT	14 Apr	22 Jul	14 Jun

to cause infections, and that is the critical level we used for comparisons.

For end of ascospore maturation, at the two orchards observed in 2016, RIMpro and the direct observations were quite close, only three days separated them (Table 1). In 2017, however, RIMpro estimates were from two and a half to over three weeks later than observations. Similarly, in 2018 RIMpro estimates lagged behind observations by two and a half to over five weeks. Such overestimation is potentially less catastrophic than underestimation, as a grower following RIMpro might make more fungicide sprays than needed, but at least spraying would not stop too early.

We compared the date of the first infection periods, the last infection periods, and the total number of infection periods in orchards as estimated by RIMpro and determined by potted trees placed at the orchards (Table 2). In four of the nine cases, RIMpro estimates of the first infection were within a day of the potted tree evaluation. In the other five cases, RIMpro estimated first infection as 6 to 24 days before infections occurred on trees. Such errors might result in extra fungicide sprays. In eight of nine cases, RIMpro estimated the last infection as 6 to 27 days later than the last seen on potted trees. Again, this might lead to extra sprays. In one case, RIMpro indicated the last infection was a week earlier than that seen on the potted trees. In this case, failure to spray would have led to infections. In five of nine cases, RIMpro indicated from 1 to 3 more infection periods in a season than were seen on potted trees. In two cases, there were the same number of infections, and in two there was one fewer infection. Depending on the timing of the infection, the cases where RIMpro had one less infection period may have led to scab infections.

This study indicates that when RIMpro estimates for the end of ascospore maturation differ from direct observations, RIMpro generally indicates a longer season, potentially resulting in more fungicide sprays than may be needed. In only one of nine cases did RIMpro have an earlier end to ascospore maturation, and that was by only three days. For infection periods, a combination of ascospore availability and wetting conditions that would cause infection, RIMpro differences from observed infections also generally would result in extra sprays, not a failure to spray. Overall, RIMpro made conservative estimates, recommending applications when perhaps none were needed.

Weather Stations, Weather on the Web, and RIMpro

The quality of weather data ultimately determines how accurate any decision support system is. As the saying goes, "Garbage in, garbage out." In 2018 at Belchertown, we ran RIMpro using data from a weather station (Rainwise Inc., Trenton, ME), and also used virtual data from the web service MeteoBlue (meteoblue.com), and compared RIM values from each one. We used a minimum value of RIM = 100 as the level required for infection and treatment. Generally, the two sources of weather data generated RIM values that would have led to the same scab fungicide applications. Early in the season, however, from April 27 to May 4, the first infection from the MeteoBlue data came on April 29, while the first infection from weather station data came on May 4 (Figure 1). At the end of the season, MeteoBlue data gave an infection on June 1 without a concurrent infection from weather station data.

The details in the data suggest that rainfall and leaf wetness estimates from MeteoBlue did not always match what was actually recorded by the weather station rain gauge and leaf wetness sensor. Precipitation and leaf wetness are fundamental components in apple scab prediction, and this data suggests that MeteoBlue needs to improve this data in order to perform adequately in RIMpro.

Though we have identified some potential issues with decision support systems, they can be excellent tools to help growers in managing apple scab, as long as growers use them for support rather than as the ultimate decision maker. Of the available systems, we feel RIMpro offers the most detailed and accurate description of primary scab infections. It has the ability to estimate not only when an infection starts, but differentiates stages in the process: spore release, spore germination on the

Table 2. Comparison of RIMpro and laboratory observations of infection periods at orchards in Massachusetts and Connecticut.

		First infection period		Last infection period		Total infection periods	
Year	Site	RIMpro	Potted trees	RIMpro	Potted trees	RIMpro	Potted trees
2016	Belchertown MA	7 Apr	1 May	11 Jun	5 Jun	6	7
	Deerfield MA	7 Apr	1 May	5 Jun	30 May	7	4
2017	Belchertown MA	20 Apr	21 Apr	29 May	5 Jun	8	8
	Deerfield MA	20 Apr	21 Apr	4 Jun	29 May	5	6
	Amherst MA	20 Apr	21 Apr	16 Jun	31 May	6	6
2018	Belchertown MA	3 May	3 May	18 Jun	4 Jun	8	5
	Deerfield MA	6 May	12 May	23 Jun	1 Jun	7	4
	Amherst MA	27 Apr	6 May	24 Jun	4 Jun	8	7
	Southington CT	25 Apr	12 May	23 Jun	27 May	5	4

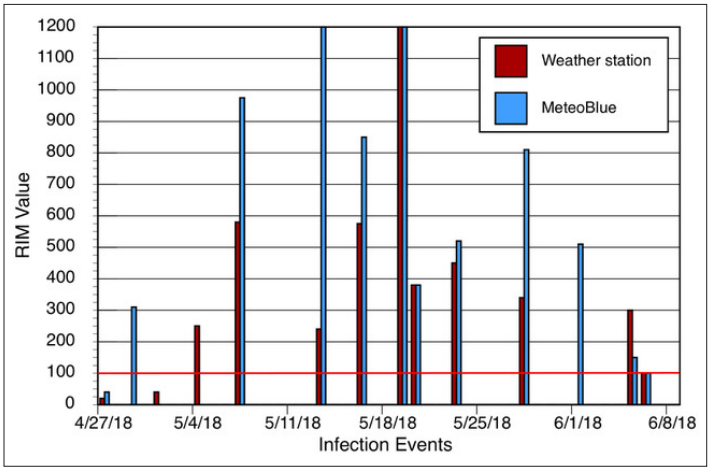

Figure 1. Comparison of RIM values generated in RIMpro by two different weather data sources, an on-site Rainwise weather station (red) and a web-based virtual service, MeteoBlue (blue). The red horizontal line indicates a RIM of 100, the minimum level necessary for infection in an orchard with low levels of scab inoculum.

leaf, and spore penetration and infection in leaf tissue. This can be very useful for post-infection fungicide applications, and offers a more complete understanding of each infection period than is available from other decision support systems.

Based on this, in 2017 and 2018 we formed a New England-wide UMass RIMpro Advisory service. This service set up and managed a system of RIMpro sites, and provided users with access to RIMpro output for their orchards. Users could access orchards using a site map provided by RIMpro with a customized web page specifically for participants (Figure 2). In 2017, the New England Tree Fruit Research Committee (NETFRC) provided funding ($1,500) while 21 participating orchards paid $150 each, which provided access to the RIMpro models, e-mail alerts (mostly during primary apple scab season), and one on-site consultation by UMass staff (Figure 3). In 2018, lacking funding from NETFRC, still twelve-member orchards paid $250 for the same service as 2017 though not all orchards had an on-site visit. Orchards with a NEWA weather station had to pay the NEWA fee of $55 for weather data and free weather forecasts from a web-based service (yr.no) provided by RIMpro. Alternatively, for €50, a user could elect to use only virtual data from MeteoBlue, no weather station required, provided by RIMpro. An additional feature of the RIMpro Advisory service was the creation of regional summaries (Figure 4). In 2018, the Service also provided access to an experimental Apple Thinning Model if subscribers were using the virtual MeteoBlue weather data.

During the 2017 and 2018 growing season, we sent several emails to Advisory group members advising them on our interpretations of the RIMpro output for apple scab, fire blight, and codling moth. RIMpro outputs were also used in Healthy Fruit, the UMass Extension tree fruit weekly newsletter (http://ag.umass.edu/fruit/publications/healthy-fruit).

Another very useful feature of RIMpro is the capacity to enter fungicide spray information for apple scab and get an estimate of fungicide wash-off, which tells users when they need to reapply a spray. A short on-line survey of the Advisory participants was conducted at the end of the season, with the following results:

- The scab and fire blight disease models (vs. sooty blotch, codling moth, etc.) were most frequently used;
- Nine percent of users were 100% confident in basing

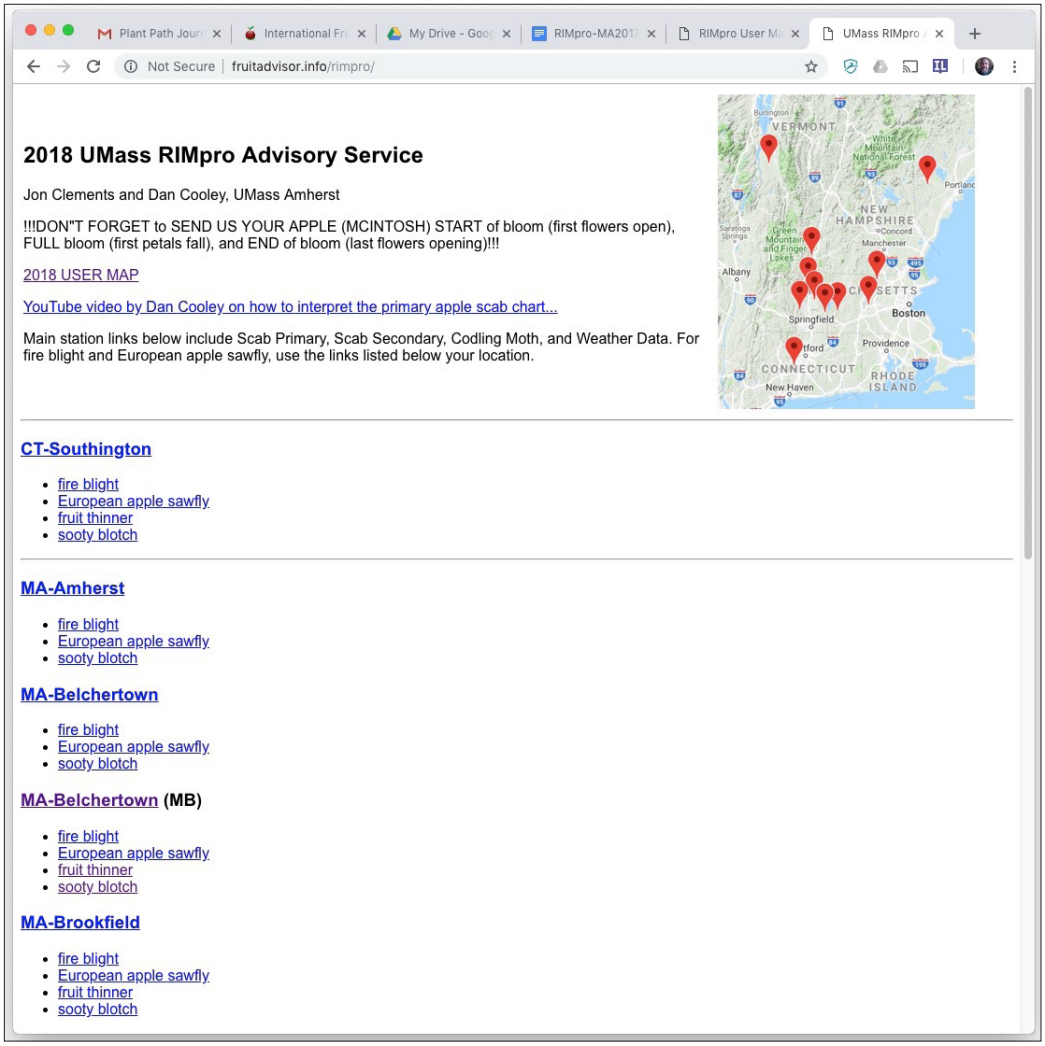

Figure 2. RIMpro User Map as seen on a custom website when logged-in as Advisory Service user.

orchard management decisions on RIMpro; the remainder were somewhat confident but still used other sources of information;

- Nearly 1 in 5 users said they would definitely use and pay for RIMpro in the future, but 1 in 5 also said no they would not use RIMpro;
- Half the users said they would continue to use RIMpro if they did not have to pay the full price and received continued support from Extension or a consultant.

It was not surprising that growers used the scab and fire blight models the most. These are disease problems for which there are good weather-based risk forecast models, but it's difficult to collect data and interpret it. Decision support systems offer an accessible way to do this, and RIMpro offers a level of detail that isn't found in other widely used systems. We do not and did not recommend that growers rely totally on RIMpro. As we showed in the first sections of this article, RIMpro output sometimes differs from what we are seeing in terms of actual infections. This may in part be a difference between conditions in Europe where it was developed and is widely used, and the northeastern US where it's relatively new. RIMpro provides a detailed picture of the infection process behind major apple diseases, particularly scab, and is a valuable tool. But other sources of information, particularly a grower's experience and knowledge, should be used in making pest management decisions.

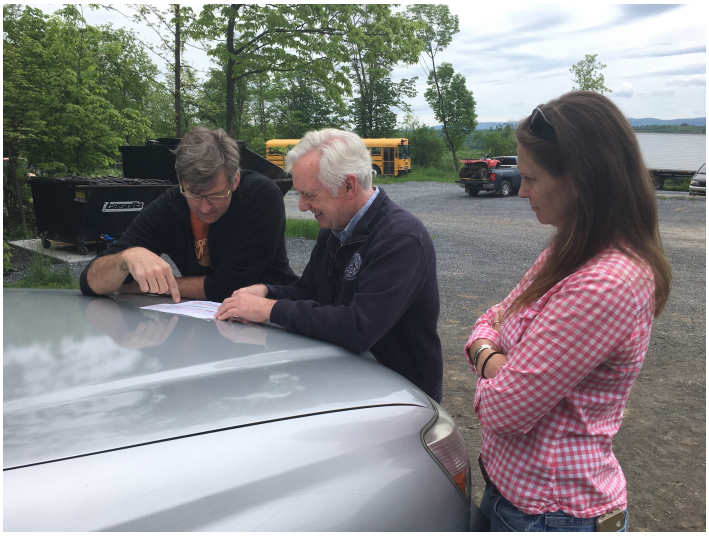

Figure 3. Dan Cooley and Liz Garofalo discuss RIMpro apple scab model output with Barney Hodges Jr. of Sunrise Orchard, Cornwall, VT in May 2017.

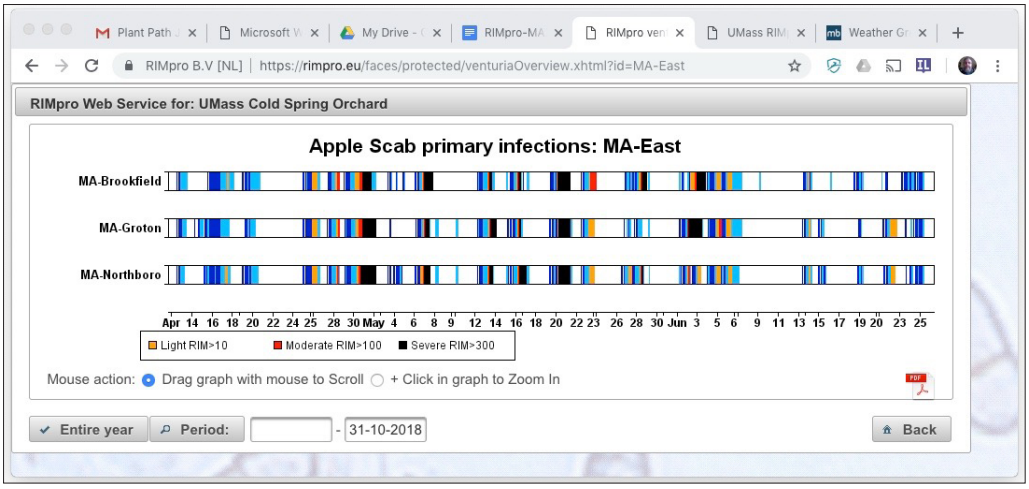

Figure 4. Example of a RIMpro regional summary showing apple scab RIM values for three orchards.

With regard to the last bullet point from the survey, growers did not feel that the RIMpro price was prohibitive, but valued it in combination with Extension or consultant advice. RIMpro is not easy to understand at first sight, but neither are the other systems available in the region. The detailed information available in RIMpro takes some work to access and understand. However, in our experience, if growers are assisted in learning to use RIMpro, they better appreciate its usefulness, are better able to integrate it into their management systems, and become more confident in pest management decisions.

References

Clements, J. and D.R. Cooley. 2013. A comparison of two sources of environmental data and three model outputs for primary apple scab in 2012 at the UMass Cold Spring Orchard. Fruit Notes 78 (2):4-11.

Garofalo, E.W., A.F. Tuttle, J.M. Clements and D.R. Cooley. 2016. Discrepancies between direct observation of apple scab ascospore maturation and disease model forecasts in the 2014 and 2015 growing seasons. Fruit Notes 81 (2):7-18.

Acknowledgements

This work was supported, in part, by the Extension Implementation Program, grant no. 2-14-700006-22579/project accession no. 1005350, and Integrated Pest Information Platform for Extension and Education award number 2015-68004-23179 both from the USDA National Institute of Food and Agriculture, the New England Tree Fruit Research Committee, and the University of Massachusetts Amherst Center for Agriculture and the Environment.

Elizabeth W. Garofalo is a graduate student who works with Dan Cooley, **Jon M. Clements** an extension educator for fruit crops at the University of Massachusetts and **Daniel R. Cooley** is a professor of plant pathology at the University of Massachusetts Amherst.