Two Years of Experience with RIMpro Apple Scab Prediction Model on Commercial Apple Farms in Eastern New York

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Correctly timing early-season fungicide sprays is essential in regions where spring rains favor development of apple scab caused by the fungus *Venturia inaequalis*. Overly conservative spray programs can result in wasted fungicide applications and increased costs whereas leaving trees unprotected during a critical apple scab infection period can result in significant losses from development of scab lesions on fruit and/or development of primary scab lesions on leaves. When scab becomes established on new leaves in the spring, then more conservative fungicide protection programs may be required throughout the summer to prevent further infection of fruit, and the cost of that extra fungicide protection during summer can take a bite out of profits. While experienced apple growers and consultants usually know how to protect trees from primary scab during the period of peak risk from tight cluster through petal fall, it is much more difficult to determine when the first spray of the season is really needed and when the supply of apple scab ascospores has been depleted after bloom. The latter is important because fungicide sprays can be applied on more extended intervals after the supply of ascospores is depleted, i.e. after the primary scab season has ended, so long as no primary infections were allowed to become established in the trees. In the absence of any information from biological monitoring or computer-based models, apple growers have generally assumed that apple scab ascospores will be mature about the same time that apple trees reach the green-tip bud stage and that trees must therefore be protected from apple scab beginning at green tip. Relatively low rates of fungicide (e.g., 3 lb/A of mancozeb or 2 lb/A of captan-80) are usually considered sufficient for the first spray when relatively little inoculum in available. However, in some years, ascospore maturation is delayed compared to tree phenology, meaning that the first fungicide spray could be delayed for a week or more, whereas in other years ascospore maturity may be advanced compared to tree phenology, thereby creating a higher risk with the very first infection period.

> **"Our comparisons of RIMpro and NEWA apple scab models indicated that RIMpro's model might provide opportunities for apple growers to reduce number of early season fungicide sprays, depending on the year. It seems that the RIMpro apple scab model incorporates valuable advances in describing *V. inaequalis* biology by increasing the accuracy for infection prediction early in the season and at the end of the season when ascospore inoculum is depleted from leaf litter. However, RIMpro will benefit only those growers willing to (1) learn how to use it, (2) check model outputs on a regular basis as they plan their fungicide spray applications, and (3) properly maintain their NEWA RainWise stations to ensure accurate weather data recording."**

In the Hudson Valley, Dr. David Rosenberger and his predecessors provided growers with information on apple scab ascospore maturity by having their technicians use overwintered leaves to conduct ascospore discharge tests and/or pseudothecial squash mounts that allowed assessment of spore maturity. These assessments provided information on the relative risks from early season wetting periods and an indication of when all ascospores had been discharged after bloom. However, these assessments required a skilled technician and a lot of time (at least three hours for each assessment), and their usefulness was limited by statistical uncertainties and by the fact that they were usually conducted using leaves from only one or two sites in the Hudson Valley. The fact that development and release of apple scab ascospores is entirely dependent on weather presents both a problem and an opportunity. The problem is that assessments of ascospore maturity in one location may not apply to locations a few or more miles away where rainfall and temperatures are slightly or significantly different. The opportunity involves linking apple scab model forecasts to automated weather stations such as those provided by the NEWA network that now has on-farm RainWise stations throughout much of northeastern United States. The NEWA website includes various temperature and moisture driven models, including one for apple scab, that are updated at hourly or daily intervals and that include infection predictions for the next four days based on the temperatures and rainfall that are predicted by the National Oceanographic and Atmospheric Administration (NOAA).

The apple scab prediction model in NEWA (http://newa.cornell.edu/index.php?page=apple-diseases) is initiated at green tip and provides a temperature-driven estimate of the number of ascospores that are available for discharge during any given wetting event. It also uses the recorded weather (for past events) or predicted weather (for five days forward) to indicate whether or not a scab infection has occurred or is likely to occur based on the Mills Table as modified by Gadoury and McHardy (1985). However, the apple scab model incorporated into the NEWA website may not accurately account for variations in actual apple scab ascospore discharge as affected by temperatures during a wetting event (less ascospores are released in cold rains), by differences between day and night time wetting events (few ascospores are released at night), or by effects of extended dry periods when the leaf litter beneath trees becomes so desiccated that ascospore development is completely arrested. As a result, the NEWA model has limited capabilities for assessing the likely severity of ascospore infections during early-season wetting events and for determining when all ascospores are finally depleted after bloom. The former would overestimate infection risks leading the grower to apply fungicide when it is not needed, while the latter would facilitate earlier reporting of the end of primary scab season leading the grower to stop fungicide applications where in reality they might still be needed.

Introduction to RIMpro

A more complex decision support system for managing apple scab, RIMpro (RIMpro B.V., Zoelmond, Netherlands), has been developed by Marc Trapman and tested by scientists in Europe for more than 20 years. It has been evaluated at the Hudson Valley Research Laboratory (HVRL) for the past five years. RIMpro is a cloud-service program accessed via computer or smart phone that, in addition to providing information on apple scab, also contains software modules that, when coupled with weather stations and weather forecasts, provides management information for pear scab, fire blight, apple powdery mildew, sooty blotch, Marsoninna leaf blotch of apple, apple canker, cherry leaf spot, Monilinia blossom blight and brown rot, grape downy and powdery mildew, and grape black rot. RIMpro also includes models for prediction of emergence and outbreaks for apple codling moth and apple sawfly. Finally, RIMpro delivers model for plant stress prediction and is developing a model for crop load adjustment (thinning) which is in testing mode and not yet functional in the U.S. RIMpro's proprietary prediction models are available through an annual subscription (more information about subscribing can be found by clicking on "Create a new RIMpro account" on this link: RIMpro. RIMpro's disease and pest model forecasts are driven by a weather forecast model through a Norwegian world-wide weather service identified as "yr.no", which is also used in the U.S. Currently, there are no satisfactory options for using other weather forecast models/networks such as the NOAA, which is widely used in the U.S. Weather data collected from the ground by NEWA-RainWise weather stations are fed into the RIMpro models for an additional license fee via NEWA. By using the latest weather forecast data from "yr.no" and the most recently recorded historical data from the NEWA stations, users can monitor the past, present and the future status of plant pathogens or insect pest populations and the pest forecasts for each location. To allow data flow from a NEWA-RainWise or other weather station to RIMpro one needs to obtain a NEWA license (more information available by clicking here: http://blogs.cornell.edu/yourenewa/licensing/rimpro/request/

Setting Biofix Dates for the RIMpro Apple Scab Model

To run accurately, the RIMpro apple scab model requires users to enter the date when apple fruit reach green tip (GT) at the location/s of interest. The date of green tip growth stage is defined as the day when 50% of fruit buds are at green tip on the earliest apple cultivar of interest to the user. The second biofix required for the apple scab model in RIMpro to run correctly is the date when the first *V. inaequalis* ascospore release is detected from overwintering leaf litter. This biofix is usually determined by using a spore trap and requires special equipment and expertise. In general, first mature ascospores can be detected plus or minus ~2 weeks from GT. The model provides the most accurate outputs if user/s enter the biofix for spore release based on the actual testing, but in most years, accuracy will not be too much diminished by simply using the date of green tip alone (as described above) for the spore release biofix if data on first spore release is not available. After one logs into the RIMpro cloud and sets the green-tip date and spore biofix dates for the apple and pear scab model, a graphic labelled "Scab primary" appears on the screen (Figure 1). Early in the season, the graphic will have very little to show, but a full season of data is shown in Figure 1 for illustration purposes. The red RIM value curve is the single most valuable indicator showing whether an infection period has occurred or is predicted to occur given current weather forecasts. For example, a RIM value of 1000 means that 10% of the total season's spores has/will probably trigger infections during an infection event (wetting). In orchards that had little or no scab last year due to good spray programs, wetting periods that generate RIM values less than 300 are usually of no economic consequence. However, in orchards with high levels of carry-over scab inoculum from infections the previous year, any wetting periods generating RIM values greater than 100 should not be ignored.

The second most important feature to look for on RIMpro scab model graphs is the white camel-humps, like the one visible on 16 - 18 April and 10 - 12 May in Figure 1 where the red line indicating a RIM value is either non-existent or stays below the thresholds described above. These white humps are not significant apple scab infection periods. Instead, these humps indicate that only a spore release and germination events occurred, but the weather conditions were unfavorable and prevented germinating spores to establish i.e. complete the infection process. Even though the RIMpro scab model shows a 10-day prediction for future infection risks based on a 10-day weather forecast from the Norwegian weather model (Figure 1), weather forecasts that extend more than 96 h into the future are very unreliable. However, the 10-day forecasts are useful for tentative spray planning, especially as it relates to weather fronts that are moving in from the west. Because weather forecasts, including 24 - 48 h forecasts, frequently change as the predicted events approach, it is wise to check the RIMpro prediction model daily so as to pick up changes in predicted weather and scab events and to make any necessary changes in plans for applying fungicides.

Implementing a RIMpro User Group in New York State

In 2017, Cornell faculty at the HVRL established a partnership with interested eastern NY apple growers to facilitate introduction of the RIMpro apple scab and fire blight models to commercial farms. Owners of 21 and 18 NEWA-RainWise stations on commercial fruit farms subscribed to use RIMpro service in 2017 and 2018, respectively (Figure 2). We provided extensive technical support in subscribing growers

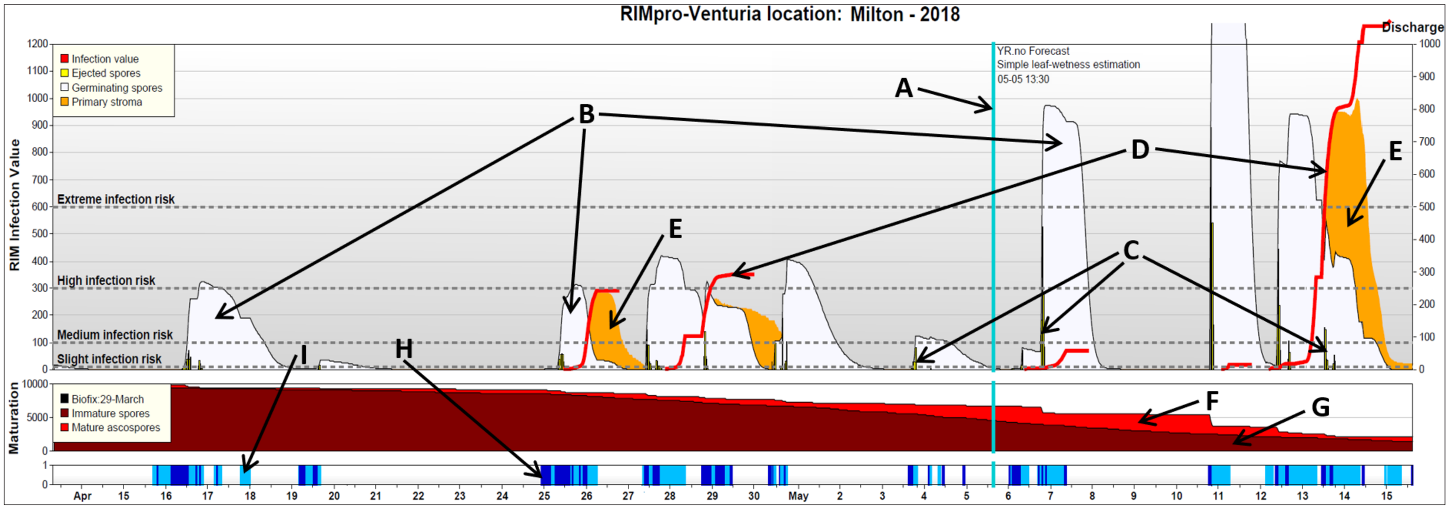

Figure 1. Example of RIMpro apple scab model output on 5 May 2018 for Milton NY. (A) A vertical light blue line marks the current date and time within that day. (B) White camel hump-like areas labelled "Germinating spores" designate cumulative number of *Venturia inaequalis* ascospores that germinate over time and are read using the right-side vertical Y-axis scale that is labelled "Discharge". (C) Small yellow-black bars, which are seen better by using the zoom-in tool on the RIMpro screen, show the number of spores ejected from leaf litter in the orchard during each one-hour interval. (D) The red curved line is the RIM infection value which, when divided by 100, is roughly the percentage of the total season's ascospores that are likely to cause infection in any given infection period. Read each curve's peak RIM infection value/s using the vertical Y-axis scale on the left-hand side of the graph labelled "RIM Infection Value". (E) Orange area called "Primary stroma" represents scab lesions that were initiated by infection from germinating spores and that are incubating in the leaf after which scab lesions will become visible. Incubating infections are worth noting because, if no fungicide was in place before the infection event began, some or all of the incubating infections can still be eliminated by using fungicides with post-infection activity. (F) The light red area in the middle "Maturation" graph is the proportion of mature ascospores that are ready for discharge with wetting events whereas the dark red area (G) shows the proportion of immature ascospores remaining in leaf litter. (H) The dark blue bars in the wetting graph with dates, at the bottom, are the actual or predicted rain periods. (I) The light blue bars are actual or predicted wetting periods when no rain is falling but trees continue to be wet after rain. Used by permission of RIMpro B.V., Netherlands.

to RIMpro and helped connect their NEWA-RainWise weather stations with RIMpro. We provided education to growers on how to interpret and use RIMpro apple disease models and provided time-sensitive apple and pathogen development data to calibrate RIMpro models for accurate functioning (biofixes). By using RIMpro in our extension activities, we organized timely delivery of predicted apple scab and fire blight infection periods with appropriate management recommendations to eastern NY apple growers. In the fall of both 2016 and 2017, we collected dead apple leaf litter from orchards with a history of apple scab and overwintered these scabby leaves in three different regions in eastern NY, namely Highland, Rexford and Peru. Starting in late winter, from 20 March onward, in both 2017 and 2018 we collected leaf litter samples 1 – 2 times per week and examined them for release of ascospores, by using an apple scab vacuum tower i.e. spore trap and microscopy. Ascospore monitoring on the vacuum tower was conducted on 27, 29 March and 7, 11 April in 2017, and on 31 March and 4, 5, 12 and 22 April in 2018. In 2017 and 2018 growing seasons, we detected first ascospores and determined location specific biofixes for RIMpro apple scab model on the dates presented in Table 1. Based on the number of detected ascospores in the

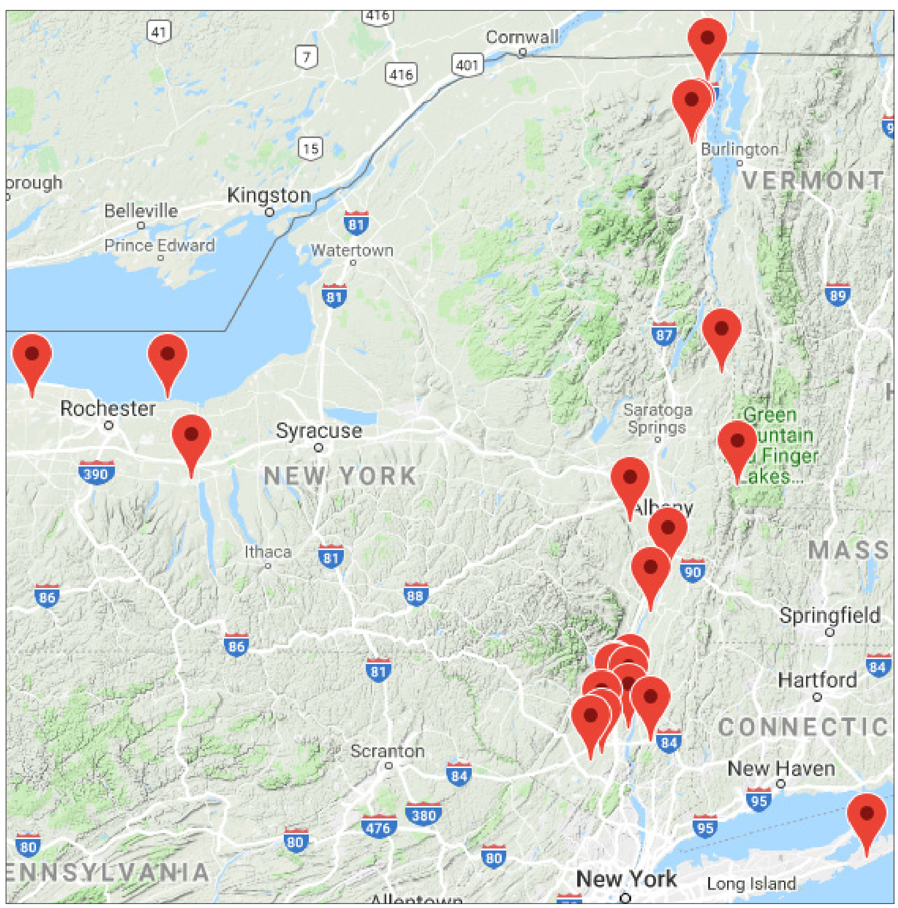

Figure 2. Locations of the 21 apple farms with NEWA stations that subscribed to RIMpro. In 2018 the three farms in western NY were not subscribed (Used by permission of RIMpro B.V., Netherlands).

tower on the date when spores were first detected (Table 1) and using historical data and experience from the squash mount examinations of *V. inaequalis* pseudothecia made in prior years, we adjusted RIMpro biofix dates to a certain number of days before the green tip date for the earliest apple cultivar on the farm to increase accuracy of the RIMpro forecasts (Table 1). This adjustment of the first spore release biofix was necessary because leaf litter was sampled only at roughly weekly intervals and large spore numbers on the date of first detection implied that the first mature spores may have appeared soon after the previous assessment was completed whereas lower spore counts on the first assessment suggested that the actual date of first spore maturity was closer to the date when the testing was conducted. We reported the dates listed in Table 1 to NY apple industry via e-mails and Acimovic Lab blog posts. To increase the accuracy of infection prediction in NEWA's apple scab model using ascospore data in Table 1, we recommended to growers that had not subscribed to RIMpro that they might also wish to set their green tip date in NEWA apple scab model to the same date when first mature spores were estimated to have been available for release since that provides a more accurate biofix for the NEWA model as well as for the RIMpro model.

Table 1. Dates and abundance of first mature *Venturia inaequalis* ascopores detected in East New York during 2017 and 2018 using vacuum tower spore trap, with green tip dates and adjusted biofixes.

Locations in East New York	2017			2018		
	Date of ascospore detection and their number range	*RIMpro Biofix adjusted to ascospore number	Apple green tip date for Zestar!	Date of ascospore detection and their number range	*RIMpro Biofix adjusted to ascospore number	Apple green tip date for Zestar!
Peru	11 April (50-127)	6 April	16 April	22 April (7-15)	13 April	3 May
Rexford	7 April (25-30)	31 March	6 April	5 April (1-2)	3 April	17 April
Highland	29 March (9-15)	26 March	30 March	31 March (6-16)	29 March	7 April

*As described in the text, the biofix date was adjusted backward after the first spore detection to adjust for the fact that leaf litter was tested for ascospore release only at 7 to 13 day intervals.

Delivery of RIMpro Interpretations to New York Apple Growers

We used a two-prong delivery approach to help the NY apple industry by delivering critical apple disease prediction information and management recommendations in advance of infection risks. The first approach was delivering e-mails to RIMpro subscribers that contained date-precise data on apple scab infection predictions for their farm location. We sent 19 of these e-mails in 2017 and 22 in 2018. The second approach was delivering short blog posts on tree fruit disease management which were available to the entire NY apple industry via Acimovic Lab website http://blogs.cornell.edu/acimoviclab/. We published 43 blog posts in 2017 and 44 in 2018. In both cases, the key goal was quick information delivery timed to assist NY growers in planning their disease management efforts 5-7 days in advance of potentially major infection events. The e-mails sent to the RIMpro user group delivered screenshot images of the RIMpro apple scab model outputs containing 10-day predictions for pathogen infection periods and potential disease outbreaks for the subscribed farms and provided (1) updates on apple growth development stages and pathogen monitoring in eastern NY, (2) interpretations and commentary of predicted scab infection periods as shown in the RIMpro output, and (3) disease management recommendations for three regions: Lower Hudson Valley, NY Capital Region/Upper Hudson Valley, and Champlain Lake Valley.

We published blog posts two or more times per week, depending on predicted weather conditions. These posts allowed growers in the Hudson Valley and eastern NY on a weekly basis to (1) know when major infection risks for tree fruit diseases were expected in relation to tree growth stages and pathogen maturity, (2) plan and decide when to apply protective spray applications for disease management ahead of infection risks, (3) be aware of when the first symptoms of apple scab occurred in their region, and (4) be aware of predicted severe thunderstorms or other unusual weather events that could contribute to scab problems. In addition to posts, when severe disease infection risks were predicted, growers in NY would receive e-mail alerts and emergency phone calls as necessary. Before publishing blog posts, we analyzed and compared outputs from RIMpro and NEWA apple disease models to determine any differences in dates when infection risks were predicted. However, in the published blog posts we did not provide location-specific dates of predicted scab infection periods (i.e. risks from RIMpro's model) as this data is owned by the RIMpro subscriber and is protected by copyright laws. Instead, we used publicly available weather forecasts, NEWA's apple scab model for each region and revised Mills' table to determine scab infection period date ranges and deliver them in blog posts.

To determine whether RIMpro allows an opportunity for reduction of fungicide spray applications per year in comparison to NEWA's apple scab model, we compared basic model output parameters listed in Table 2, such the dates of first apple scab infection periods and symptom occurrence in 2017 and 2018. To determine when the first apple scab symptoms would occur in 2017 and 2018, we collaborated with growers in eastern NY by arranging with them to leave small unsprayed plots of Zestar! and/or Jersey Mac at three locations listed in Table 2. When we compared the dates when RIMpro and NEWA reported the first major apple infection period/s that required fungicide protection (Table 2), we found that NEWA's model in 2017 reported 3-4 infection periods that in RIMpro's apple scab model did not require fungicide protection (dates with orange text color for in Rexford and Highland). In 2018, there were 1-2 NEWA infection periods on all three locations that did not require fungicide protection as per RIMpro's model. Depending on the year weather conditions, this would allow apple growers to omit 1-3 early fungicide spray applications in these locations.

According to RIMpro and NEWA apple scab models, on apple farms that have not had scab occur in the previous year, primary scab seasons in 2017 and 2018 were over on the dates in Table 3. In both years, the RIMpro and NEWA models for *V. inaequalis* ascospore maturity showed a discrepancy of 6-14 days between dates when primary scab season was declared over (Table 3). In RIMpro's ascospore maturity model, the primary scab season is over when predicted infection events fail to reach RIM threshold values of 300 for clean orchards or 100 for high-inoculum orchards and petal fall has passed. This usually occurs after ascospores remaining to be discharged are less than 5% of the season total (Figure 1, middle graph labeled "Maturation"). In NEWA, the ascospore maturity model predicts that after 95% of ascospores have been discharged or are ready for release, the primary scab season will end after next daytime rain of more than 0.1 inch with temperatures above 50ºF. In both NEWA's and RIMpro's management recommendations, scab infection events after the day when all ascospores are depleted should be monitored and spray coverage maintained for at least two more weeks to ensure that fungicide protection throughout the primary scab season was effective and that no last-minute infections would emerge and contribute secondary inoculum that could initiate infections if fungicide coverage was allowed to lapse too soon. Following this rule we found a discrepancy of 6-14 days between the dates in NEWA and RIMpro when spray coverage must be maintained after primary scab season ended. We found that in two (2017) and all three monitored locations (2018) there were 1-3 infection periods recorded in NEWA that still required fungicide protection according to RIMpro but not according to NEWA (Table 3). Hence, the overestimation in the NEWA's ascospore maturity model indicating an earlier end of primary scab season might lead growers to miss applying 1 or 2

Table 2. Dates of green tip occurrence and apple scab infection periods in RIMpro and NEWA during 2017 and 2018 with dates when first apple scab symptoms were detected in unsprayed control plots in eastern NY. Dates with orange text color are infection periods reported in NEWA's model for which fungicide spray application/s were not needed as per RIMpro's apple scab model.

Locations in East New York	2017				2018			
	RIMpro's first weak apple scab infection (spray not needed)	RIMpro's first apple scab infection (spray needed)	NEWA's first apple scab infections	First apple scab found on Zestar! leaves	RIMpro's first weak apple scab infection (spray not needed)	RIMpro's first apple scab infection (spray needed)	NEWA's first apple scab infections	First apple scab found on Zestar! leaves
Peru – GT 2017: 16 April; GT 2018: 3 May	12 April	20 April	27 March* 6 April* 11 April* 15 April* 19 April	25 May	28 April	19 May	12 April* 25 April* 27 April* 3 May* 15 May 19 May	7 June
Rexford – GT 2017: 6 April; GT 2018: 17 April	17 April	20 April	26 March* 4 April* 6 April 12 April 15 April 20 April	23 May	25 April	6 May	29 March* 25 April 27 April 6 May	/**
Highland – GT 2017: 30 March; GT 2018: 7 April	4 April	20 April	7 March* 25 March 30 March 4 April 6 April 19 April	10 May	17 April	25 April	2 April* 15 April 24 April	11 May

*Dates of apple scab infection events reported in NEWA's model not requiring fungicide spray applications since they were reported before the green tip growth stage occurred i.e. when no susceptible apple green tissue was exposed. **Fungicide drift from protective sprays in grower orchards affected unsprayed Zestar! plot and prevented detection of early apple scab symptoms in this location.

Table 3. Comparison of dates in RIMpro and NEWA apple scab models when primary apple scab season ended in 2017 and 2018 due to depletion of ascospores in leaf litter and of the dates when both models advise to continue spray coverage. Dates with blue text color are the apple scab infection periods reported in NEWA's model that required fungicide spray protection as per NEWA's recommendations to continue coverage for two weeks after ascospore discharge is completed. Dates with green text color are infection periods reported in NEWA that did not require fungicide spray protection according to NEWA but did according to RIMpro.

Locations in East New York	2017					2018				
	Primary scab season over date in		Maintain spray coverage until in		NEWA infection periods after primary scab end date in NEWA	Primary scab season over date in		Maintain spray coverage until in		NEWA infection periods after primary scab end date in NEWA
	RIMpro	NEWA	RIMpro	NEWA		RIMpro	NEWA	RIMpro	NEWA	
Peru	1 June	22 May	15 June	5 June	25 May 29 May 5 June	24 May	1 June	21 June	15 June	3 June 13 June 18 June
Rexford	27 May	13 May	10 June	27 May	18 May 22 May 25 May 29 May 4 June	29 May	19 May	12 June	2 June	22 May 27 May 1 June 4 June
Highland	15 May	6 May	29 May	20 May	13 May 22 May 25 May 29 May	21 May	15 May	4 June	29 May	19 May 22 May 1 June

fungicide applications that would still be essential for controlling primary scab.

If we look at three years of historical apple scab data from RIMpro model for Highland NY (Figure 3), we can see there were only 3 - 4 major scab infection periods in 2016, four in 2017 and six in 2018. In retrospect, by looking at the actual data it would be easy to accurately time protective fungicide applications to control apple scab. However, this is not the case during the early primary scab season (April-May) when the weather forecast changes drastically, sometimes in less than 24 h after one looked at the model. Therefore, the first problem of plant disease prediction models is the low level of accuracy of weather forecasts early in the season that feed into the scab models. More reliable weather forecasts would provide more reliable disease infection predictions. In Figure 3A, there were 8 early ascospore ejections with germination in 2016 (white humps) preceding the first major infection period on 1 May. These ejections did not lead to infections and did not require protective fungicide applications. In 2017 there were four and in 2018 there were two such ascospore ejections that did not require fungicides applications (Figure 3B & C). Using the RIMpro model, if weather forecasts were reliable, would allow apple growers to omit at least three unnecessary fungicide spray applications in 2016. In 2017, growers would have been able to omit three and in 2018 one early fungicide spray application (Figure 3). Figure 3 confirms the data for 2017 and 2018 in Table 2 for Highland NY, where the dates with orange text color were infections in NEWA that did not require fungicide protection in RIMpro. This could reduce the total number of fungicide sprays depending on year's weather conditions and reduce the costs of apple production.

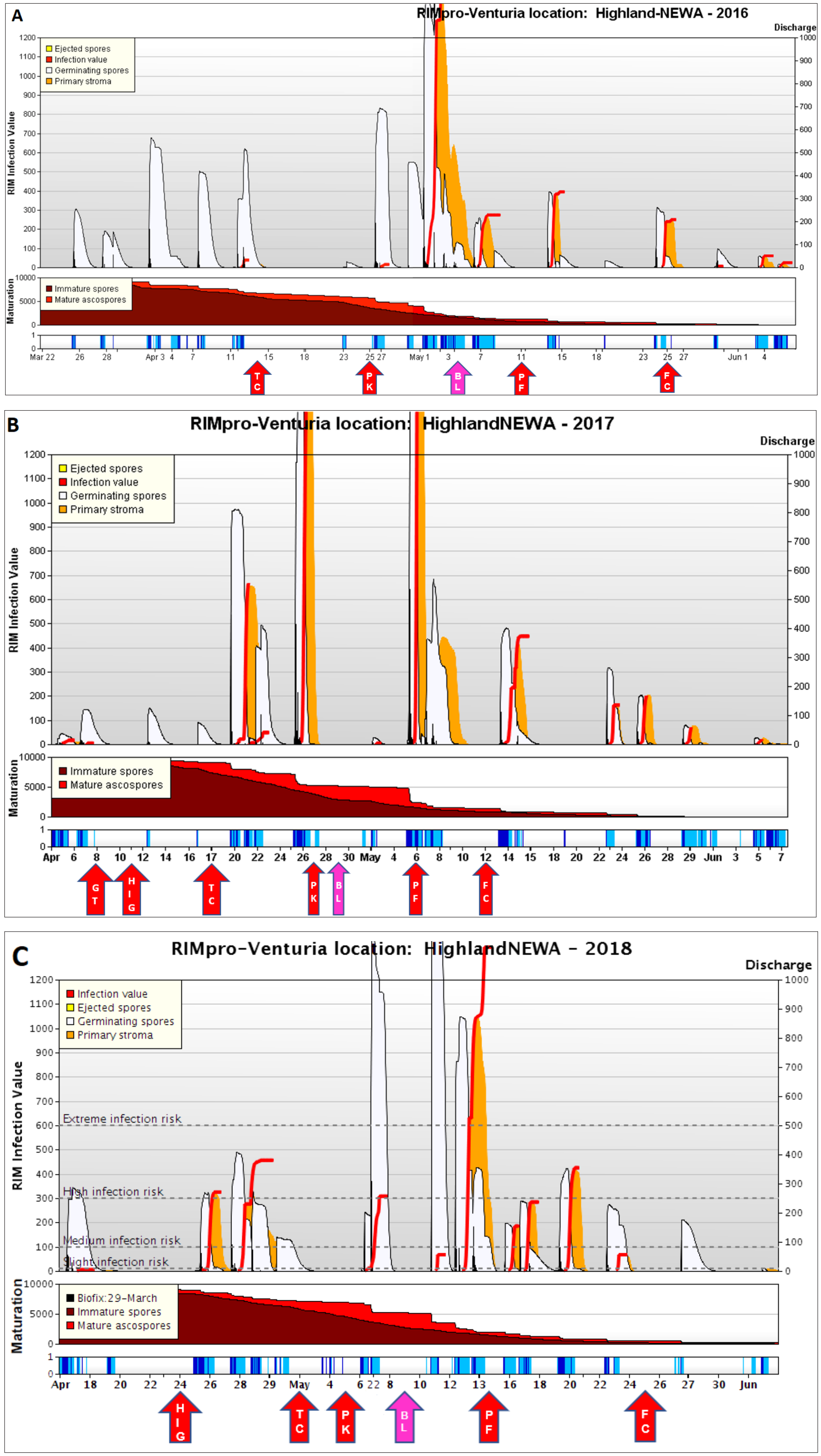

Figure 3. RIMpro apple scab infection periods and apple growth stages in (A) 2016, (B) 2017 and (C) 2018 for Highland NY showing obvious differences in disease pressures between years and hence need for adjusted apple scab protection programs as per apple scab model predictions. GT- green tip, HIG – ½" green, TC – tight cluster, PK – pink bud, BL – bloom, PF – petal fall, FC – first cover. Used by permission of RIMpro B.V., Netherlands.

Conclusion

Our basic comparisons of RIMpro and NEWA apple scab models indicated that RIMpro's model might provide opportunities for apple growers to reduce number of early season fungicide sprays, depending on the year. In 2017 and 2018, if RIMpro's apple scab model was used growers could have omitted 1-3 unnecessary fungicide sprays. After the end of primary scab season, RIMpro's model allowed growers to better protect their crop from scab than NEWA by requiring 1 or 2 additional fungicide applications necessary to control primary scab. If we estimate a cost of $25/A for each fungicide application, growers could save between $310,000 – $930,000 for the total of 12,375 acres of apples in the eastern NY.

Based on our comparisons, it seems that the RIMpro apple scab model incorporates valuable advances in describing *V. inaequalis* biology by increasing the accuracy for infection prediction early in the season and at the end of the season when ascospore inoculum is depleted from leaf litter. However, RIMpro will benefit only those growers willing to (1) learn how to use it, (2) check model outputs on a regular basis as they plan their fungicide spray applications, and (3) properly maintain their NEWA RainWise stations to ensure accurate weather data recording. As with any of the NEWA models, the disease models are reliable only if the weather stations are properly calibrated and maintained. All of these models are driven by the environmental parameters that are recorded into the NEWA network from on-farm weather stations (Aćimović & Rosenberger, 2018). Bearing in mind that the RIMpro apple scab model has been widely used in Europe for many years and was developed in collaboration with plant pathologists who spent more than 20 years in model development, optimization and validation, we recommend RIMpro as an option for US apple growers seeking to better time their fungicide sprays and/or reduce the number of scab sprays needed each year.

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Literature Cited

Aćimović, S. G., Rosenberger, D. A. 2018. An introduction to the RIMpro apple scab prediction model. Scaffolds Fruit Journal, Vol. 27, No. 5, April 2018.

McHardy, W.E. and D.M., Gadoury. 1985. Forecasting seasonal maturation of ascospores of *Venturia inaequalis.* Phytopathology 75: 381-385.

Stensvand, A., H. Eikemo, D.M. Gadoury, and Robert C. Seem. 2005. Use of a rainfall frequency threshold to adjust a degree-day model of ascospore maturity of *Venturia inaequalis.* Plant Disease 89:198-202.

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