C2021-0283 Apple Growth & IPM project

This is the second year of the project, which continues the initial work done on implementing the use of Davis weather monitoring technology for orchard management in New Brunswick.
The weather stations in the participating orchards located in the Fredericton, Sussex and Moncton regions were upgraded with two additional soil moisture probes and one additional leaf wetness sensor. The additional soil moisture probes allow for soil moisture content to be measured at 12” and 18” depths and the additional leaf wetness sensor allows for monitoring of full sun and shaded conditions.
The Davis Mobilize app used with the Davis weather monitoring technology has showed this year that it can be an excel-lent tool for irrigation management and frost risk monitoring and management. Mixed results were seen with the integrated pest management (IPM) modules of Davis Mobilize and their accuracy for use in New Brunswick orchards. Several life cycle models of insect and disease pests affecting apple production in New Brunswick appeared to give accurate alerts for risk of damage while several did not. Further research/testing is needed in order to properly apply the models that gave inaccurate alerts for New Brunswick’s climate and growing conditions, which we hope to complete this year.

C2021-0283 Croissance de Pommes et le Projet lutte intégrée contre les ravages

Il s'agit de la deuxième année du projet, qui poursuit le travail initial effectué sur la mise en oeuvre de l'utilisation de la technologie de surveillance météorologique Davis pour la gestion des vergers au Nouveau-Brunswick.
Les stations météorologiques des vergers participants situés dans les régions de Fredericton, Sussex et Moncton ont été améliorées avec deux sondes supplémentaires d'humidité du sol et un capteur supplémentaire d'humidité des feuilles. Les sondes supplémentaires d'humidité du sol permettent de mesurer la teneur en humidité du sol à des profondeurs de 12” et 18 " et le capteur supplémentaire d'humidité des feuilles permet de surveiller le plein soleil et les conditions ombragées.
L'application Davis Mobilize utilisée avec la technologie de surveillance météorologique Davis a montré cette année qu'elle peut être un excellent outil pour la gestion de l'irrigation et la surveillance et la gestion des risques de gel. Des résultats mitigés ont été observés avec les modules de lutte intégrée contre les ravageurs (IPM) de Davis Mobilize et leur précision pour une utilisation dans les vergers du Nouveau-Brunswick. Plusieurs modèles de cycle de vie d'insectes et de maladies nuisibles affectant la production de pommes au Nouveau-Brunswick semblaient donner des alertes précises pour le risque de dommages, alors que plusieurs ne l'ont pas fait. D'autres re-cherches / tests sont nécessaires afin d'ap-pliquer correctement les modèles qui ont donné des alertes inexactes pour les conditions clima-tiques et de crois-sance du Nouveau-Brunswick, que nous espérons terminer cette année.

CANADIAN AGRICULTURAL PARTNERSHIP

New Brunswick Soil & Crop Improvement Association

Apple Growth & IPM C2021-0283, Year 3

Final Report

December 13th, 2021

Project Title: Apple Growth & IPM C2021-0283, Year 3

Project Collaborators

NBSCIA Coordinators (Project Lead)
Amy McFadgen, Crop Development Officer, NBDAAF
Leigha Beckwith, Crop Development Officer, NBDAAF
Garth Nickerson, Tree Fruit Specialist, NBDAAF

Abstract

This project continues the initial work done on implementing the use of Davis weather monitoring technology for orchard management in New Brunswick in 2020 by NBSCIA. The weather stations in the four participating orchards (Bear Island, Keswick Ridge, Kiersteadville and Memramcook) were upgraded with two additional soil moisture probes and one additional leaf wetness sensor. The additional soil moisture probes allow for a greater portion of the rooting zone to be monitored and the additional leaf wetness sensor allows for monitoring of full sun and shaded conditions. Wireless signal repeaters were acquired and installed as needed in order to place the weather station and additional sensors directly in the orchard for improved monitoring. The Davis Mobilize app used with the Davis weather monitoring technology has showed this year that it can be an excellent tool for irrigation management and frost risk monitoring and management. Mixed results were seen with the integrated pest management (IPM) modules of Davis Mobilize and their accuracy for use in New Brunswick orchards. Several phenology models of insect and disease pests affecting apple production in New Brunswick appeared to give accurate damage risk alerts while several did not. A greater understanding was acquired on using the Davis Mobilize and the IPM modules. However, further research/testing is needed in order to properly apply them to New Brunswick's climate conditions and use for orchard management in New Brunswick.

Introduction

The NB apple industry has a history of over 100 years of commercial production. Apple production occurs on about 200 hectares (500 acres) of apples in two main areas: South East region (Cocagne / Memramcook area) and the Central region (St. John River Valley from Woodstock to Gagetown / Queenstown). The industry's economic value is estimated at $3 million dollars annually.

Detailed monitoring of the environment or weather conditions is critical to understanding the success or failure of a new variety as well as the ongoing production management of a successful orchard. Integrated Pest Management (IPM) in apple production, rather than simply trying to eradicate pests considers all available information, accounts for multiple objectives, and considers every preventive and curative option. Fundamental to an IPM program is a network of weather monitoring devices and the robust delivery of the sensor data for further analysis and interpretation.

This is the third year of the project. In 2021, the Davis Mobilize app used with the Davis weather monitoring technology showed that it can be an excellent tool for irrigation management and frost risk

monitoring and management. Mixed results were seen with the integrated pest management (IPM) modules of Davis Mobilize and their accuracy for use in New Brunswick orchards. Several phenology models of insect and disease pests affecting apple production in New Brunswick appeared to give accurate damage risk alerts while several did not. A greater understanding was acquired on using the Davis Mobilize and the IPM modules. However, further research/testing is needed in order to properly apply them to New Brunswick's climate conditions and use for orchard management in New Brunswick, which was the objective of this year of the project.

Project Objectives

The objective of this project is to demonstrate the use of Davis weather monitoring devices in orchard management and the subsequent utility of phenology models to predict the growth stages of apple insect and disease pests.

Project Deliverables

Improved understanding of weather monitoring instrumentation and data analysis for orchard management by orchard owners, NBSCIA coordinators and NBDAAF crop production specialists. Definition of procedures and operating manuals to deliver various models in the 2021 season.

Technical Innovation

Davis weather monitoring and IPM technology was adopted for this project in 2020 and expanded upon in 2021 with two additional soil moisture probes and one additional leaf wetness prober per orchard. The full scope of the technology used includes:

- **Vantage Pro2 weather station**: used for measuring outside air temperature, humidity, rainfall, wind speed and wind direction. The outside temperature is utilized as the canopy temperature of the apple trees for the IPM phenology models.

- **Weatherlink Live:** connects weather station to the internet for real-time uploads of sensor data.

- **Davis Weatherlink app:** Displays real-time weather data collected by the weather station and sensors as well as past records.

- **Davis Mobilize app:** uses the data collected from the weather station and sensors to provide IPM data. Tracks the development of insect and disease pests and gives alerts when there is risk of damage on a scale of no risk of damage, low risk, medium risk and high risk. Users can select which pests are monitored and which phenology model is used. Displays data in real time. Weatherlink Pro+ subscription is required for access to the IPM program in Davis Mobilize.

- **1 x leaf wetness & soil temperature/moisture station**: collects sensor data from leaf wetness sensors, soil temperature sensors and soil moisture sensors.

- **3 x stainless steel temperature sensors:** Sensors are placed at 6” and 12” soil depth to record soil temperature. One sensor is placed a few inches above ground level to record temperature at ground level.

- **3 x soil moisture probe:** placed at 6”, 12” and 18” soil depths to measure soil moisture between 0 centibars (saturated soil) and 200 centibars (extremely dry soil).

- **2 x leaf wetness sensor:** measures water sitting on the leaf and placed at the top of the tree canopy. Gives wetness readings on a scale of 0 to 15, where 0 indicates leaf is completely dry and 15 completely wet. One sensor is north facing and the other is south facing to measure potential differences in leaf wetness in shaded and/or full sun conditions.

- **1 x radiation shield:** goes over the stainless steel temperature sensor placed at ground level to prevent sunlight from influencing temperature reading.

- **Wireless Signal Repeaters (as needed):** extends the connectivity of weather station and leaf wetness & soil temperature/moisture station range with the weather station console by up to 300 m per repeater. Allows for greater flexibility in where monitoring equipment can be placed.

Evaluation Plan

The utility of the Davis cloud database and IPM models for application in New Brunswick were evaluated. This was done by consulting with NBDAAF staff and literature if high-risk alerts for insect/disease damage and infection given by the Mobilize app were valid. Codling moth and apple maggot traps were placed in orchards to help validate risk ratings given by Davis Mobilize.

Results and Discussion

This is the second year of the project. The primary goals were to have a full season of weather monitoring, pest/disease cycle modelling, installation of additional sensors and to determine the utility of Davis Mobilize for orchard management. A full season of weather monitoring was achieved and the additional sensors were installed in the same four orchards that participated in the project last year (located in Bear Island, Keswick Ridge, Kiersteadville and Memramcook). Over the course of the 2021 season, good results for using Davis Mobilize for tree growth related management were seen while there were mixed results on the utility/validity of the IPM features.

As previously stated, two additional soil moisture probes were installed this season. The three probes in total are placed at 6”, 12” and 18” depths which covers the majority of the rooting zone.

Fig. 1: Soil moisture data in mid-August with rainfall events as seen from Davis Weatherlink

In Figure 1, "Soil Moisture 1" is the probe at 6" depth, "Soil Moisture 2" is the probe at 12" depth, and "Soil Moisture 3" is the probe at 18" depth. Rainfall events are the black vertical lines. As seen in Figure 1, the soil at 12" and 18" depths dried out at a much slower rate than the soil at the 6" depths (increase in Soil Moisture cb indicates drier soil). Producers that have irrigation capabilities can use the data from the deeper soil moisture probes to decide how long to run irrigation, instead of just relying on one moisture probe at a relatively shallow depth or no sensors at all. For example, if the soil at shallow depths show that irrigation is necessary but the deeper soil were still moist the producer could run the irrigation system for a shorter amount of time, which would reduce inputs. The additional sensors can also help prevent over watering of trees. Having three soil moisture probes in the weather station configuration ultimately allows for significantly better irrigation management and profitability.

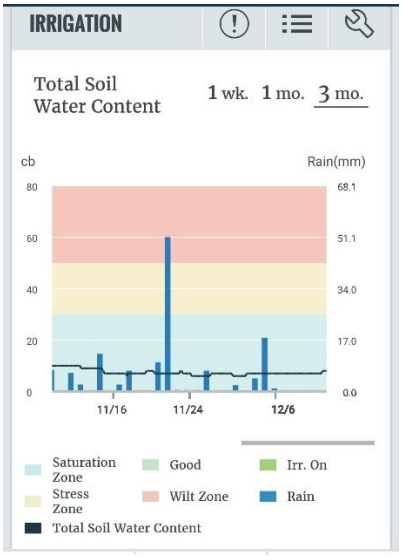

Fig.2: View of soil moisture content from Davis Mobilize (thresholds for saturation, stress and wilt are for demonstration purpose only and do not necessarily reflect actual thresholds)

Current soil moisture content can be viewed in real time in Davis Mobilize. Thresholds for soil saturation, drought stress and tree wilt can all be individually set according to the soil characteristics of the orchard. Alerts are given when soil moisture content enters stress and wilt zones, which can notify producers when to start and stop irrigation. Only one soil moisture sensor is displayed per irrigation page so a separate irrigation page needs to be set up for each individual sensor. Davis Mobilize can be an extremely useful tool for producers who irrigate their orchards.

Davis Mobilize uses sensor data collected from the weather station and local weather forecasts to track frost risks.

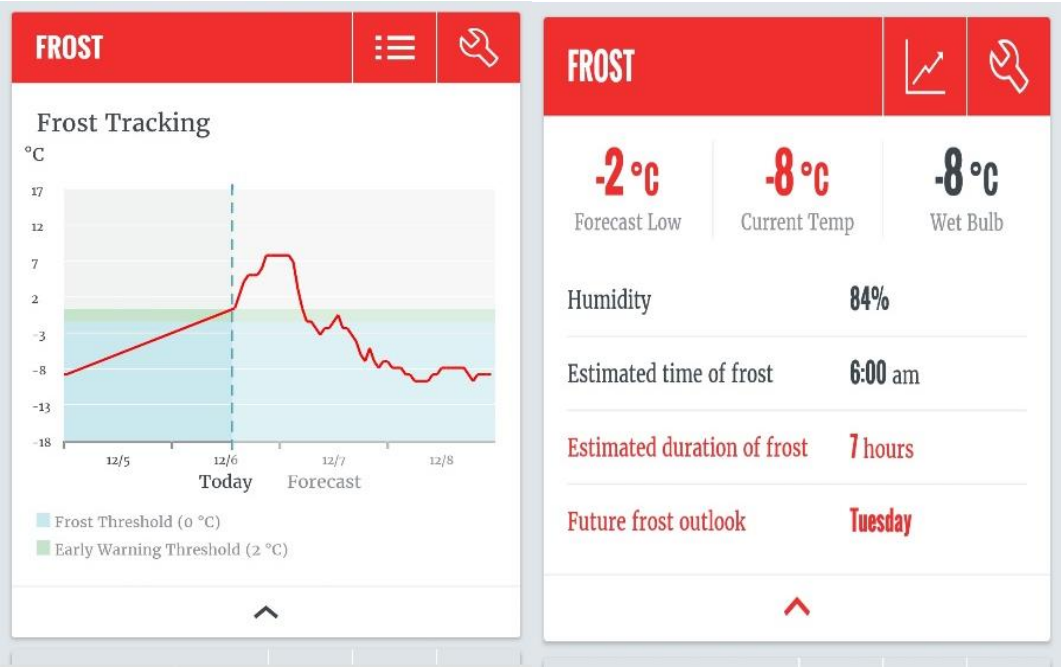

Fig. 3: Side by side view of two frost tracking screenshots in Davis Mobilize. Graph of daily temperature and forecasted temperature with frost thresholds (left) and time estimates for upcoming frost (right)

Davis Mobilize gives producers estimates of when frost will occur and for how long a frost event will last, as seen in Figure 3. Frost thresholds can be adjusted to best suit individual orchards. Since early season frost has the potential to cause significant economic damage, producers could use Davis Mobilize in the decision making process on whether to undertake protective measures to reduce frost damage and associated economic loss.

Similar to last year, several insect and disease pests were modeled to varying degrees of accuracy during the growing season, such as fire blight, apple scab, oriental fruit moth, fruittree leaf roller and codling moth for example.

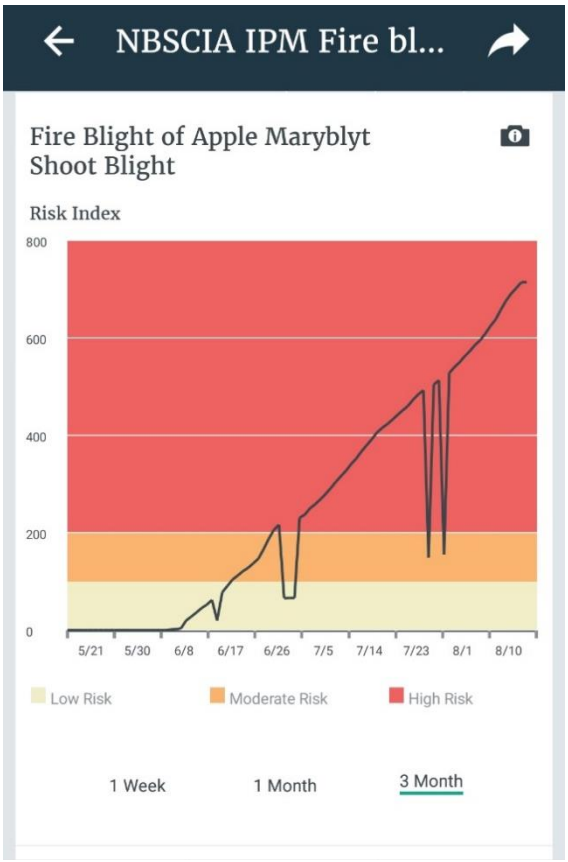

Fig. 4: Model of fire blight risk level as determined by sensor data from late May to Early August.

Fire blight infections typically occur in hot and humid conditions. As seen in Figure 4, the risk of fire blight infection on shoots increased as daytime and nighttime temperatures increased throughout the season. The dips indicate cooler days and nights, which would create less ideal conditions for fire blight infection. This results in a lower risk rating. Producers can use the risk ratings given by this model to know when to increase/decrease monitoring for fire blight infections or potentially spray.

The dealer from where the Davis equipment was acquired from recommended that two leaf wetness sensors be used in the weather station configuration for the IPM modules. Mixed results were seen, where in some cases there were clear differences in the leaf wetness readings between the two sensors but no differences in risks of non-insect pests such as fire blight.

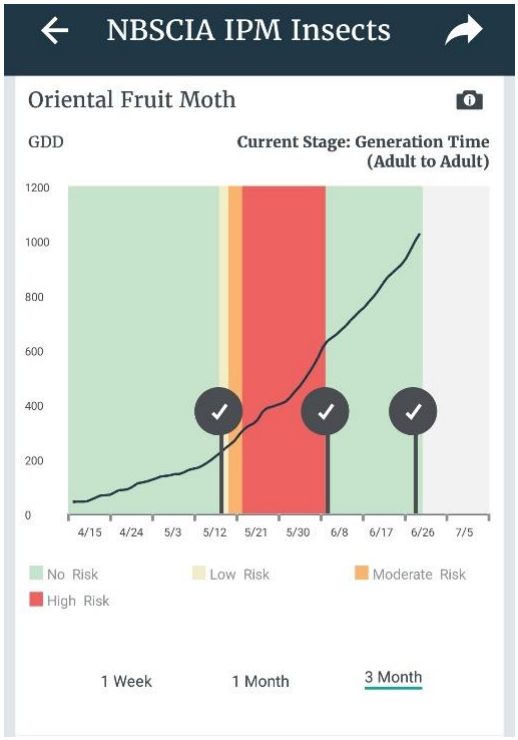

Fig. 5: Model of oriental fruit moth and risk level as determined by sensor data from late April to late May

Many insect pests have more than one generations per year, such as oriental fruit moth. The first generation typically emerges around the end of May to the beginning of June, so the high risk of damage alert given by Davis Mobilize can be considered an accurate alert. The high risk alert is triggered by growing degree day (GDD) accumulation that would correspond with peak emergence of oriental fruit moth. Low and moderate risk prior to high risk indicates that emergence has begun but the population is not at a level where it could cause considerable damage. Once the generation has completed its lifecycle (based on time elapsed and GDD accumulation), the risk level drops until the next generation emerges based on GDD requirements. Although Davis Mobilize may give an accurate alert, producers should still use insect traps in conjunction with Davis Mobilize to determine if they should spray or not since an insect may or may not be present in the orchard.

An important aspect of the insect models identified this year is setting the start date of GDD accumulation correctly. If the start date is set too early or too late, the timings of risk alerts will be inaccurate, which could result in improper control of insects. Davis Mobilize has recommended start dates for the insect models however it was determined that many of these start dates may be too early for New Brunswick. For example, several insect models have recommended start dates in January and February. Although there would be no GDD accumulation in New Brunswick at this time, it could result in GDD accumulation in March and April and give risk alerts for pests when there would not be any new growth on trees for insects to damage. This is seen with the fruittree leafroller model in Fig. 6.

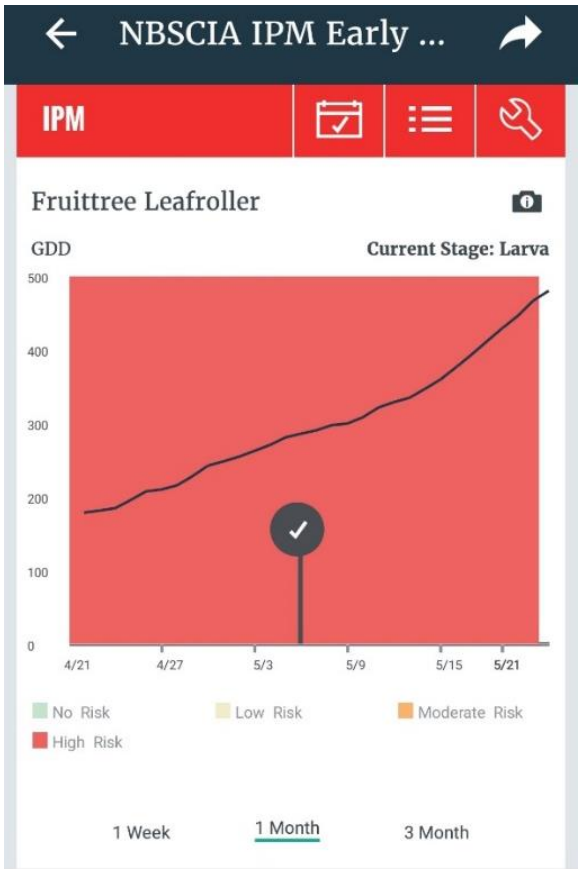

Fig. 6: Model of fruittree leafroller and risk level as determined by sensor data from late April to late May

Fruittree leafrollers are early season pests. Although not seen in Figure 6, the model recommended treatment for fruittree leafroller on May 27. This indicates that the model met a GDD threshold that would correspond with a population level that could potentially cause enough economic damage to justify a pest control treatment. Although fruittree leafrollers are typically seen in June, GDD accumulation started earlier than usual this year so the late May recommendation for treatment could still be considered accurate depending on vegetation development in the orchard. The recommended start date for this model was February 1st, which resulted in GDD accumulation in April. This caused the model to reach its threshold for high risk of damage in April, however damage from fruittree leafroller in April is atypical for New Brunswick. To make the model more accurate for New Brunswick, the start date of the model should be set later in order to delay GDD accumulation so the high risk alert will better match New Brunswick conditions. The specific date or date range when to start the model to make it accurate for New Brunswick conditions is currently unkown.

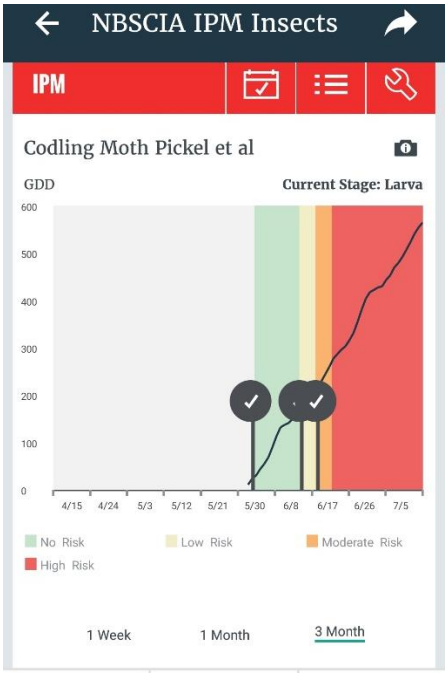

Fig. 7: Model of codling moth from the end of May to early July

Codling moth traps were placed in orchards to help assess the risk ratings given by the codling moth models. Note the model in Figure 7 was mistakenly started at the end of May instead of based on the biofix date, which for this model is when moths are trapped on two successive nights and sunset temperatures average 16.7 °C or above (Pickel, Bethel & Coates 1984). The biofix date would likely have been sometime between June 18 and June 25, based on the results in Table 1.

Table 1: Results of codling moth trap from one orchard site

Date	Codling moths caught per week
18-Jun	1
25-Jun	6
2-Jul	3
9-Jul	2
16-Jul	5
23-Jul	4
30-Jul	2
6-Aug	0

Accounting for pre-biofix date GDD accumulation, it appears that the high risk rating from the model for the end of June and early July would be accurate. Had the start date/biofix been set for between June 18 and June 25, the high risk rating likely would have extended further into July. This likely would have been consistent with the results from the codling moth traps set in the orchard. Since Davis Mobilize tracks GDD accumulation, producers can time their subsequent spray applications with GDD accumulation to more effectively control codling moths as opposed to spraying by calendar dates for example. This could result in producers experiencing less damage from codling moths and higher economic returns.

No apple maggot flies were caught in the traps hung. Although not pictured, the IPM model used for apple maggot IPM met the GDD threshold for adult fly emergence in the beginning of June. This is earlier than the usual late June - early July emergence. This could mean that the model was started too early or the earlier and quicker than usual GDD accumulation seen this season could have accelerated insect pest development.

With the plum curculio and two spotted spider mite models, the model only ever indicated there was no risk of damage throughout the entire growing season. There was more than sufficient GDD accumulation for development of these pest populations, so this justifies the need for further testing of the IPM module of Davis Mobilize to determine which pest phenology models can be used in New Brunswick.

Davis Mobilize provides IPM models for numerous insect and disease pests of apples. Several of the major pests have more than one model users can choose from such as fire blight, codling moth and apple maggot for example. Since each model has different thresholds for pest development and risk levels, choosing the most appropriate model for New Brunswick is critical for proper IPM. However, extensive knowledge and/or research of these models is required to determine which model may be best suited to New Brunswick orchards. The specific models to use for pests with multiple models has not been fully determined yet. Davis Mobilize does not appear to provide any guidance to users on which model to use for their location. None of the IPM models available were developed in New Brunswick, which leads to questions on how confidently the models can be applied to New Brunswick. For example, all of the codling moth models available were developed in California where climate is significantly different from New Brunswick. Further testing is needed before recommendations on the IPM features can be made for use in New Brunswick orchards.

There were no models for European apple sawfly and powdery mildew which are significant pests in New Brunswick orchards. This means that risk tracking is unavailable for these two pests.

A drawback of Davis Mobilize IPM identified in this year of the project is that it is not particularly user friendly. There are no built-in instructions on the app on how to use Davis Mobilize. Online information on the app is limited and does not offer in-depth instructions/information on the IPM features. Data from the IPM models can only be accessed for a maximum of three months from the present date, which results in data that is older than three months being permanently lost. This could potentially limit the use of the IPM models for use in research and for farm record keeping. No historical data is lost for raw sensor data, which includes temperature, humidity, rainfall, wind speed and direction, soil temperature, soil moisture and leaf wetness.

Wireless signal repeaters were acquired and installed based on producer need in order to place the weather station and additional sensors directly in the orchard for improved monitoring of orchard conditions. To date, two repeaters were installed in Bear Island.

The weather monitoring equipment is expensive to acquire. For a producer to purchase a new weather station, additional sensors and subscription for Davis Mobilize it would cost between $3000 and $4000. Since it is difficult to quantify an economic return from using Davis Mobilize, producers may need to assess their own operations and needs to determine whether investing in this technology would be economical.

Conclusions

The additional leaf wetness and soil moisture sensors were installed at the four orchard sites. Wireless signal repeaters were installed as needed. A full season of weather monitoring was achieved. Davis Mobilize has been shown to have excellent potential as a tool for irrigation and frost management in apple orchards, however mixed results were seen for the IPM modules. The project deliverables outlined for 2021 were partially met. A much greater understanding on the weather monitoring instrumentation and use of Davis Mobilize was achieved while definitions of procedures and creation of operating manuals could not be developed yet for Davis Mobilize. This is due to ongoing questions on the proper use of the IPM modules for New Brunswick where further research is needed.

Required Next Steps

NBSCIA recommends that this project be extended into its third year. The primary next steps include:

- Determine proper start dates for many of the IPM models in order to better suit them to New Brunswick's climate and determine if the IPM models can be reliably used in New Brunswick orchards. This should include the use of insect traps to determine biofix dates and for determining the accuracy of risk alerts given by Davis Mobilize.

- For pests that have more than one model to choose from, determine which model is most appropriate to use in New Brunswick.

- Reach out to Davis about adding IPM models to Davis Mobilize, like European apple sawfly and powdery mildew.

- Potentially add weather stations and additional sensors in Gagetown and Salisbury areas to better cover the main apple growing regions in New Brunswick and more climate areas.

Communication

The final report will be posted on the NBSCIA website. Project team leaders will deliver presentations in early 2022 and/or after the 2022 growing season at commodity professional meetings and to industry professionals. Meetings will likely take place virtually due to Covid-19 pandemic.

References

Pickel, C.P., R. S. Bethell, W. W. Coates. 1986. Codling Moth Management Using Degree-days. University of California Statewide IPM Project. Publication #4.