Southern Region Small Fruit Consortium Grant

Progress report (Outreach)

Title: Building a platform for disease risk assessment system using OpenWeatherMap data.
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Public abstract
Our goal is to develop an adaptable system to display or deliver plant disease risks based on past and forecast weather data using OpenWeatherMap. To achieve this goal, we are developing a system to deploy a grape downy mildew risk assessment system using previously published models, R language, OpenWeatherMap data, and a web server.

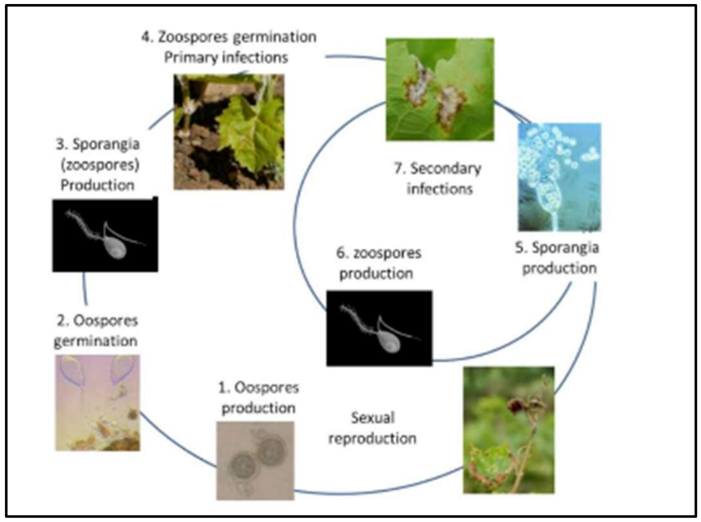
Introduction

To produce healthy wine grapes in the region east of the Rockies, it is critical to manage multiple fungal diseases. Among five to seven key diseases, grape downy mildew is getting more attention in recent years. Two Virginia grower surveys conducted in 2022 indicated that growers need more tools to manage downy mildew (Nita and VA Wine Research Exchange, both are unpublished data).

Grape downy mildew, caused by an Oomycette, *Plasmopara viticola*, is a common disease across the southeastern region of the US. It can infect leaves to negatively impact photosynthesis and flowers and berries to cause direct yield loss. Moreover, a heavy infection can cause defoliation, which can reduce vines' capacity to survive winter months.

Growers use EBDC fungicides (e.g., mancozeb), captan, and copper as their basic tools to manage grape downy mildew. However, these materials are reviewed regularly by the European Commission and EPA for their impacts on the environment and human health. Thus, we may need to face some level of use restriction for these materials. Unfortunately, resistant isolates have been found for recently introduced materials such as carboxylic acid amide (CAA), which is probably one of the reasons for the recent increase in the interest in downy mildew management. Fosetyl-Al or Phosphonate materials can be used as a tool, but they tend to work better as a posterior application. There are some biological agents that list downy mildew, e.g., Lifeguard, but their effectiveness is not consistent. Also, for the biological control materials to work, it is often necessary to apply them before the onset of the disease.

Disease risk models can be used to aid growers to apply proper material(s) at the right moment. For prediction of downy mildew, leaf wetness, temperature, and relative humidity data have been often used. However, many weather stations do not have a leaf wetness sensor. Agricultural weather stations, such as the ones used in the NEWA (http://newa.cornell.edu) have leaf wetness sensors, but their recommended weather stations start from $1,800 or above and many growers are reluctant to purchase them. In addition, there will be costs of maintenance and data, which will be additional burdens for growers.



P. viticola overwinters in infected leaves and causes the primary infection in the spring. Epidemiologically, the management of the primary infection is important, and thus, some models, such as the one developed in Canada, use cumulative growing degree day to determine the activity of *P. viticola* in the spring. It makes sense if *P. viticola* becomes active after grapes start to develop shoots for the season. However, in northern Virginia, the threshold for the activity reaches by the time grapes start to break their buds (i.e., mid-April), thus, it is most likely that the trend is similar in the states south of Virginia. Also, there are many wild grapes that are grown in our regions and can host the primary infection, thus, the model for the primary infection may not be suitable.

Thus, it is important to plan season-long downy mildew management by focusing on the secondary infection cycle, which can cause damage rapidly. DMCast, which is used in the NEWA, can be used for this purpose; however, currently, it is only available in their system. Some agricultural weather station companies offer their version of the disease and insect models, but once again, it costs growers to purchase and maintain weather stations. Therefore, we need to develop a new cost-effective system that can be accessed by growers who do not have weather stations.

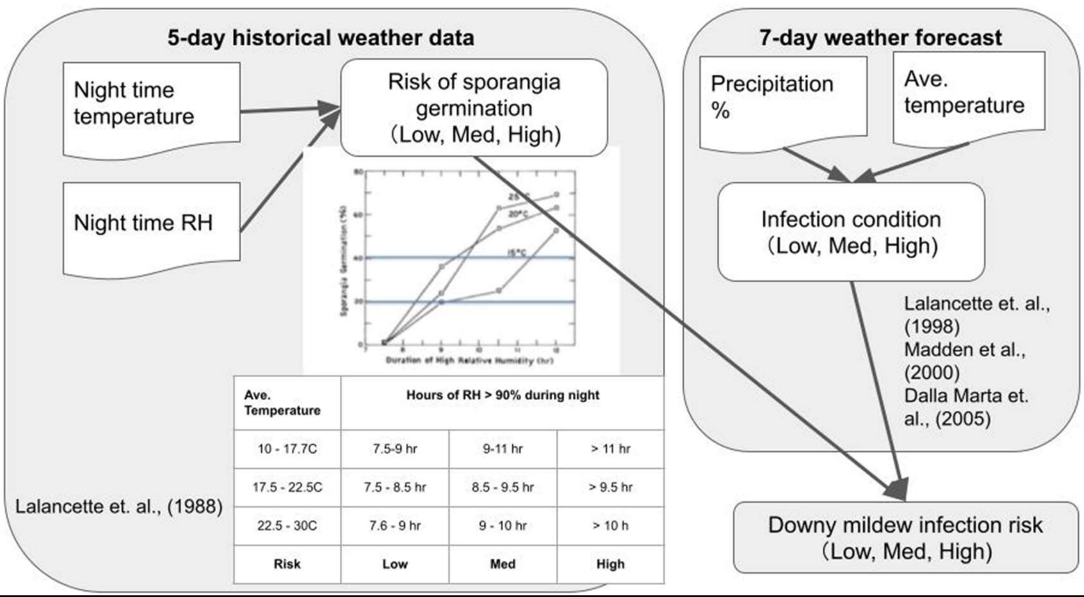
Objective: deploy a grape downy mildew risk assessment system using previously published models, R language, OpenWeatherMap data, and a web server.

To address this issue, the PI (Nita) started a collaboration with Drs. Kazunori Hayashi of Kyoto University and Syuichi Ohno of Osaka Public University in 2021 to develop an online grape downy mildew forecasting system using data from OpenWeatherMap (http://OpenWeatherMap.org) (OWM) (Murayama, Y., et al., 2022). The OWM is a global weather data service that uses its weather models and weather stations to deliver both historical and forecast weather.

Using a statistical programming language, R (R Core Team 2022), we developed a code to retrieve past and forecasted weather data from the OWP, and estimate the risk of sporangia germination based on the work by Lallancetter et al., 1988. We have tentatively created low, medium, and high-risk indices based on the combinations of hours, the relative humidity is higher than 90%, and the average temperature during the high RH condition (Fig. 2). Then it estimates the risk index of downy mildew infection

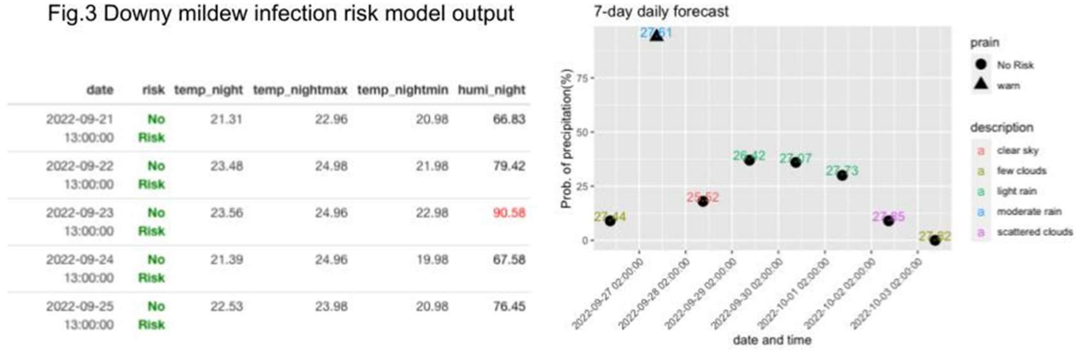
(Lalancette et al., 1988, 1998; Madden et al., 2000) (Fig. 2), using the probability of precipitation and temperature during the forecast rain period were used. By combining the two indices, we will develop an overall risk of grape downy mildew infection.

Figure. 2. A flowchart of grape downy mildew risk assessment model



Currently, our R code prints out the risk information (Fig. 3). In addition, we placed greenhouse-grown grapevines in various parts of AHS AREC's vineyards every week to monitor the development of downy mildew and to validate our model outputs.

Fig.3 Downy mildew infection risk model output



Sporangia germination risk based on weather condition in the past five days.

7-day forecasted downy mildew risk based on the spore germination risk and precipitation forecast

Current work:

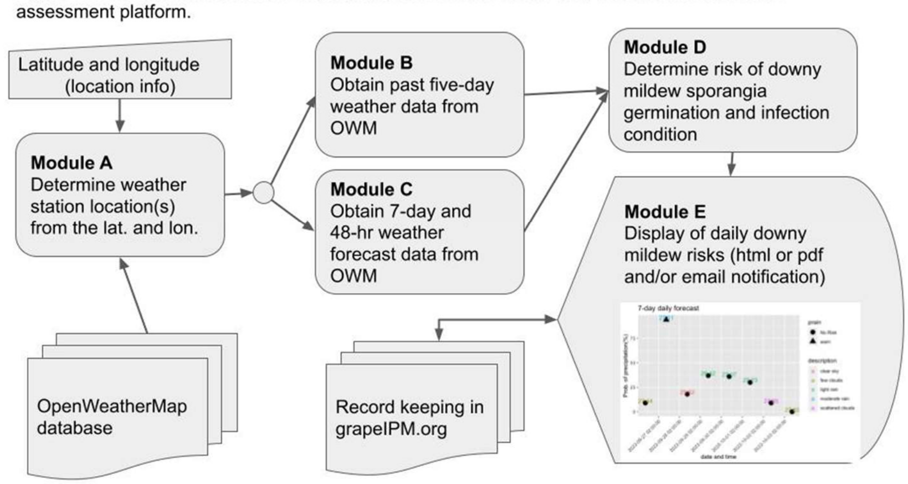
The main objective of this study is to transfer the model written in R code to our existing website (http://grapeIPM.org). This is a Linux-based web server on Amazon Web Services (AWS), and we use Drupal (ver 9, Drupal.org) as a content management system. Drupal can host R as a module, and we have published a database that is specialized for grapevine trunk diseases, which runs R in the background to search DNA sequences (http://trunkdiseaseid.org). We will upload our R code to the system so that it will run remotely on AWS.

Implementation in the future:

What we envision is to have a simple user interface to register user information such as latitude and longitude of the target site, then the system will determine the nearest weather station(s), obtain past and forecasted weather data, generate risk information either each day, and then store it as an HTML or a pdf file (Fig. 4). We also want to experiment with an email-based delivery system so that registered users will receive daily updates.

Although we will start with a single disease, we envision that the system can be easily expanded to other plant diseases and insect pests. E.g., module D in Fig. 4 can be switched to assess the risks of another disease that uses a similar dataset. Or module B can be used to obtain temperature data to calculate a cumulative growing degree day to assess the risk of insect pest activity. Thus, the sub-objective of this project is to develop a modular system where other users or we can add other risk information easily in the future.

Figure 4. A conceptual framework of the proposed modular-based crop disease and insect risk assessment platform.



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