

A web-based interactive system for risk management of potato late blight in potato canopies in Michigan.

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Introduction

Potato late blight (PLB), caused by *Phytophthora infestans* (Mont.) de Bary, is a fungal disease that affects foliage and tubers and is the most limiting factor to profitable potato production in the US. PLB spreads in potato canopies by continuous leaf and stem infection when inoculum is present and favorable environmental conditions exist. The pathogen is most successful when moderate temperatures (15 to 26°C) are combined with high canopy moisture and leaf wetness, caused by dew or rainfall and prolonged by high humidity. Environmental conditions during the growing season in Michigan are sporadically but frequently conducive to development of epidemics of PLB, and significant financial costs, in terms of crop protection (up to \$700/ha), and crop losses (up to \$5,000/ha) are incurred when intervention measures to control PLB are unsuccessful. No fungicides presently in use completely arrest late blight epidemic development, and even fields protected with five-day fungicide applications at a maximum rate of active ingredient can become infected when environmental conditions are conducive to PLB development and inoculum is plentiful. Thus, estimation of conducive conditions and appropriate application of controls is crucial to PLB management as infected plants reach 100% foliar infection approximately 25 days after initial inoculation. A web-based expert system was developed to help potato growers in Michigan make important decisions on optimal use and timing of fungicide applications to mitigate the risk of PLB disease development. The system is based around a relational database that stores information on PLB risk that is generated using a PLB prediction model. The model uses data on relative humidity and temperature from the Michigan Automated Weather Network (MAWN) to estimate if environmental conditions are favorable for PLB epidemic development. Management recommendations are produced based on the level of risk. Information stored in the database is presented to users through a series of interactive web pages that are dynamically generated on-demand through scripts that interface between the website and relational database. Recommendations include application timing and spray rates for common fungicides.

MSU Model Development

MSU uses a modified Wallin-type model for making disease management recommendations to growers. The model predicts the first occurrence of PLB and its subsequent spread based on seasonal accumulation of disease severity values (DSV). DSV are based on various combinations of the hours with a relative humidity (RH) of 80% or greater and the average temperature during these periods (Table 1). Accumulation of DSV should start at plant emergence. The MSU model starts accumulating DSV on May 1st, but users can select their own emergence date (Fig. 5).

Table 1. Environmental parameters used for disease severity value (DSV) calculation.

Temperature Range (°C)	Disease severity values for the number of hours with > 80% relative humidity				
	0 (none)	1 (minimal)	2 (slight)	3 (moderate)	4 (severe)
7.2 to 11.7	< 16 h	16-18 h	19-21 h	22-24 h	n/a
11.7 to 15.0	< 13 h	13-15 h	16-18 h	19-21 h	22-24 h
15.0 to 26.7	< 10 h	10-12 h	13-15 h	16-18 h	19-24 h

Recommendation triggers were established for varying fungicide application rates based on favorability of environmental conditions and the geographic proximity of known PLB infections (Table 2). If late blight is reported near a location (pink or red risk level) then DSV accumulation is no longer used to give management recommendations.

Table 2. Criteria for changing spray recommendations

RISK LEVEL	DSV ACCUMULATION	LATE BLIGHT
GREEN	7-Day Total ≤ 3 - AND - Season Total < 30	- AND late blight not seen
YELLOW	7-Day Total ≥ 3 - OR - Season Total ≥ 30	- AND late blight not seen
ORANGE	7-Day Total ≥ 21	- OR isolated outbreak in county in < 200 ha
PINK	DSV accumulation not relevant	isolated outbreaks in county in 200-400 ha
RED	DSV accumulation not relevant	late blight widespread in county on > 400 ha

Unless otherwise specified, the recommendations follow a typical seven day spray schedule, modifying type and rate of fungicide of application (Table 3). Since growers in Michigan begin fungicide sprays soon after emergence regardless of conditions, no fungicide initiation threshold is used in the MSU model. An up-to-date list of fungicides registered for use in Michigan is maintained on the website (Fig. 7).

Table 3. Risk Levels and their corresponding fungicide rate recommendations

RISK LEVEL	RECOMMENDATION
GREEN	Lowest labeled rate of protectant fungicide recommended -- minimum 7 day application interval
YELLOW	Highest labeled rate of protectant fungicide recommended -- minimum 7 day application interval Protectant fungicide plus Spegurin at 2 oz/acre if near end of season at early senescence
ORANGE	Highest labeled rate of protectant fungicide recommended -- minimum 7 day application interval Protectant fungicide plus Spegurin at 2 oz/acre if near end of season at early senescence
PINK	Systemic fungicides recommended at full application rate or protectant fungicide plus Spegurin at 3 - 3.75 oz/acre -- minimum 7 day application interval
RED	Systemic fungicides recommended at full application rate or protectant fungicide plus Spegurin at 3 - 3.75 oz/acre

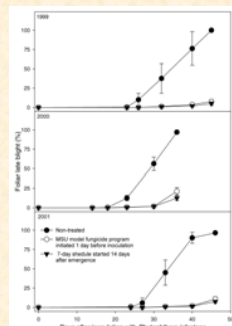


Figure 1. Model validation field trials. Development of foliar potato late blight in potato canopies protected by fungicides applied on a 7-day schedule initiated 7-days after emergence (○) or based on a weather-dependent MSU model (●). (●) Non-treated plot.

Model Validation

Field trials were established beginning during the 1999 growing season and continued through 2001. Side-by-side research plots were established at the MSU Muck Soils Research Farm in Bath, MI. Manual inoculation of plots with a liquid suspension of *P. infestans* ensured heavy PLB disease pressure. PLB lesions developed in the non-treated plots 14 to 21 days before the plots treated with standard fungicide rates and the timings of treatments determined according to weather-based recommendations in each of the 3 years (Fig. 1). Furthermore, more PLB developed in the canopy of non-treated plots than in the treated plots. The weather-based recommendations had three fewer fungicide applications than the standard fungicide program in each of the 3 years.

Model Implementation

The web-based Late Blight Risk Management (LBRM) system includes a set of dynamic applications that interact with a database system (Fig. 2). Information is presented to users through a series of interactive web pages which are dynamically generated on-demand. The LBRM system was deployed in a Linux environment, and is built around the PostgreSQL relational database management system. Web pages are served to users through the Apache webserver, using the PHP and Perl programming languages to interface between the database and the webserver. In addition, the system uses the Google Maps application programming interface to display interactive map-based information to users (Fig. 3).

Figure 2. Schematic representation of the Late Blight Resistance Management system.



The front page of the website, contains an interactive Google map of Michigan with colored markers on it, and a navigation menu on the left hand side (Fig. 3). Along with the map of Michigan these links allow the user to access data on PLB risk in the state with various levels of detail. For an overall summary of the levels of risk in the state the user can just refer to the map on the front page. The colored markers correspond to the various levels of late blight risk (Table 3), and may be green, yellow, orange, purple or red. The purple marker represents the pink risk level as pink is not available as a marker color in the Google Maps API. Each marker corresponds to a MAWN weather station, and when a user clicks on it, it opens up an information window with a summary of details for that station (Fig. 6).



Figure 3. Front page of the Late Blight Resistance Monitoring website. Users can navigate around the site through the left hand menu or by clicking on markers on the interactive Google map.



Figure 4. Schematic representation of the ways to access various levels of detailed information on late blight risk.

The color of the markers on the map (Fig. 3) is updated daily along with the DSV using a Perl script that connects to the LBRM database and generates an XML file which contains all the information for each marker on the Google map.

Model Implementation (cont.)

Users can get detailed information about a particular location either by clicking on a station marker on the front page map or by selecting Compare Stations from the navigation menu on the front page. These pages are called Station Details pages (Fig. 4). Each station has its own page. The pages are dynamically generated using data from the LBRM database, and present the user with up-to-date DSV data for that particular station, and a spray recommendation (Table 3) based on the last 10 days of accumulated DSV.

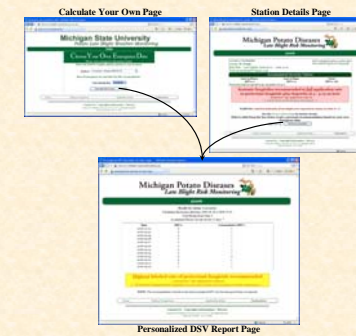


Figure 5. Schematic representation of the ways to obtain a personalized spray recommendation and table of disease severity values for a specific time period.

At the bottom of each Station Details page (Fig. 4) there is a drop down menu which allows the user to get a personalized spray recommendation based on the date of emergence of their potato crop. This performs the same function as the "Calculate DSVs" page (Fig. 5) which can be selected from the left-hand navigation menu on the front page (Fig. 3). When a user selects a date from the drop down box and hits the "Get Recommendation" button a new webpage is generated with a table listing the DSV accumulated each day for the selected period, the total DSV accumulated and a spray recommendation based on the total accumulated DSV for the time period that was selected (Fig. 5).



Figure 6. LBRM News and Alerts page. The LBRM website contains a News and Alerts section which is accessed from the front page navigation menu. This page operates like a weblog with news affecting potato growers posted to the site on a regular basis. Users are able to leave comments/feedback on particular news items by clicking on the comments link at the bottom of each article.



Figure 7. The LBRM website maintains a webpage of currently registered fungicides for use on potatoes in Michigan. The page is accessed by clicking on the "Application Rates" link in the footer bar of all the website pages.

Further Information

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