Evaluating hop downy mildew (*Pseudoperonospora humuli*) forecasting tools to manage disease in Wisconsin

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Abstract

Hop downy mildew (*Pseudoperonospora humuli*) is a potentially devastating disease affecting both foliage and cones throughout the crop life cycle. *P. humuli* can overwinter as mycelia within the hop rhizome and result in severe infections that lead to total crop loss. A disease risk index model was developed in the Pacific Northwest (PNW) to quantify the overall risk of pathogen infection. We applied the downy mildew risk index calculation to archived Wisconsin weather data from 2008 to 2013 and determined that there was significant annual variation in the number of days that the downy mildew risk index was >500 and in the seasonal occurrence of risk index periods within a given year. Spatially, risk varied greatly across the state of Wisconsin when analyzed by total risk index per year. Such variation by year, within growing season, and geographically suggests the need for site-specific and regular monitoring of weather data for use in effective disease forecasting systems.

Introduction

There has been great interest in expanding the production of hops (*Humulus lupulus)* in the Upper Midwest U.S. In Wisconsin, approximately 50 acres of hops are in production with expansion to 500 acres likely to occur within the next two years. As a result, there is a high demand for information to support disease control. Hop downy mildew has been positively confirmed in the state, though it is unknown whether the infection is due to imported diseased material or natural inoculum. Growers would greatly benefit from a disease forecasting tool based on pathogen ecology that would help target the timing of appropriate preventative fungicide applications for downy mildew control. The disease risk index tool calculates the relative risk of a severe infection (determined to be 500 risk units) based on local weather conditions over a 48 hour period. The goal of this investigation was to use this tool to examine characteristics of favorable disease conditions over the state of Wisconsin during 2008 to 2013.

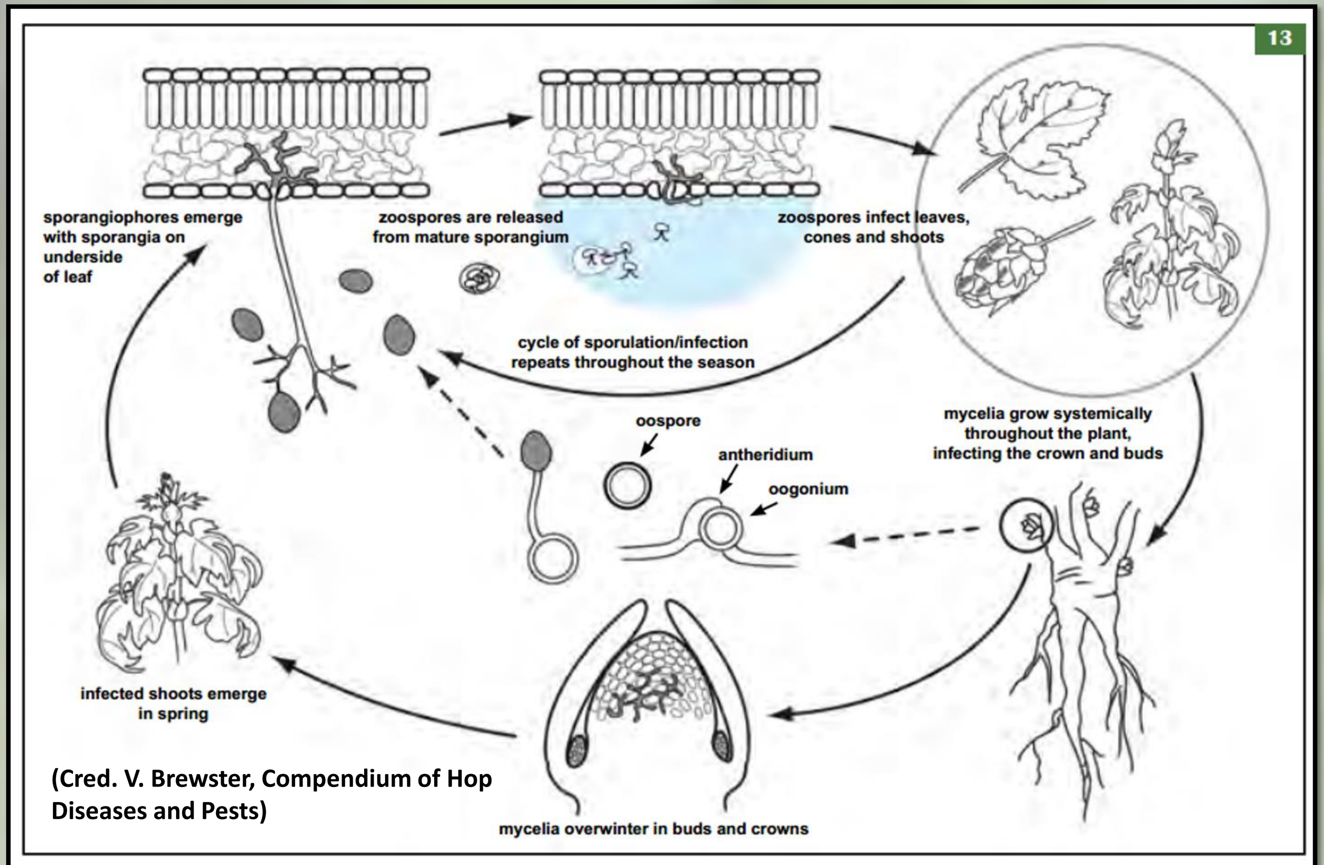

Figure 1. Disease cycle of *Pseudoperonospora humuli* on hops. Note the overwintering mycelia in the hop crown. Oospores have not been shown to play a significant role in the disease process in the Upper Midwestern U.S.

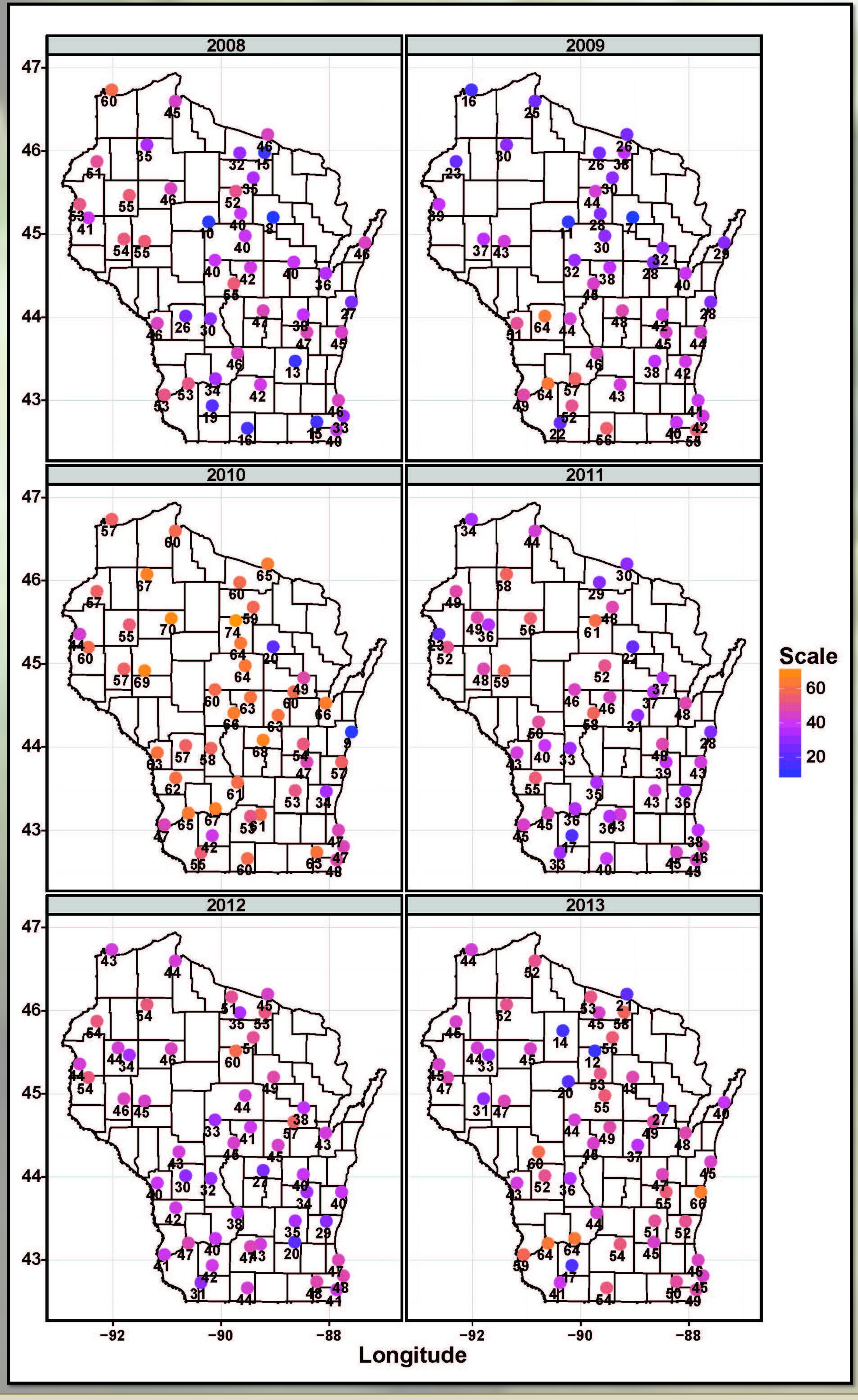

Figure 2. Number of days the downy mildew risk index was greater than 500 at multiple locations in Wisconsin (2008 – 2013). Color scale associated with values at each location ranges from blue/purple, representing the lowest risk, to orange representing the highest risk (actual data ranged from 7 to 77 days).

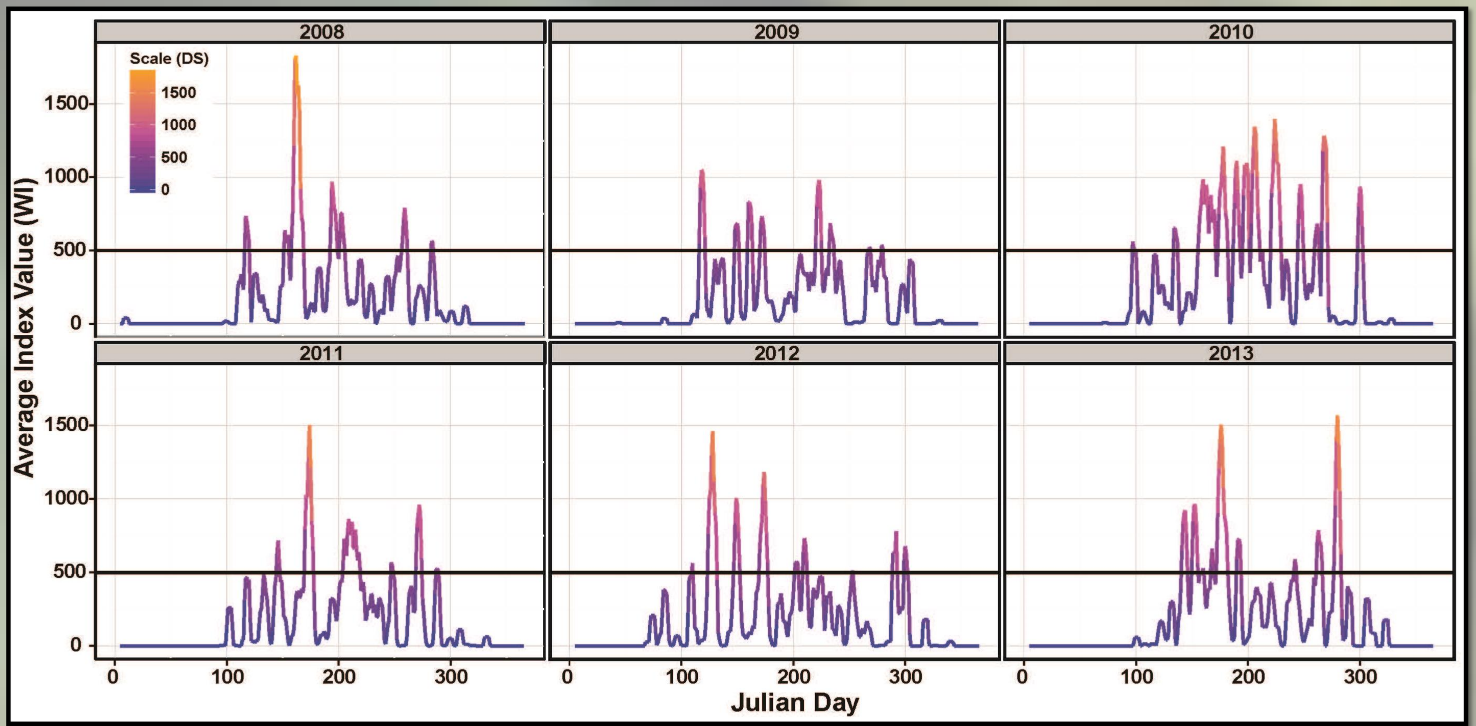

Figure 3. Downy mildew risk indices averaged over all locations for each day of the production seasons of 2008 to 2013 in Wisconsin. For reference, Julian Day 100 is 10 Apr for regular years; 200 is 19 Jul; and 300 is 27 Oct.

Materials & Methods

- Weather data were obtained from the National Oceanic Atmospheric Association (NOAA) integrated surface weather database of hourly weather data sourced from all available weather stations from 2008 to 2013.
- These weather data include hourly observations of temperature, precipitation, and dew point temperature.
- Data were used to calculate a risk index model adapted from Gent et al. (2010). The risk index was calculated as follows: (i) if no rain recorded during a 48-hr period index=0 else, (ii) if mean temperature was less than 8°C during a period of rain index=0 else, (iii) Index = -63 + (22*RH) + (84*PRCP), where RH and PRCP are the number of hours of relative humidity ≥ 90% and millimeters of precipitation, respectively, in the previous 48 hours.

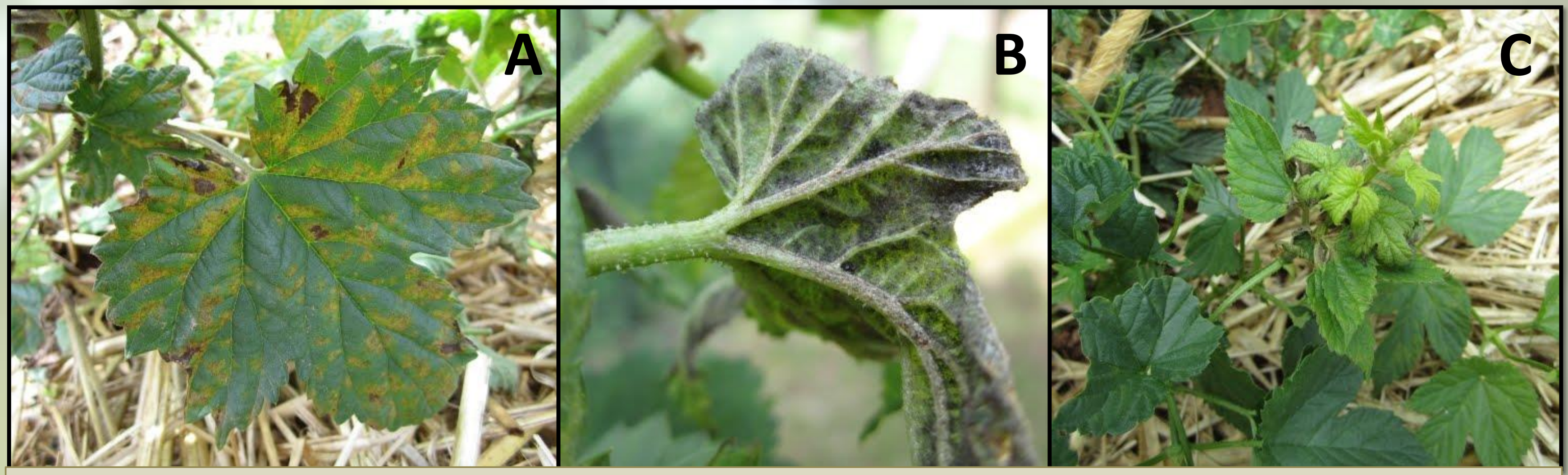

Figure 4. **A.** Hop leaf with characteristic chlorotic, angular lesions, **B.** black/gray sporulation on underside of leaf, and **C.** downy mildew spike showing shortened internodes, pale green chlorotic discoloration, and necrosis of lower leaves. Photo credit: S.J. Colucci, NC State University.

Results & Discussion

Downy mildew inoculum presence is assumed to be in the hop production system (Fig. 1). Disease risk varies spatially. Northern Wisconsin is typically at less of a risk for severe downy mildew infection according to the risk-index model (Fig. 2). Downy mildew risk varies over time. Horizontal line indicates 500 risk units, a severe infection threshold (Fig. 3). Monitoring symptoms of downy mildew in hop yards (Fig. 4) in addition to using a site specific disease risk tool may aid in preventive management of disease from emergence to harvest. Future work will focus on model validation and improving functionality/ease-of-use while promoting the use of forecasting tools to enhance disease control and productivity in Wisconsin hop yards.

Acknowledgements

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