WEB-BASED PEST AND DISEASE FORECSTING TOOL FOR ENHANCED PROCESSING VEGETABLE CROP MANAGEMENT: UPDATE ON CARROT FOLIAR DISEASE FORECASTING COMPONENT

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Research Overview. Alternaria leaf blight, caused by the fungus *Alternaria dauci*, and Cercospora leaf spot, caused by the fungus *Cercospora carotae*, infect leaves and petioles of carrot and are the most prevalent foliar diseases of carrot worldwide. These foliar blight pathogens reduce yield by limiting the plant's photosynthetic capacity and by weakening the petioles needed for mechanical harvest. Typically, carrots are harvested by implements that loosen the soil and simultaneously grasp the foliage while lifting the roots out of the soil; blighted petioles break when gripped by the mechanical harvester and carrots are left in the soil. Environmental conditions greatly influence the occurrence and progression of these foliar diseases of carrot and the anticipation of heightened disease risk through the identification and monitoring of critical environmental factors, such as, relative humidity and temperature, can enhance disease management by optimizing the timing of fungicide applications. However, implementation of the weather-based models is difficult because, typically, each field requires a customized forecast that is dependent on disease severity, weather conditions, and fungicide program, factors that are field-specific. A goal of this research is to provide a set of generalized recommendations for managing foliar diseases of carrot that can be used for the majority of WI fields without the need for grower investment in weather stations.

Methods. ***Weather data and modified TOM-CAST model.*** Computers housed in the Dept. of Plant pathology at UW-Madison ingested daily gridded weather predictions from the North American Meso-scale weather model (NAM 12km) from the National Weather Service (NWS). Weather data were organized and uploaded to a relational database created to house the forecasted weather predictions and disease forecasts. Computer code was written to organize and utilize the gridded data and a filing system was created to facilitate rapid data loading. Computer code was written to implement a modified version of the TOM-CAST model (Table 1) based on the NAM 12km weather predictions. The running of this disease model was automated so that risk predictions were updated daily following the download of the weather data. This model assumes that air temperature and relative humidity (i.e. a surrogate for leaf wetness) are the two primary weather factors that lead to disease occurrence/or progression. The model scores a severity value for each day based combinations of relative humidity and temperature and accumulates the severity values either from crop emergence or the last fungicide application. The accumulation of 20 disease severity values triggers a fungicide application. ***Results.*** Model predictions are

Table 1) TOM-CAST model logic for scoring a daily severity value. Under the current scheme, a fungicide application would be recommended after the accumulation of 20 severity values over consecutive days.

Mean Temp (C)	**Leaf-wetting time (hr) required to produce daily disease severity values (S) of:**				
	0	**1**	**2**	**3**	**4**
13-17	0-6	7-15	16-20	21+	
18-20	0-3	4-8	9-15	16-22	23+
21-25	0-2	3-5	6-12	13-20	21+
26-29	0-3	4-8	9-15	16-22	23+

currently output daily for research purposes and we have been posting static figures of DSV forecasts for Wisconsin at the vegetable pathology website (see <http://www.plantpath.wisc.edu/wivegdis/> for updates). General infrastructure improvements to improve grower accessibility are ongoing and include, 1) updating the computing hardware that currently ingest, house, and calculate the weather-based disease forecasts, 2) updating the computer software that is currently used for database management and 3) continued development of applications (i.e. writing the computer programs) for the GUI that growers can use to access the weather database directly from their home computers.

2013 field evaluation. In 2013, the modified TOM-CAST model was being evaluated in field trials for the management of *A. dauci* and *C. carotae*, respectively. Research plots were established at the UW-Hancock Agricultural Research Station and on a commercial farm in a randomized complete block design with four replicates. Plots were scouted for disease from mid-July to early September and experiments at both locations contained a standard calendar-based fungicide program (Table 2).

Table 2) Experimental treatments, at the Hancock, WI location, used to evaluate the TOM-CAST model based on in-field weather data and NAM 12km weather data.

Trt	Program	Initiation	Initiation	Fungicide Apps.	Rate	Field EIQ[1]
1	UTC	NA	-	-	-	-
2	Calendar	First Symptom	July 17	6	2.0 pint / acre	242
3	In-field DSV	First Symptom	July 17	6	2.0 pint / acre	242
4	In-field DSV	Calendar	July 17	4	2.0 pint / acre	162
5	NAM-based DSV	First Symptom	Aug 7	4	2.0 pint / acre	162
6	NAM-based DSV	Calendar	Aug 7	3	2.0 pint / acre	121

Experimental treatments were established based on fungicide application 1) initiation – fungicide programs were initiated based on the number of days after emergence or the occurrence of the first disease symptom and 2) interval – fungicides were applied according to DSV accumulations calculated based on in-field weather stations or calculated using the NAM 12 km weather model. Bravo Weather Stik was the sole fungicide used in these experiments and was applied at 2 pints per acre when an application was prescribed. ***Results.*** In 2013, we experienced low foliar disease pressure at both experimental locations. This resulted in similar disease control among all fungicide treatments (Figure 1); at Hancock, all fungicide programs performed significantly better than the untreated control and there was no difference in foliar

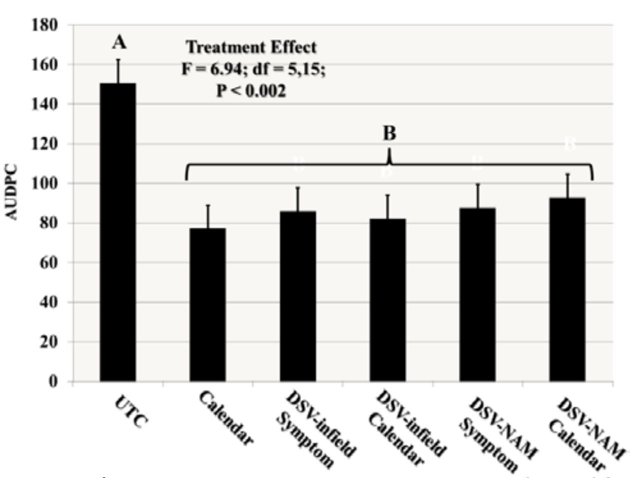

Figure 1) Average area under the disease progress curve (AUDPC) for experimental treatments at Hancock, WI in 2013.

disease control among fungicide programs. Additionally, there were no differences in yield among fungicide programs ($F=1.99$; d.f. = 5,18; $P = 0.15$). Thus, at Hancock, WI, all fungicide programs provided the same foliar disease control – those with fewer applications provided equivalent control. For the experiment conducted on-farm, no differences in yield ($F=0.94$; d.f. = 5,18; $P = 0.48$) nor disease severity ($F=0.79$; d.f. = 5,18; $P = 0.57$) were observed among fungicide programs.

Future work. ***Model validation and optimization.*** To optimize the large scale pest and disease forecasts, model predictions that have been calculated using NWS weather data, specific to field location, will be compared to model predictions that have been calculated using field-observed data. Regression analysis will be used to determine if there is a discrepancy between the action thresholds calculated using NWS weather data and those using field-based weather data. Finally, a correction factor will be developed so that model predictions made over large geographic areas can be (mathematically) mapped to field-level predictions. ***GUI development and information dissemination.*** Currently, efforts are being focused on the development of an internet-based graphical user interface to automate the functionality of the database and to make disease forecasts available to vegetable growers in WI. Stay tuned as there may be a web application coming on-line in the Spring <http://www.plantpath.wisc.edu/wivegdis/>.

Discussion. Disease forecasting systems that inform the timing of fungicide application based on environmental conditions may be useful for managing pathogens that cause foliar diseases of carrot. A typical fungicide program in Wisconsin is initiated when disease symptoms are first detected by scouting and subsequent fungicide applications typically follow a calendar-based spray schedule. However, fungicide reapplication may not be necessary if environmental conditions do not favor disease progression; the severity of disease epidemics largely depends on environmental conditions, dictated primarily by wind and weather patterns. Thus, the application of fungicide informed by a weather-based disease forecasting system could control disease while reducing the number of pesticide applications, thereby improving profitability for vegetable growers and reducing environmental impact. The implementation of the weather-based models to inform spray programs requires a customized forecast for each field that is based on disease severity, weather conditions, and fungicide program, factors that are field-specific. The primary goal of our research is to provide a decision tool for the management of carrot foliar diseases that can be used for the majority of fields and doesn't require grower investment in a weather station for each field.

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