Scheduling Fungicide Applications for Late Blight Management in the Columbia Basin of Washington and Oregon

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Late blight management has been augmented in regions of North America, Mexico. and Europe by scheduling fungicide applications using predictive disease models (3,4,15). Models developed in rain-fed agricultural regions that are based on leaf wetness or relative humidity and temperature in individual fields such as BLITECAST have not effectively scheduled fungicides applications for control of late blight in the semiarid Columbia Basin and southern Idaho (2,5).

Late blight is forecasted and managed regionally in the Columbia Basin. This is because sporangia of *P. infestans* can become airborne in turbulent air currents and be quickly and widely disseminated within the region during cloudy and wet weather (1,14), and when disease-favoring weather of mild temperatures and rainy conditions occur, they usually prevail over the entire region. Additionally, the microclimate in fields can be similar throughout sections of the region after row closure. Row closure is when foliage between rows just touches and, for the main cultivars grown, generally extends from the second week of June in the southern Columbia Basin to the end of June in the northern Basin. Late blight has not been observed before row closure in the region. However, once row closure has occurred, microclimate conditions generally are favorable for rapid late blight development whenever a field is irrigated (2). Late blight is extremely difficult to manage once the disease is established in an irrigated field. For example, in a field near Hermiston, OR with inoculum originating from infected seed tubers, incidence of late blight increased from 0.2 to 70% over a four-week period after row closure even with nine applications of efficacious fungicides (8).

Early season rain in April and May is an effective indicator of late blight outbreaks because moisture is important for the build-up of inoculum in fields during the early stage of epidemics. Early in epidemics, moisture promotes transmission of *P. infestans* from infected seed tubers and infected volunteer tubers to emerged shoots in fields. Transmission from infected tubers to shoots bearing sporangia can occur within 24 hours during rainy weather (7,10). Secondary infections will proceed almost immediately if a favorable environment with moisture continues. Moisture is also essential for effective dissemination of sporangia to additional fields. Additionally, solar irradiance is associated with incidence of late blight epidemics in the Columbia Basin (11).

Two sets of forecasting models are used to regionally forecast the probability of late blight occurrence for the Columbia Basin. The first set of models identifies the probability of late blight occurrence early in the growing season and the second gives the probability of disease occurrence in midseason (9,13). The models were derived by examining the relationship of late blight occurrence in the region with meteorological variables at four vicinities in the Basin (Prosser, North Richland, Hermiston, Othello) over 27 years using logistic regression analysis. Separate logistic regression models were derived for the early and mid-seasons for each of the four vicinities. Indicator variables for the early season logistic models include the presence of an outbreak during the preceding year and number of rainy days in April and May. Indicator variables for the midseason models include the presence of an outbreak the preceding year and either number of rainy days in July and August or number of rainy days in April and May and number of rainy days in July and August depending on the vicinity. Variation in number of rainy days in the spring occurs among the four vicinities and having more than one location or vicinity has been beneficial in making reliable disease forecasts (13).

The late blight models had high sensitivity (percentage of years with late blight outbreaks classified correctly) and specificity (percentage of years without outbreaks classified correctly) when validated. As with predictive models used for foliar diseases, a high sensitivity is desired for the models used in the Basin. All years with late blight outbreaks and 96% of the total of 27 years of data used to develop the logistic models were correctly classified using data from at least one of the four locations (13). All 17 years since the late blight models were first developed in 1997 through 2013 have been correctly classified at each of the four vicinities.

The probability of late blight occurrence for a given season can be calculated on 1 June when the number of rainy days in April and May is known. However, the probabilities can be estimated in early May from the actual number of rainy days in April and a 30-day rain forecast for May. This is currently done and a late blight forecast is usually given in early May. Early May is several weeks before row closure and sufficient time for growers to implement late blight management tactics. The advanced knowledge is beneficial because fungicides used for late blight are mostly protective, and to achieve the maximum effect, the first application must be made before the late blight pathogen is introduced into the crop (6). In addition, sufficient time and applications are also needed for fungicides to be adequately distributed throughout the plant canopy after the initial application, especially if the application is made by air.

The probabilities of late blight occurrence from the logistic models can then be coupled with rain forecasts to schedule fungicide applications. However, the accuracy of rain forecast needs to be sufficiently high to add value in scheduling fungicide applications. Subsequently, rain forecasts from a private weather forecasting group (Fox Weather, LLC, Fortuna, CA) obtained in 2010 and 2011 were evaluated for accuracy and moderately ranged rain forecasts were sufficiently accurate to be used for scheduling fungicide applications (12). In particular, specificity (accuracy of predicting non-rainy days) for 15-day rain forecasts was generally greater than 80% at Prosser (Fig. 1) and Othello (Fig. 2) both years of the study. Knowing that rain is not going to occur can be helpful in making late blight management decisions. This can be advantageous during expected “dry periods”, such as July, to lengthen intervals between fungicide applications.

Adjusted sensitivity (percentage of forecasted daily rainfall events classified correctly with a three day-target for success) was greater than 80% for the first six to seven days of 15-days rain forecasts at both locations both years (Fig. 3). Adjusted sensitivity of the 15-day forecasts was compared between the month having the highest incidence of rain (May), and the month having the least incidence of rain (July). Adjusted sensitivity was considerably higher for May than July at both locations. As an example, data for both years at Prosser are illustrated in Figure 4. Adjusted sensitivity was 100% for at least the first seven days of the May rain forecasts at Prosser each year (Fig. 4). Adjusted sensitivity as evidence from the cited study (12) has utility in scheduling late blight fungicides in the Columbia Basin. A target window wider than one day improved forecast sensitivity. A rain forecast that was targeted one to two days before the actual day of rain is valuable for disease management in that a fungicide could be applied before the wet period so that infection could be prevented.

Recommendations for initiation and intervals between fungicide applications can be based on the (1) probability of a late blight outbreak, (2) information from field monitoring on the actual presence and location of late blight, (3) 15-day rain forecasts, (4) crop canopy development, (5) time required to apply a fungicide after a rain forecast, and (6) risk tolerance of crop managers. Late blight epidemiologists in Oregon and Washington provide oversight of the regional forecasting system and add expert advice based on previous experience and knowledge of the development of potato late blight. Fields are monitored for late blight by field representatives and growers throughout the growing season to provide information on the presence of late blight in commercial fields. The late blight forecasts can also be used to determine intensity of field monitoring for late blight.

Fungicide applications should be continued until harvest if late blight is present in a field or neighboring fields. When inoculum is present in and adjacent to fields, fungicide applications are needed on a five to seven day schedule because wet periods from over-head irrigation will favor sporulation and infection. Periods with dew, especially when juxtaposed with wet periods from irrigation water, will favor infection. Furthermore two fungicide applications are needed when applied by air before the fungicide will be adequately distributed throughout the crop canopy for good protection. Recommendations are currently made available to growers via phone recordings, e-mails, and a Website. Ambient temperatures are mostly favorable for late blight development after row closure and are not incorporated into models scheduling foliar fungicides applications in the Basin.

In conclusion, rain forecasts can be helpful in scheduling fungicide applications for late blight management in the Columbia Basin. However, scheduling fungicide applications should not rely solely on rain forecasts. Rain forecasts should be consulted daily during the growing season for sudden and rapidly developing rainy periods and other possible changes in forecasts. Effective management of late blight requires that timely fungicide applications must be coupled with irrigation management that avoids overwatering and sanitation practices that eliminate sources of initial late blight inoculum from infected seed tubers, volunteer potatoes, and refuse tubers.

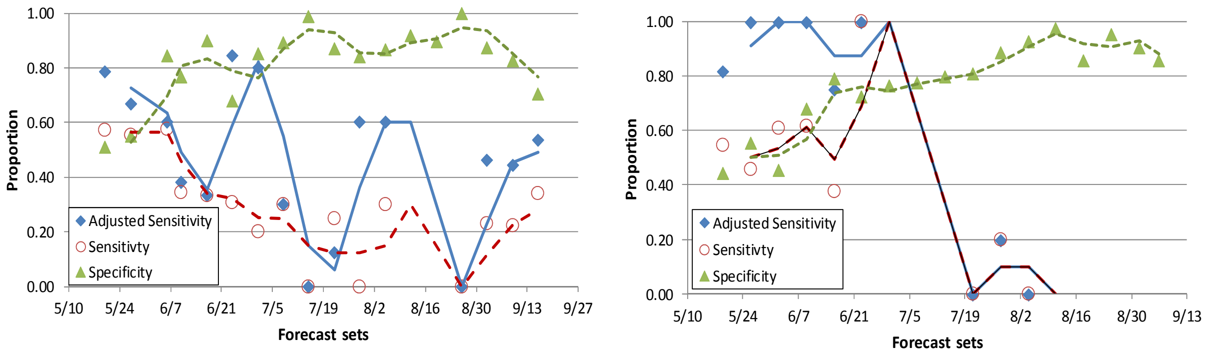

Figure 1. Specificity, sensitivity and adjusted sensitivity for 15-day forecasts for rain over the test season at Prosser, WA in 2010 and 2011, respectively (lines are 2-day moving average, squares and diamonds are actual values).

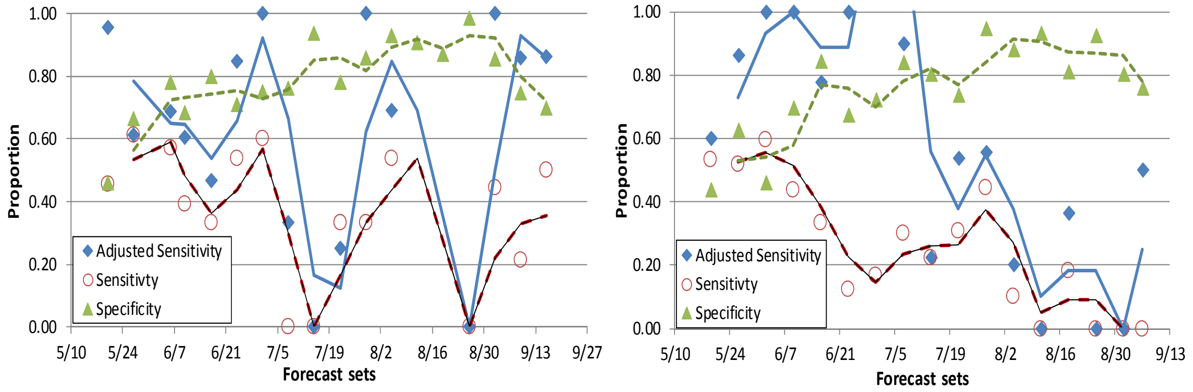

Figure 2. Specificity, sensitivity and adjusted sensitivity for 15-day rain forecasts over the test season at Othello, WA in 2010 and 2011, respectively (lines are 2-day moving average, squares and diamonds are actual values).

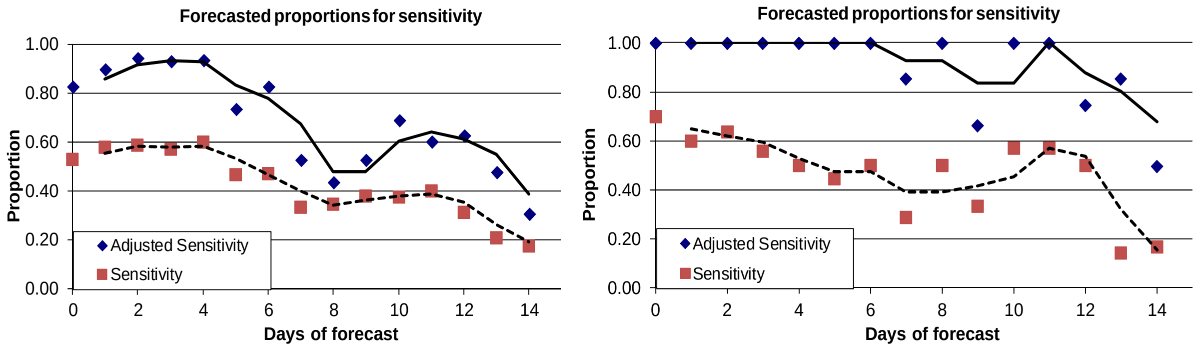

Figure 3. Mean adjusted sensitivity for 15-day rain forecasts over days of the forecast at Prosser, WA in 2010 and 2011, respectively.

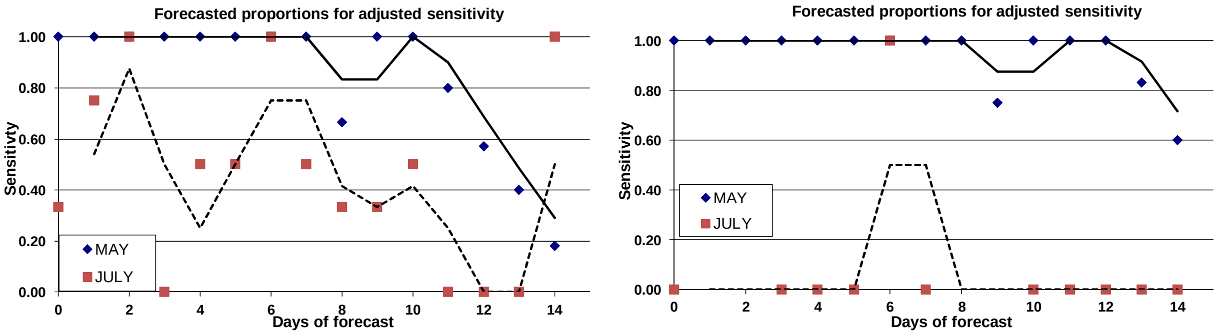

Figure 4. Adjusted sensitivity for 15-day rain forecasts over days of the forecast at Prosser, WA for May and July in 2010 and 2011, respectively.

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