SIMULATING CANOPY HUMIDITY IN POTATO PRODUCTION SYSTEMS

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Relative humidity in the crop canopy is an essential input to the disease forecasting models in the WISDOM decision support system. This is a tough thing to measure, and this requirement is surely one reason that some growers find WISDOM difficult to work into their management approaches. In this report we describe the current state of our efforts to diagnose canopy humidity, using weather measurements made outside of the field. We are using the term diagnose, because we are not forecasting conditions in the canopy, but rather trying to guess or estimate what happened there in the recent past, using some related observations.

When the disease forecasting/spray scheduling models in WISDOM were first introduced, the only option for measuring the relative humidity in the canopy (RHc from now on) was the recording hygrothermograph. These instruments are fairly expensive and, well, rather contankerous. Collection of the observations off the paper tape is tedious and causes delays in getting the needed data into the models. Electronic dataloggers came on the scene about 10 years ago, offering a more convenient way to collect the measurements. However, current dataloggers require some skills that can only be gained (in our experience) at the school of hard knocks. A final issue with in-field measurements is that they apply best to the field in which they are made. Our research shows that how wet the soil is under a potato canopy can change by 2 hours the duration of high RHc in a night.

As Bland discussed last year at this meeting, there are new sources of weather data available in Wisconsin. Most important are the new National Weather Service automated stations known as ASOS, and the numerous airport weather stations known as AWOS. The state Department of Transportation operates many of these airport systems in cooperation with local airport authorities. Another important new set of eyes on the weather is the National Weather Service's WSR-88D radar network. Finally, we now routinely use the GOES-8 satellite to measure solar radiation and nighttime cloudiness (and so the infrared radiation from the sky).

Our goal is to create a time record of the conditions around the potato crop, including the temperature of the leaves and of the soil surface, and the humidity and temperature of the air surrounding the leaves. With this record, all of the inputs needed by the WISDOM disease models are available.

How We Make the Canopy RH Diagnosis

At the heart of our ability to diagnose RHc is a computer simulation model of the potato crop canopy, including the soil, the leaves, and the air above the canopy, up to about 5 feet. We must describe to the model the soil texture and the canopy coverage (all things that WISDOM needs to know anyway). What makes the model go are inputs about the weather, gathered each hour, from weather stations, radar, and the GOES-8 satellite. The one sort-of-weather thing that
we cannot determine is irrigation; the grower must provide the model with rough estimates of
when irrigation was applied.

In the present version of our system, a WISDOM user fires-up a small "helper" program,
enters irrigation times for the field he needs RHc estimates for, hooks up to the Internet, and
clicks a button in the helper's window. The helper program contacts a computer in our
laboratory and tells it the latitude and longitude of the field, when irrigation was on, and the
period for which RHc is needed. Our computer then gathers up all of the needed weather, radar,
and satellite data from our databases, runs the RHc model, and sends back to the grower's
computer our diagnosis of RHc. WISDOM can then use this record of RHc just as it would
similar information from a hygrothermograph or a datalogger in the field. We anticipate that the
RHc model will be built into the next version of WISDOM. This means that the grower's
computer/WISDOM will simply ask our computer for the needed weather data, by sending us
only the location and time for which RHc will be calculated.

How Well We Can Diagnose RHc

We are testing the model against measurements of RHc made by Walt Stevenson's team
in several fields in Wisconsin during the 1997 season. In all cases shown here we used the
precipitation recorded in the field, to be sure that all irrigations were properly input, and because
the radar-derived rain is the weakest of the remote weather observations that we use. More
research is needed to determine if the radar will be sufficient, or if rain records must be supplied
by the user, along with irrigation (this actually should not be a burden, because proper irrigation
scheduling requires good rain observations for each field).

Figure 1 shows the measured and modeled RHc for the Hancock site from June 21
through July 10. The top panel is the result using the remotely-sensed inputs (except
rain/irrigation), which is how we intend the model to operate. The bottom panel shows how the
model performs using air temperature and humidity measured in the field, rather than at the
remote ASOS/AWOS stations. It seems that using the remote weather estimates is fine.
Additionally, we believe that in the future we will have better remote measurements, as more of
the data collected at the ASOS/AWOS stations becomes available to the public (which includes
us).

At Plover and Grand Marsh, we could run the model using only remotely-sensed data,
because the extra weather measurements were not made. Figure 2 shows that, as at Hancock, the
modeled and measured RHc agree remarkably well. There are times when the modeled RHc
does not remain high, say above 90 or 95% RH, as long as did the measurements.
Disagreements like these may be due to the model, the input data available to the model, or
errors in the measurements. Specifically, we are concerned that the (relatively) simple sensors
used at the field sites may be quite slow in returning to lower air RH. Further testing may show
that the ASOS/AWOS network of weather stations does not provide adequate coverage for all of
our potato growing regions. If this is so, the industry could lobby the Wisconsin DOT for an
additional installation at a nearby airport, or a station in the UW Ag Weather network could be
reconfigured/relocated to provide the additional coverage. Next year, in collaboration with Walt
Stevenson, we plan to conduct field experiments to test how well both measurements and the model can forecast disease pressure.

In summary, we have developed a computer model of potato canopy relative humidity that we hope will make WISDOM and similar disease forecasting models easier for growers to use. We anticipate that WISDOM users will be able to obtain most of the weather inputs needed by the model from our databases, over the Internet. We believe that we are building a good scientific understanding of the potato canopy environment, thanks to research funding from the potato industry. Additionally, we are learning to use new weather data sources in combination with computer models, to improve management of crop disease, thanks to the NASA-funded TiSDat project. Now, what should we be doing to make it possible for more growers to incorporate these new tools into their management? How can we learn what parts of the system make it awkward for growers to use these tools?

Figure 1. Measured and modeled relative humidity in a potato crop canopy of LAI=3 and growing on sandy soil, at Hancock, Wis. The top panel shows model results using air temperature and humidity and wind from analysis of regional ASOS and AWOS weather stations, and solar and sky thermal radiation from the GOES-8 satellite. The lower panel shows model results using locally measured temperature, humidity, and wind.
Figure 2. Measured and modeled relative humidity in a potato crop canopy of LAI=3 and growing on sandy soil, at Grand Marsh, Wis (top panel) and Plover, Wis. (bottom panel). Model inputs were local rain/irrigation measurements, air temperature and humidity and wind from analysis of regional ASOS and AWOS weather stations, and solar and sky thermal radiation from the GOES-8 satellite.