Biology and Management of Septoria Spot of Citrus

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Septoria spot of citrus caused by *Septoria citri* is a re-emerging disease of citrus in California. The disease occurs infrequently on fruit, leaves, and twigs and causes only superficial infections of fruit. Outbreaks have occurred sporadically over the decades since the first report in the 1940s.

Due to recent outbreaks, Septoria spot has become a quarantine disease in some export countries and domestic markets for California orange fruit. Thus, Septoria spot has caused trade restrictions for California grown oranges in some markets where the disease has not been reported. Thus, this research project is conducting studies on the biology of the pathogen and on the epidemiology and management of disease. Additionally, we are working in cooperation with California citrus industry representatives, as well as USDA-APHIS and Korean NPQS regulatory agencies in developing annual protocols for sampling, detecting, and certifying disease-free fruit lots for exportation.

Previously, we have reported on symptoms of the disease, statistical sampling methods, laboratory-based molecular detection methods, and infection requirements including types of injuries, duration time from inoculation to visual symptoms, and optimum temperatures for disease development. We have also studied temporal and spatial distribution of the disease in the central valley of California, as well as fungicide toxicity and efficacy of pre- and postharvest treatments in managing the disease. Recently we have focused on the development of a risk assessment model for the disease and on alternatives to copper and zinc-based field treatments for disease management.

Similar to previous growing seasons, the temporal detections of Septoria spot follow a normal distribution with most symptomatic detections on Navel orange occurring in March with the first detections in early January and the last in early May (Fig.1). Based on laboratory inoculations, the disease does not develop for 4 to 6 weeks under constant optimum temperatures. Thus, we evaluated environmental factors that favor disease from November through March.

Temperature (accumulated in hours below -1C) and precipitation (accumulated in mm) that occur in the early to mid- portion of the orange harvesting season were evaluated for developing our risk assessment model for Septoria spot. This model is being developed to optimize timing and prevent un-necessary applications of fungicides for the management of Septoria spot.

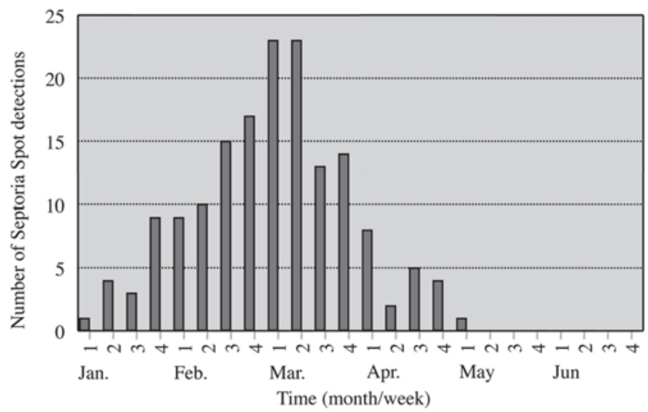

Figure 1. Chronological detection of Septoria spot on Navel oranges in the 2007-08 season. Detections were based on the presence of the pathogen (signs) or based on PCR amplifications using septoria citri-*specific DNA primers. The total number of samples processed during the harvest season was 4995 (ca. 20-40 fruit per sam- ple).*

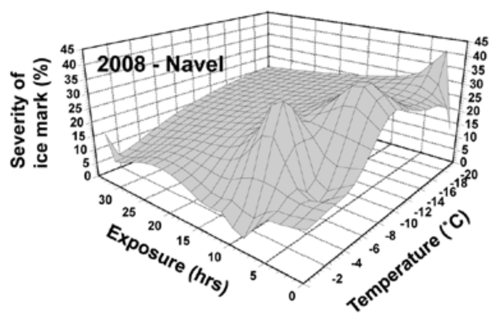

Figure 2. Severity of low temperature damage (i.e., ice mark) on wet Navel oranges exposed for selected durations at low temperatures and then incubated at 20˚C for7-14 days.

As we indicated previously, *S. citri* can only infect fruit with injuries, and low-temperature or cold injury (i.e., ice mark) is one of the most common injuries associated with the disease. In laboratory studies, we evaluated the effect of freezing temperatures at selected durations on the development of ice mark on wet fruit. Navel and Valencia orange fruit were pre-cooled, treated for selected times and freezing temperatures, incubated at 20C, and evaluated for the severity of ice mark damage. A three-dimensional graph (Fig. 2) illustrates the relationship between temperature, duration, and severity of ice mark for our 2008 experiments. Severity of ice mark at temperatures below -6˚C for durations longer than 12 hr is shown without relief in the figure because of the unlikely occurrence of these temperatures and durations under California conditions. Thus, continuous exposures for 5 to 10 h at temperatures below -1C (-2 to -6 and below) resulted in significant amounts of low-temperature rind damage similar to injuries seen in the field. Similar results were obtained in previous years and with Valencia oranges.

The pathogen produces spores in a sticky mass that is exuded from a fruiting structure (i.e., pycnidia), and precipitation is required for dissemination. Thus, we correlated total precipitation after an initial freeze event with disease progress or accumulated detections of Septoria spot for the 2007-08 harvest season.

Disease progress followed a typical sigmoidal development curve during the orange harvest season. Accumulated precipitation and the natural log of disease progress were fitted to linear models (Fig. 3). The correlation coefficient for accumulated precipitation and natural log of disease progress was 0.92 when data arrays were temporally adjusted for latency in disease development.

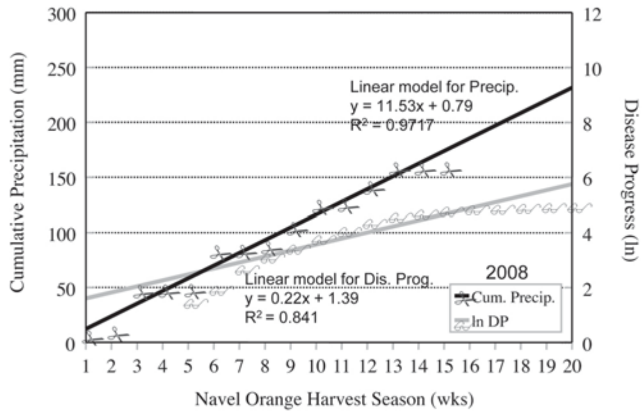

Figure 3. Precipitation accumulation and Septoria spot disease progress after the first freeze. Note that values are the average of accumulated precipitation (Cum. Precip) and the natural log of disease progress (ln DP) or accu- mulated number of diseased fruit detected in the 2007-08 season.

	Precipitation (mm)				
Hrs with T< -1 C	31-60	61-90	91-120	121-150	151-180
<10	0	1	2	3	4
10-20	1	2	3	4	4
21-30	2	3	4	4	4
>30	3	4	4	4	4

Figure 4. Numerical risk assessment model for forecast- ing Septoria spot. The numerical scale 0-4 represents in- creasing levels of risk of the disease.

Similar results were obtained for 2004-05, 2005-06, and 2006-07 seasons with correlation coefficients of 0.92, 0.82, and 0.84, respectively. Information from low temperature exposure studies (Fig. 2) and from the correlation studies de- scribed above (Fig. 3) were used to develop threshold values of cold temperature exposure and accumulated precipitation as components in the risk assessment model (Fig. 4).