Forecasting and Management of Septoria Spot of Citrus

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Year 3 of 3 (100% Complete)

Objectives

1. Develop and validate a Septoria spot forecasting and risk assessment model
2. Evaluate the efficacy of fungicides in field trials
3. Continue to certify fruit lots for the industry in the NAVEK program and revise and improve guidelines with industry on the management of Septoria spot

Problem and Significance

Septoria spot is a quarantine disease in Korea. This project is part of an international trade agreement that keeps the Korean market open for trade. The goal is to develop an integrated management strategy including forecasting the disease using a risk assessment based on environmental data, develop new fungicides that are more effective and environmentally friendly than copper-based treatments, and continue to certify fruit lots in near real-time.

Benefits to Industry

Management strategies of Septoria spot of oranges and other citrus crops are being developed as an integrated approach with disease forecasting and use of pre- and postharvest fungicide treatments. New fungicides are being identified and registered to minimize the overuse of copper. An improved understanding of the disease is being obtained through epidemiological studies in forecasting of Septoria spot by monitoring orchard environmental conditions, as well as by disease detection through the Navel and Valencia Export to Korea (NAVEK) program over the navel orange season. The NAVEK program is evolving to minimize fungicide applications where the disease is not detected by providing an exemption for the second fungicide application. The program is now allowing orchards in the export program even if a low level of disease is detected. In this case, the second application has to be done with new anti-sporulation fungicides but increases eligibility of fruit lots in the export program. Upon arrival in Korea, inspectors are required to find spores of the pathogen, and therefore, anti-sporulation fungicides will help that shipment lots remain negative for the disease.

Progress Summary

Develop and validate a Septoria spot forecasting and risk assessment model. In epidemiological studies, environmental monitoring was conducted from Oct. through Feb. using 30 CIMIS and private stations in 10 counties: 3 central counties (District 1), 5 coastal counties (District 2), and 2 desert counties (District 3).

Numerical Risk Model for forecasting Septoria Spot

	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

County (No. of stations)	Date	Total Hrs < 1	Avg. accumul. Pp (mm)	Risk (12/31/20)
Fresno (3)	12/31/20	1.3	38.0	0
Tulare (2)	12/31/20	15.0	34.6	1
Kern (3)	12/31/20	9.0	22.0	0
W. Riverside (2)	12/31/20	0.0	49.7	0
Ventura (3)	12/31/20	0.0	53.3	0
Santa Barbara (4)	12/31/20	17.3	62.2	1
SLO (3)	12/31/20	0.0	44.6	0
San Diego (4)	12/31/20	0.0	76.1	1
Imperial (4)	12/31/20	0.0	0.1	0
E. Riverside (2)	12/31/20	0.0	4.6	0

Figure 1. Risk assessment model (top panel) and risks (bottom panel) determined for ten counties (values in parentheses are the number of environmental monitoring stations included in the analyses) as of Dec. 30, 2019.

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The model is being evaluated and compared between years to determine if improvements can be made. Predictions of risk factors by the model are also verified by the overall incidence of disease later in the spring season in our trial plots and with NAVEK detections of grower lots. The model is also validated by comparing the number of forecasted spray applications recommended for each county (Figure 1) and this is compared to previous harvest seasons.

Precipitation and temperature differences among regions resulted in different forecasts and subsequently different announcements and timings of applications for counties in the three districts in the winter of 2020/2021. A second copper or approved alternative (Quadris Top™, Luna Sensation™, Priaxor™) fungicide application was not needed for counties in all citrus growing districts as of Jan. 12, 2021. Citrus groves in Tulare, Santa Barbara, and San Diego counties were at Level 1 (green), whereas all other counties were at level zero according the Septoria environmental model. Applications are generally called for when Level 3 (red) is reached.

A second fungicide application was suggested for only Fresno, Tulare, Santa Barbara, and San Diego Co. due to some forecasted rain as of Feb. 2 with a deadline of application by Feb. 28, 2021. Average accumulated rainfall for Districts 1 and 2 was less than 38.0 and 76.1 mm (1.5 and 2.9 inches), respectively. Total hours with temperatures less than -1C (30.2F) were <20 for all counties. Tulare (15.0 h) and Santa Barbara (17.3 h) had the most hours, but this is still moderately low (second tier in the model). These data are verifying the model and providing a service to the citrus industry that help pest control advisors and orchard managers make disease management decisions that reduce costs, potential phytotoxicity, environmental contamination with copper, and the total number of applications of fungicides in counties with low risk for disease. It also explains the low number of sample submissions to the NAVEK lab.

Evaluate the efficacy of fungicides in field trials. In fungicide evaluations, applications were made in Nov. 2020 in one plot (Table 1) and in early Feb. 2020 in a second plot (Table 2), both in Sanger, CA. Single-site fungicides used by themselves (e.g., Ph-D™, Cevya™) or pre-mixtures (e.g., BAS-751, Luna Sensation™, Miravis Top™, Priaxor™) were compared to the copper fungicides Kentan™ + lime (4+4 lb/A) or MasterCop™ (3.5 pints/A), and a non-treated control.

Table 1. Efficacy of single fall applications of fungicides for the management of Septoria spot of Navel oranges. Treatments applied 11/30/2020.

No.	Treatment*	Formu-lation	Rate (400 gal/A)	Septoria infection (%)
1	Check	---	---	0.12
2	Priaxor	SC	11 fl oz	0.03
3	Cevya	SC	5 fl oz	0.00
4	Quadris Top	SC	14 fl oz	0.00
5	BAS 751	SC	10 fl oz	0.05
6	Luna Sensation	SC	7.6 fl oz	0.00
7	Miravis Top	SC	14 fl oz	0.00
8	Kentan +	DF	4 lb +	0.00
	Lime	DF	4 lb	
9	MasterCop	SC	3.5 pints	0.09
10	Ph-D	WG	6.2 oz	0.04

Table 2. Efficacy of single winter applications of fungicides for the management of Septoria spot of Navel oranges. Treatments applied 2/1/2021.

No.	Treatment	Formula tion	Rate (400 gal/A)	% Septoria infection
1	Check	---	---	0.07
2	Priaxor	SC	11 fl oz	0.00
3	Cevya	SC	5 fl oz	0.00
4	Quadris Top	SC	14 fl oz	0.00
5	BAS 751	SC	10 fl oz	0.00
6	Luna Sensation	SC	7.6 fl oz	0.00
7	Miravis Top	SC	14 fl oz	0.06
8	Kentan +	DF	4 lb +	0.00
	Lime	DF	4 lb	
9	MasterCop	SC	3.5 pints	0.08
10	Ph-D	WG	6.2 oz	0.10

In trial 1, where a single application of each fungicide was made on Nov. 20, 2020, all treatments had low disease incidence levels including the control, and

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there were no significant differences among treatments. Still, Luna Sensation™, Miravis Top™, Quadris Top™, and Kentan™+Lime mixtures had 0% incidence. Priaxor™, BAS 751, MasterCop™ and Ph-D™ had some disease (≤0.09%), whereas incidence of the control was 0.12%. On average, >800 fruit were evaluated per treatment.

In trial 2, where a single late application was made on Feb. 1, 2021, there were also no significant differences among treatments. All fungicides treatments had 0% incidence of disease except Miravis Top™, MasterCop™, and Ph-D™ with an incidence of ≤ 0.1% incidence as compared to the control with 0.7% (Table 2). Efficacy data is needed to support the registration of Miravis Top™ and BAS 751. All other products are registered.

These trials and application timing comparisons should be continued because disease pressure and overall incidence of disease has decreased in the last few years due to warm temperatures and low precipitation in Nov., Dec., and Jan. Identifying effective management practices is very important so that growers can manage the disease effectively and economically, minimize the use of copper, and prevent the detection of Septoria spot in Korea. This will ensure that this major California export market remains open for trade.

Continue to certify fruit lots for the industry in the NAVEK program and revise and improve guidelines with industry on the management of Septoria spot. Good Agricultural Practices (GAPs) were developed as guidelines for the industry in managing Septoria spot. The NAVEK certification program is continuing under a voluntary submission program in agreement between United States Department of Agriculture-Animal and Plant Health Inspection Service and Korean regulatory agencies. As advised by California Citrus Quality Council (CCQC), the goal is to help packers and shippers ensure that fruit lots positive for Septoria spot are diverted to other markets, and fruit shipments to Korea are free of this quarantine disease. All procedures to evaluate fruit using visual and molecular methods are being done as expected. Proper controls are in place for verifying extraction of DNA and for evaluating the presence or absence of pathogen DNA using species-specific primers. Positive samples are used as controls to verify that the primers for *Septoria citri* are functioning.

The NAVEK lab provides information to packinghouses and regulators on the real-time detection of Septoria Spot. This helps the industry manage the disease at a high level. Submission of samples continues, no detections have been reported in Korea for the past 11 seasons, and the market remains open. To keep the NAVEK program going, the program has been modified with incentives to reduce the number of fungicide applications and keeping Septoria-positive lots in the program under specific criteria. Incentives are: 1) if a lot is negative for Septoria spot for NAVEK samples collected after Jan. 1, then the lot is exempt from the 2nd fungicide application; and 2) If a lot is positive for Septoria spot, the second application must be done with an anti-sporulation fungicide, and the lot can stay in the program (Figure 2). The NAVEK program has been in operation for many years, and processing of the samples has been optimized. These modifications are now in operation as we move forward with the program, and outcomes include reduced number of fungicide applications and more fruit lots that are eligible for export.

In the 2020-2021 NAVEK program, a total of 71 navel orange samples were submitted with zero detections of Septoria spot. Most of the submitted samples were from Fresno (15) and Tulare (50) Co., six were from Madera Co., and none were from Kern Co. No Valencia samples were submitted. Rainfall was low in Dec. 2020 in most counties and extremely low in Jan., Feb., and March of 2021, This, together with <20 h of temperatures below -1°C (30.2°F) during Dec. and Jan. accounted for the low incidence of Septoria spot in the 2020/21 harvest season. The new modified program that allows for positive orange lots to be shipped to Korea if an

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additional application of an anti-sporulation fungicide is made was not utilized by the industry due to low disease levels.

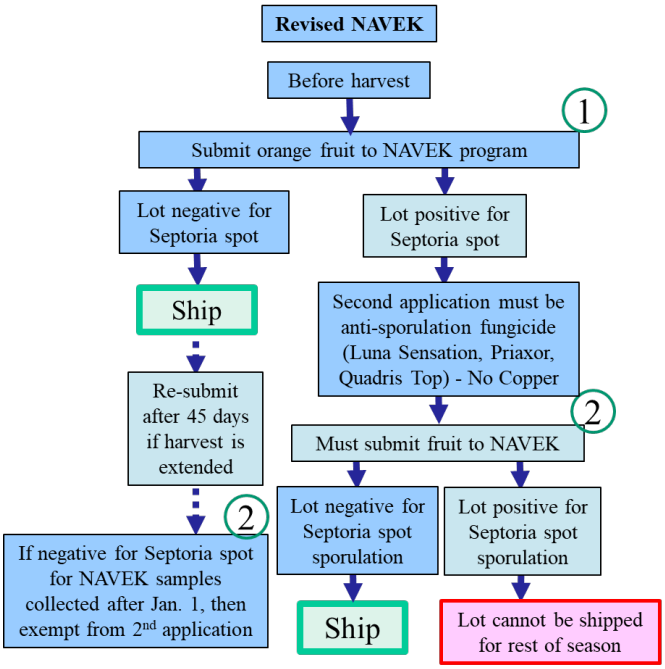

Figure 2. Revised NAVEK program showing exemption from the second application with a NAVEK sample negative after Jan. 1 and inclusion of a positive sample provided there is no sporulation on the second NAVEK sample submitted after a preharvest application of an anti-sporulation fungicide. All fruit should be treated with a postharvest application of fludioxonil/azoxystrobin to inhibit sporulation.

Conclusions

This project will continue next year as part of the Pre- and Postharvest Citrus Disease Management Core Program. To date, the Korean market is open without detections of Septoria spot in 11 seasons. The program makes forecasts and provides risk management assessments for most citrus counties in the three districts, and this has saved the citrus industry millions of dollars in unnecessary spray applications across the entire state. The NAVEK program has evolved to provide exemption for additional fungicide applications for clean orchards (reducing applications from 2 or 3 to 1) and allows orchards with positive detections to remain eligible for export provided pre- and postharvest anti-sporulation fungicides are used. The research from this project has helped register multiple new fungicides [Abound™ (FRAC Code or FC 11), Quadris Top™ (FC 3/11), Luna Sensation™ (FC 7/11), Priaxor™ (FC 7/11), and Ph-D™ or Oso™ (FC 19)] for Septoria management in California and has reduced the use of copper that has helped the citrus industry's stewardship of pesticides and helped minimize soil and water contamination to protect watersheds in citrus producing counties. The program also provides a comprehensive Good Agricultural Practice guideline annually that is posted on the California Citrus Quality Council website.

CRB Project # 5400-156

Publications and Presentations

Adaskaveg, J. E. 2020. Pre-and Post-Harvest Diseases in Citrus. CRB/UCANR Webinar Series Oct. 22, 2020

Adaskaveg, J. E. 2021. The revised NAVEK certification program. Citrograph 12:46-48.

Adaskaveg, J. E. 2021. Navel and Valencia Exports to Korea (NAVEK) – Plans for the 2021/22 Growing Season. CCQC Export meeting. Sept. 2021.

Adaskaveg, J. E. 2021. Pre- and Postharvest Diseases of Concern for Worldwide Marketing of California Citrus Fruit-Field and Packinghouse Management Strategies. CRB Annual meeting. Oct. 2021.

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