

Epidemiology and Control of Alternaria Leaf Spot

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Project Leader: James Adaskaveg, Dept. of Pathology, UC Riverside

Cooperating Personnel: G. Driever and A. Mila (UC Riverside), H. Förster (UC Davis), M. Viveros and P. Schrader (UCCE, Kern Co.)

Objectives

- I. Epidemiology
 - A. Growth chamber studies to evaluate disease development under defined environmental conditions (wetness, relative humidity, temperature).
 - B. Develop disease progress curves in relation to microclimates in commercial orchards
 - i. Compare environmental parameters (wetness, relative humidity, temperature) occurring at the edges and within an orchard and relate these to disease development.
 - ii. Compare environmental parameters between different orchards and relate to disease development. Dataloggers will be placed in these different locations.
 - C. Determine the pathogen species composition within and between selected orchards at the beginning and at the end of the log phase of the epidemic.
 - i. Identify species by morphological characters and molecular methods.
 - D. Evaluate the DSV model as a method of forecasting the disease with the goal of improved timing of fungicide treatments.
 - i. Evaluate different lower temperature thresholds of the DSV model and determine the best fit for the 2003 trials by re-calculating DSV values.
 - ii. Modify other parameters of the DSV model and apply model in fungicide application timings.
- II. Management
 - A. Evaluate new fungicides for their efficacy in managing Alternaria leaf spot. Fungicides to be evaluated include strobilurins (Abound, BAS500), Pristine (pyraclostrobin + boscalid), and non-strobilurin fungicides (e.g., difenoconazole, polyoxin-Z, and kasugamycin, as well as the experimental Valent V-101114).
 - B. Evaluate rotation programs that use a minimal number of fungicide applications in comparison with applications based on the DSV model.
 - C. Monitor for strobilurin resistance in *Alternaria* spp. populations.

Summary

In this year's trials, we focused on evaluating the DSV epidemiological model for forecasting and managing Alternaria leaf spot of almond and on evaluation of new fungicides. The DSV model was developed for predicting *Alternaria* diseases of other

crops and we are currently adjusting it for use on almond. In this model, disease severity values or DSVs are a function of leaf wetness duration and temperature during the leaf wetness period. DSVs are accumulated over time and rapid increases in this value are indicative of infection periods. In two orchard locations in Kern Co., field dataloggers were placed in each orchard with sensors recording leaf wetness, temperature, rainfall, and relative humidity. Additionally, disease incidence and severity were measured periodically from May through the end of August. A critical observation made previously and confirmed this year was that an increase in 7-day DSV values was followed by an increase in disease 21 to 27 days later (latent period) when temperatures were above 62 F. This modification in the temperature threshold to allow for accumulation of values only when temperatures were greater than 62 F resulted in a more responsive 7-day DSV index that followed the disease progress curve with a ca. 25-day latent period. In disease management studies all fungicides evaluated significantly reduced the incidence and severity of disease. Overall, Abound, Pristine, and Flint (strobilurin fungicides) were the most effective registered fungicides, whereas both experimental agricultural antibiotics (Kasumin and Polyoxin Z) and the SBI fungicides including Score and Elite were also very efficacious. Isolates of *Alternaria* spp. that are less sensitive to strobilurin fungicides in laboratory studies were again found in test orchards in Kern Co. Still, the strobilurin fungicides were highly efficacious and no crop losses have been associated with the occurrence of the less sensitive isolates. Thus, field resistance has not occurred at this time but a shift in fungicide sensitivity among isolates of *Alternaria* spp. has been documented. New chemistries are needed to develop resistance management strategies before the pathogen develops field resistance to the strobilurin fungicides. Thus, research will continue to identify new classes of fungicides for managing this disease.

Application strategies for Abound and other fungicides based on a 15- to 20-point increase in 7-day DSV values resulted in a significantly lower incidence of disease than in the control. Disease incidence in these treatments, however, was generally higher than in a calendar-based program. Thus, the forecasting strategy will need more modifications. An early first calendar-based fungicide application could be followed by model-based applications. For this, increases in 7-day DSV accumulations should be predicted before they occur, possibly using web-based microclimate weather services.

Introduction. *Alternaria* leaf spot of almond is a disease that is caused by three species in the *A. alternata* complex, *A. arborescens*, *A. alternata*, and *A. tenuissima*. The disease occurs throughout the almond production areas in the central valleys of California but is most serious in the lower San Joaquin valley where dew forms, the air is stagnant, and temperatures are high. Under favorable conditions for disease development, trees can be completely defoliated by early to mid-summer.

Epidemiology. The occurrence of *Alternaria* leaf spot of almond is greatly influenced by microclimatic conditions within orchards. Prediction models for *Alternaria* diseases that are based on wetness and temperature parameters have been developed for other crops where they are being used successfully. To optimize the timing of fungicide applications on almond and to minimize costs, the Disease Severity Value (DSV) model

for forecasting Alternaria diseases on other crops was evaluated on almond. For the last several years we have investigated correlations between the actual disease increase and increases in DSV. The disease severity in this model is determined based on the number of hours of wetness within defined temperature ranges. Based on previous studies, increases in the DSV value were followed by an increase in disease 21 to 27 days later. Using this unit of measure, disease progress was followed in a cv. Sonora orchard and in a cv. Carmel orchard in Kern Co. Field dataloggers were used with sensors recording leaf wetness, temperature, rainfall, and relative humidity. This was done in cooperation with Jeff Diebert at Western Farms. Orchards were evaluated periodically for disease development from May to mid-August. Two to three terminal

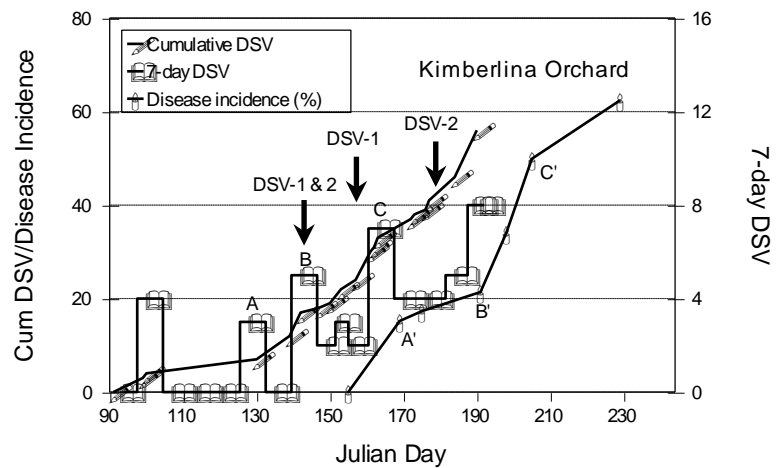


Fig. 1. Disease progress curves for Alternaria leaf spot and an evaluation of the DSV model in the Kimberlina almond orchard. Cumulative DSV (Cum DSV) and disease incidence (%) are shown on the left y-axis, whereas the 7-day DSV and severity values are on the right y-axis. Disease incidence values were based on leaves remaining on the tree and were not corrected for defoliation. Using a 25-day latency, increases in DSV and disease incidence were: A-A', B-B', and C-C'. Arrows indicate application dates based on increases in DSV above 20.

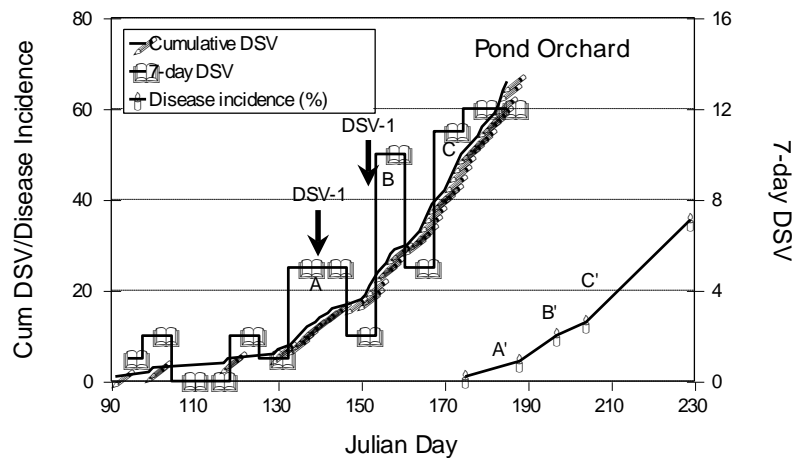


Fig. 2. Disease progress curves for Alternaria leaf spot and an evaluation of the DSV model in the Pond Ave. almond orchard. Cumulative DSV (Cum DSV) and disease incidence (%) are shown on the left y-axis, whereas the 7-day DSV and severity values are on the right y-axis. Disease incidence values were based on leaves remaining on the tree and were not corrected for defoliation. Using a 25-day latency, increases in DSV and disease incidence were: A-A'. Dots indicate application dates based on increases in DSV above 20.

branches from opposite sides of each of 5-7 unsprayed trees were tagged and the number of infected leaves and the number of lesions per leaf larger than 2 mm in diameter were counted. From the evaluation data, disease incidence (number of infected per total leaves counted at each evaluation date) and disease severity (number of lesions per leaf) were calculated. Disease progress curves for both orchards are shown in Figs. 1 and 2. When the cumulative and 7-day DSV were graphed out together, a correlation was evident between disease increase and increase in the 7-day DSV values. Thus, as in previous years, an increase in the 7-day DSV values was followed by an increase in disease 21 to 27 days later when temperatures were above 60-62F. In the cv. Carmel orchard, three infection periods were identified as indicated by A-C in Fig. 1. These infection periods were characterized by a rapid increase in the accumulation of DSV and subsequently, by a rapid increase in observed disease (A', B', C') approximately 25 days later when temperatures were above 62 F. Thus, our temperature threshold adjustment of the DSV model that accumulated values only when temperatures were above 62 F resulted in a more responsive model. In the Pond Ave. orchard, several infection periods were also evident by the peaks in the 7-day DSV plot (Fig. 2). The beginning of the increase in the 7-day DSV values >20 is shown by an A and the subsequent increase in disease is shown by an A'. Again, the latent period was approximately 25 days as in the Kimberlina plot. The cumulative DSV in the Pond Ave. orchard did not increase as fast as in the Kimberlina orchard (Fig. 2) but paralleled the season-long disease progression. By the end of the evaluation period the disease incidence values were similar but the Kimberlina location had more disease. Thus, the DSV model looks very promising as a tool for predicting infection periods for the Alternaria pathogen on almond and, with additional adjustments, probably can be used to time fungicide applications (see below).

Fungicide evaluations for management of Alternaria leaf spot of almond. Two field trials were established again in 2004 in Kern Co. in orchards with a history of the disease. Fungicides evaluated as single-fungicide applications or as mixtures and rotations included: Abound (azoxystrobin), Flint (trifloxystrobin), Cabrio (BAS500; pyraclostrobin), Pristine (mixture of pyraclostrobin and boscalid), Echo (chlorothalonil), Elite (tebuconazole), Rovral (iprodione), Score (difenoconazole), and the antibiotics Kasumin (kasugamycin) and Polyoxin Z. Two or three calendar-based applications were done in each orchard using an air-blast sprayer. In addition Abound applications were done in each orchard based on the DSV model. All DSV-1 model sprays followed increases in the 7-day DSV values of 20 points (at temperatures >62 F) and fungicide applications were done on May 21 and June 3 for both orchards. A DSV-2 model was also evaluated and this followed increases in the 7-day DSV values of 20 points (at temperatures >62 F and more than 2 weeks since the last increase in DSV values greater than 20). DSV-2 fungicide applications were done on May 21 and June 18. For disease evaluation in the field on August 17, leaves of 10 terminal branches of each tree were assessed for disease. For the laboratory evaluation, 10-15 terminal branches were collected from each tree and were scored for incidence and severity (number of lesions/leaf) of disease.

In the first orchard, two calendar-based applications of the antibiotic polyoxin numerically reduced the severity to the lowest values as compared to the control in the

field evaluation (Table 1). Most of the other treatments also significantly reduced disease severity as compared to the control. Kasumin (the antibiotic kasugamycin) was less effective. In the laboratory evaluations of field-collected leaves all treatments significantly reduced the disease from the control, but there was no difference among treatments. Abound and the Elite-Flint mixture numerically had the lowest disease incidence (11.5 to 13.1% as compared to 48.8% in the control). An additional early-April application with Rovral or Echo to the two Pristine treatments did not further reduce the incidence or severity of disease. Two applications with Abound that were done using the DSV model performed similarly to the calendar-based treatments, indicating that the application on May 21 that was common for both the calendar- and DSV-based treatments was the more critical one of the three timings (April 22, May 21, and June 3).

Table1. Evaluation of fungicides for management of Alternaria leaf spot on almond cv. Sonora in Kern Co.

Treatment	Rate/A (Product)	Application Dates				Field evaluation		Laboratory evaluation			
		4-6	4-22	5-21	6-3	Severity	LSD	Inc. (%)	LSD	Sev.	LSD
Check	---	---	---	---	---	1.0	a	47.8	a	1.8	a
Score 250SC	6 fl oz	---	@	@	---	0.5	bc	21.0	b	0.6	b
Abound 2F	12.8 fl oz	---	@	@	---	0.6	abc	13.1	b	0.3	b
Pristine 38WG	0.92 lb	---	@	@	---	0.3	bc	23.5	b	0.5	b
Elite 45WP/Flint 50WDG	2.9 oz/2.6 oz	---	@	@	---	0.4	bc	11.5	b	0.2	b
Vanguard 75WG	10 oz	---	@	@	---	0.6	abc	14.2	b	0.3	b
Kasumin 2L -Topfilm	50 ppm - 8 fl oz	---	@	@	---	0.7	ab	22.0	b	0.5	b
Polyoxin Z 11.3DF	2.2 lb	---	@	@	---	0.2	c	18.8	b	0.4	b
Elite 45WP	8 oz	---	@	@	---	0.4	bc	16.7	b	0.4	b
Flint 50WDG	3 oz	---	@	@	---	0.4	bc	20.8	b	0.5	b
Rovral 4F	1 pt	@	---	---	---	0.4	bc	15.9	b	0.4	b
Pristine 38WG	0.92 lb	---	@	@	---						
Echo 720	4 pts	@	---	---	---	0.4	bc	17.0	b	0.4	b
Pristine 38WG	0.92 lb	---	@	@	---						
Abound 2F - DSV	12.8 fl oz	---	---	@	@	0.4	bc	17.0	b	0.4	b

*- Fungicides were applied using a backpack air-blast sprayer at a rate of 100 gal/A.

**- Disease was evaluated on August 17. For the field evaluation 10 shoot tips were rated for disease severity using a scale with 0 = all leaves healthy, 1 = <33% of leaves infected, 2 = 33-66% of leaves infected, and 3 = >66% of leaves infected. Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ($P > 0.05$).

Incidence of disease in the second orchard where fungicide evaluations were done was higher than in the first orchard. Differences among treatments were most easily recognized in the orchard using a defoliation rating of trees. A large portion of the leaves of the untreated control trees had dropped at evaluation time on August 17, whereas treated trees had a much healthier appearance. Using this rating, all calendar-based treatments significantly reduced defoliation (Table 2). Of the treatments evaluated, Pristine and Abound had the lowest defoliation values. The Abound-spray program that was based on the DSV-1 and -2 models had significantly less disease than the control treatment but they were generally less effective than the calendar-

based treatments (Table 2). Between the two models, DSV-2 was slightly more effective than DSV-1 based on severity and defoliation ratings in the field.

Thus, as in the last two years, strobilurin fungicides including Abound and Pristine, as well as Flint were effective fungicides against Alternaria leaf spot in our 2004 trials. Effective alternatives for management of this disease are becoming increasingly important. Pathogen population shifts to less sensitive isolates appear to be common in Kern Co. where we evaluated orchard populations for their sensitivity against azoxystrobin and other strobilurins. Efficacy was not lost and crop losses did not occur, however, in these orchard plots. Thus, the strobilurin fungicides are still effective fungicides for reducing the incidence of Alternaria leaf spot of almond. Thus, we cannot confirm field resistance at this time but a shift in fungicide sensitivity has been documented. Still, resistance management strategies that include development of new classes of fungicides and fungicide rotations between different classes of fungicides and mixtures have to be implemented. For this, effective fungicides have to be available. The antibiotics Kasumin and Polyoxin Z, as well as the SBI fungicides Elite and Score also may be developed as alternative classes for managing Alternaria leaf spot. Pristine has recently been federally registered and we have requested that the PHI interval be changed for a shorter preharvest interval. We will continue to evaluate new materials against Alternaria leaf spot in our trials next year.

Table 2. Evaluation of fungicides for management of Alternaria leaf spot of almond on cv. Carmel in Kern Co.

Treatment	Rate/A (Product)	Application Dates				Field evaluation				Lab evaluation	
		4-22	5-21	6-3	6-18	Sev.	LSD	Defoliation	LSD	Inc. (%)	LSD
Control	---	---	---	---	---	2.8	a	3.6	a	78	a
BAS500 22.2WG	9.5 oz	@	@	---	---	1.8	cde	1.9	bc	41	bc
Pristine 38WG	0.92 lb	@	@	---	---	1.5	e	1.3	d	41	bc
Flint 50WDG	3 oz	@	@	---	---	1.9	bcd	1.8	bcd	35	c
Abound 2F	12.8 fl oz	@	@	---	---	1.7	de	1.5	cd	37	bc
Abound 2F - DSV1	12.8 fl oz	---	@	@	---	2.2	b	2.3	b	39	bc
Abound 2F - DSV2	12.8 fl oz	---	@	---	@	2	bc	1.7	bcd	49	bc

* - Fungicides were applied using a backpack air-blast sprayer at a rate of 100 gal/A.

** - Disease was evaluated on August 17. For the field evaluation 10 shoot tips were rated for disease severity using a scale with 0 = all leaves healthy, 1 = <33% of leaves infected, 2 = 33-66% of leaves infected, and 3 = >66% of leaves infected. For defoliation a scale with 0 = no defoliation, and 1 = <25%, 2 = 25-50%, 3 = 51-75%, and 4 = >75% of leaves dropped was used. In the laboratory evaluation disease incidence was based on the number of diseased leaves of the total number of leaves evaluated. Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ($P > 0.05$).