Studies on Biology and Control of Almond Scab and Alternaria Leaf Spot

Project No.: **11-PATH3-Adaskaveg**

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Objectives

- Etiology
  - Identify pathogenic species of *Alternaria* using molecular methods.
  - Determine the *Alternaria* species composition within selected orchards. This objective is contingent on the development of molecular methods for identification of the pathogens.
  - Determine the *F. carpophilum* population composition within selected orchards and determine if sexual reproduction occurs within orchard populations using molecular methods.
- Management
  - Evaluate new and registered fungicides for their efficacy in managing scab and Alternaria leaf spot. Fungicides to be evaluated include non-QoI fungicides (e.g., fluopyram - Luna Privilege, fluxapyroxad - Xemium, penthiopyrad (Fontelis), metconazole - Quash, difenoconazole - Inspire, polyoxin-D - Ph-D, chlorothalonil - Bravo and efficacy will be compared to QoI fungicides.
    - Single-fungicide programs
    - Rotation programs of different fungicide chemistries
  - For scab management, evaluate the effect of dormant applications (new formulations of copper or Bravo used with oil) on sporulation of infected twig lesions, as well as registered (Bravo, Mancozeb, Ziram) and new fungicides (Inspire, Syllit, Quash, Ph-D, and pre-mixtures) for in-season use. (Focus on Bravo for extended spring time usage for disease control - i.e., 60 day PHI as the fungicide moves through the IR-4 program for re-registration on almond).
  - Establish and expand baseline sensitivities and monitor for shifts in sensitivity in populations of *Alternaria* and *Fusicladium* spp. to sub-groups of the SDHIs: pyridine-carboxamides (boscalid), pyrazole-carboxamide (fluxapyroxad), and pyridinyl-ethyl-benzamides (fluxopyroxad), DMIs, polyoxin-D, and QoIs.
  - Develop and use a modified DSV model based on dew point (instead of leaf wetness) and temperature (i.e., onset of dew formation and rising temperatures during mid-spring) with a goal for county-wide forecasts for the first in-season fungicide application. Time additional applications in 2- to 3- week intervals under low-rainfall conditions.

Interpretive Summary: *(Note - This report is mainly based on our 2011 data because our 2012 project is ongoing. Goals and plans for the 2012 season are discussed).*

Scab (caused by *Fusicladium carpophilum* formerly *Cladosporium carpophilum*) and Alternaria leaf spot (caused by three very closely related species in the *Alternaria alternata* complex: *A. arborescens*, *A. alternata*, and *A*. *tenuissima*) have become of increasingly problematic in recent years in many growing areas in California. Both diseases are summer diseases that especially occur in locations with high humidity and where air circulation is poor such as in high-density plantings or in orchards with soils with inadequate drainage or where trees require frequent and extended irrigations throughout the summer. Because Alternaria leaf spot is greatly influenced by microclimatic conditions such as temperature and wetness within orchards, we previously successfully modified the Disease Severity Value (DSV) model to predict infection periods and to time fungicide treatments.

With widespread resistance to QoI and MBC fungicides and a high level of natural insensitivity against the SDHI boscalid (one of the active ingredients in Pristine) in *F. carpophilum* populations, and with widespread resistance against QoI and SDHI (i.e., boscalid) fungicides in *Alternaria* spp. populations, we are developing alternative treatments to manage these diseases. For Alternaria leaf spot, the highly effective polyoxin-D (Ph-D) and several DMI fungicides (e.g., Quash, Inspire) have been registered through our research. These fungicides also fit well into a scab management program, especially since treatment timings are overlapping for the two diseases when the delayed dormant treatment suppresses sporulation of twig infections until May-June. Because several in-season applications are needed to control both diseases and because of the continuous risk of resistance development, we have been evaluating additional alternatives. New sub-groups of the SDHI class are being introduced that are more effective than boscalid (that belongs to the pyridine-carboxamides). Some of these sub-classes differ in their target binding site (succinate dehydrogenase in complex II of respiration) so that there is limited cross-resistance between some of the sub-groups. New SDHI fungicides include the pyrazole-carboxamides penthiopyrad (Fontelis) and fluxapyroxad (a component of Merivon) and the pyridinyl-ethyl-benzamide fluopyram (a component of Luna Sensation and Luna Experience). These fungicides showed high promise in our field trials. We are currently evaluating cross-resistance properties among SDHI sub-groups in the scab and Alternaria pathogen populations. The multi-site mode of action fungicide chlorothalonil that is effective against both diseases potentially will have a critical role in preventing the over-use of SDHI and DMI fungicides, thus, reducing the potential for selecting resistant pathogen populations. The proposed label changes for chlorothalonil will allow for a shortening in the preharvest interval on almond. We are recommending a change from 155 days to 60 days PHI. Thus, in our field trials we continued to collaborate with the agrochemical industry and regulatory agencies to develop and design sustainable treatment programs where several classes of fungicides are mixed or rotated, so that no single class is over-used.

For scab, we also continued to evaluate inoculum reduction treatments that delay the sporulation of twig cankers in the springtime. Dormant applications with chlorothalonil-oil again provided very effective sporulation control at several field sites, and this treatment will be an excellent alternative to copper-oil treatments.

Materials and Methods:

Etiology of scab and Alternaria leaf spot and scab. Populations of *F. carpophilum* are being evaluated by AFLP analyses. Fragment patterns are scored on computer-generated gels. Possible evidence for sexual recombination will be provided through multilocus genotypic analysis. The etiology of *Alternaria* spp. populations is also done by AFLP analyses. Fragment patterns are analyzed, compared to reference isolates, and data are presented using tree-building programs that visualize relationships among isolates.

Fungicide evaluations for management of scab in 2011 and 2012. Data for evaluation of dormant treatments are presented for 2012 and for in-season treatments for 2011. Dormant treatments were applied in commercial orchards in January 2012 (cv. Carmel in Butte Co.; see **Table 1**), in December 2011 or January 2012 (cvs. Carmel and Monterey in Kern Co.; see **Table 2)**, or in February 2012 (cv. Monterey in Colusa Co.). Treatments included Bravo WeatherStik (4 and 6 pts/A) without or with the addition of a spray oil, Manzate, and Catamaran (a pre-mixture of phosphate and chlorothalonil). Samples of last fall's twigs growth were collected periodically from each location and evaluated in the laboratory for sporulation of overwintering scab lesions. Sporulation was expressed as incidence of sporulating lesions and as severity using a rating scale with 0=no sporulation, 1=very little sporulation, 2=lesion partially covered with sporulation, and 3=lesion completely covered with sporulation or a full concentric ring of sporulation.

In-season treatments were done at selected times after petal fall after the onset of twig sporulation on cvs. Peerless and Carmel in Butte Co. as indicated in **Tables 3 and 4**. Treatments included Ph-D (FRAC 19), Syllit (FRAC U12), S-2200 (class unknown), Fontelis (FRAC 7), Quash (FRAC 3), Adament (FRAC 3+11), Luna Sensation (FRAC 7+11), Luna Experience (FRAC 3+7), Inspire Super (FRAC 3+9), Quadris Top (FRAC 3+11), Pristine (FRAC 7+11), Merivon (FRAC 7+11), Bravo WeatherStik (FRAC M5), mixtures of Bravo with Ph-D, Quash, or Syllit, a mixture of Quash with S-2200, as well as rotations of Ziram with Ph-D/Captan, or of Dithane with Bravo. The cv. Carmel trial was conducted using a split-plot design. The main plots consisted of rows treated or not treated with dormant applications (Bravo-Weather Stik or Kocide 3000-Oil). The sub-plots consisted of the in-season treatments. Disease was evaluated based on incidence of fruit with scab lesions and on the number of lesions per fruit (disease severity).

Fungicide evaluations for management of Alternaria leaf spot of almond in 2011. Our modified DSV model was used to determine initiation times of spray programs **(Figure 1).** Two trials were established in Kern Co. (cv. Monterey and Fritz), one trial in Butte Co. (cv. Carmel), and two trials in Colusa Co. (cv. Carmel). As indicated

Figure 1. The DSV model for forecasting diseases caused by *Alternaria alternata*

Disease severity values (DVS) as a function of leaf wetness duration and average air temperature during the wetness period.

Mean temperature (C) during wetness	Leaf wetness duration (hours)				
15-17*	0-6	7-15	16-20	21	---
17.1-20	0-3	4-8	9-15	16-22	23+
20.1-25	0-2	3-5	6-12	13-20	21+
25.1-29	0-3	4-8	9-15	16-20	23+
DSV	0	1	2	3	4

*- Original model was 11-17C

Websites for DSV model:
1) www.irrigate.net
2) www.ipm.ucdavis.edu/DISEASE/DATABASE/tomatoblackmold.html
* Note: Models not modified at these websites.

in **Tables 5-7**, all trials received three applications between early May and late-June, except one of the Colusa Co. trials where only one application was done in late June. Treatments included two formulations of polyoxin-D (Ph-D and CX10440 (FRAC 19), Xemium (FRAC 7), Fontelis (FRAC 7), Quash (FRAC 3), YT669 (picoxystrobin, FRAC 11), IKF-5411 and S-2200 (class unknown for both), Luna Sensation (FRAC 7+11), Luna Experience (FRAC 3+7), Inspire Super (FRAC 3+9), Quadris Top (FRAC 3+11), Pristine (FRAC 7+11), Merivon (FRAC 7+11), Q8Y78 (penthiopyrad + picoxystrobin, FRAC 7+11), as well as selected mixtures and pre-mixtures. Evaluations were done between mid-August and early September. For disease incidence leaves were collected and evaluated for the presence of disease. For disease severity (lesions/leaf), a rating was used with a scale from 0 to 4. Trees were also rated for defoliation based on a scale from 0 (= no defoliation) to 4 (= more than 75% of the leaves fallen).

In vitro sensitivity of *Fusicladium carpophilum* and *Alternaria* spp. to selected fungicides - 2012 Research ongoing. Isolates from orchards in Kern, Butte, Colusa, and Stanislaus Co. are being evaluated for their sensitivity against several SDHI fungicides (i.e., boscalid, fluopyram, fluxapyroxad, penthiopyrad) using the spiral gradient dilution method. Inhibition of mycelial growth is measured after 3 to 4 days of incubation and EC_{50} values are determined. Data are currently being summarized.

Statistical analysis of data. All data were analyzed using analysis of variance and least significant difference (LSD) mean separation procedures ($P > 0.05$) of SAS. Data for the large scab field trial were analyzed using split plot procedures.

Table 1. Efficacy of dormant treatments on sporulation of overwintering scab lesions - Butte Co. 2012

		Samples collected 4-3-12				Samples collected 6-12-12			
		Twig sporulation**				Twig sporulation			
Treatment*	Rate/A	Inc. (%)	LSD^	Rating	LSD	Inc. (%)	LSD	Rating	LSD
Control		46.0	a	0.7	a	42.0	a	1.0	a
Bravo Weather Stik	4 pts/A	17.9	bc	0.2	b	53.7	a	1.1	a
Bravo Weather Stik	6 pts/A	24.1	ab	0.3	b	27.1	a	0.4	bc
Bravo Weather Stik + Oil	4 pts/A	1.2	cd	0.0	b	38.5	ab	0.7	ab
Bravo Weather Stik + Oil	6 pts/A	0.0	d	0.0	b	8.4	b	0.1	c

* - Treatments were applied in January 2012 using an air-blast sprayer at 100 gal/A.
** - Lesions were evaluated using a rating scale: 0=no sporulation, 1=very little, 2=lesion partially covered with dark sporulation, 3=lesion completely covered with sporulation, or full concentric ring sporulating.
^ Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation (P > 0.05) procedures.

Results and Discussion:

Etiology of scab and Alternaria leaf spot and scab. *Alternaria* spp. populations are currently being evaluated by AFLP analyses and results are pending. We also conducted AFLP studies on *F. carpophilum*, and data are currently being analyzed.

Scab management – 2011 and 2012 Research. Dormant treatments to reduce the production of primary inoculum in the springtime from overwintering twig lesions were evaluated in the spring of 2012 in several trials. The focus was on chlorothalonil, because this fungicide in combination with oil gave the best sporulation control in 2011 and performed superior to

copper-oil. At the Butte Co. location, sporulation in early April was numerically reduced by both rates of Bravo, without or with the addition of oil (**Table 1**). At both rates of Bravo, however, reduction was much higher when used with oil and was the same for both rates. In a mid-June sampling, only the 6-pt rate of Bravo used with oil significantly reduced sporulation from the control. At this time, 42% of the control lesions sporulated, whereas 8.4% of the 6-pt Bravo-Oil treated lesions sporulated. Additionally, the amount of sporulation (sporulation rating) was reduced by 90%.

Table 2. Efficacy of dormant treatments on sporulation of overwintering scab lesions - Kern Co. 2012

				Samples collected 4-12-12				Samples collected 5-9-12			
				Twig sporulation**				Twig sporulation			
Cultivar	Treatment	Rate/A	Application	Inc. (%)	LSD^	Rating	LSD	Inc. (%)	LSD	Rating	LSD
Monterey	Control			77.0	a	1.0	a	77.0	a	1.0	a
	Bravo Weather Stick	4 pts	12/20/11	36.3	ab	0.4	ab	69.4	a	1.0	a
	Bravo Weather Stick	4 pts	1/16/12	47.9	ab	0.7	ab	71.5	a	1.1	a
	Bravo Weather Stik + 4% Oil	4 pts	12/20/11	10.4	b	0.1	b	0.0	b	0.0	b
	Bravo Weather Stik + 4% Oil	4 pts	1/16/12	7.0	b	0.1	b	6.7	b	0.1	b
Carmel	Control			26.4	a	0.4	a	23.0	a	0.5	a
	Bravo Weather Stik	4 pts	12/20/11	14.6	ab	0.2	ab	11.9	bc	0.1	b
	Bravo Weather Stik	4 pts	1/16/12	5.2	bc	0.1	bc	15.9	ab	0.2	b
	Bravo Weather Stik + 4% Oil	4 pts	12/20/11	0.0	c	0.0	c	7.0	bc	0.1	b
	Bravo Weather Stik + 4% Oil	4 pts	1/16/12	2.6	c	0.0	c	2.4	c	0.0	b

*Treatments were applied using an air-blast sprayer at 100 gal/A.
** Lesions were evaluated using a rating scale: 0=no sporulation, 1=very little, 2=lesion partially covered with dark sporulation, 3=lesion completely covered with sporulation or full concentric ring sporulating.
^ Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation (P>0.05) procedures.

Table 3. Efficacy of fungicide programs for management of scab of cv. Peerless almonds Butte Co. 2011.

			Application		Dis. Incid. on fruit**		Dis. Sev. on fruit	
			4-6-11	5-24-11				
Program	Fungicide	Rate	3 wkPF	5 wk PF	(%)	LSD^	Lesions	LSD
---	Control	---	---	---	55.2	a	3.1	a
Single	Ph-D 11.2DF org. form.	6.2 oz	@	@	11.0	b	0.5	bc
fungicides	Syllit 65W	32 oz	@	@	14.4	b	0.7	bc
	S-2200	3 fl oz	@	@	8.8	b	0.4	bc
	Fontelis1.67SC	2 pt	@	@	20.9	b	1.0	b
	Quash 50WG	3.5 oz	@	@	10.3	b	0.5	bc
Mixture	Quash + S2200	2 oz + 2 fl oz	@	@	11.8	b	0.6	bc
Pre-	Adament 50WG	6 oz	@	@	15.0	b	0.7	bc
mixtures	Luna Sensation	5 fl oz	@	@	14.9	b	0.7	bc
	Luna Experience	6 fl oz	@	@	8.0	b	0.4	c
	Inspire Super	20 fl oz	@	@	16.5	b	0.8	bc
	Quadris Top	14 fl oz	@	@	11.9	b	0.6	bc
	Pristine 38WG	14.5 oz	@	@	9.0	b	0.4	bc
	Merivon (BAS703)	6.8 fl oz	@	@	12.7	b	0.6	bc

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A.
** - Incidence of scab was based on 100 fruit from each single-tree replication for each treatment on 7-28-11
Severity was based on a rating from 0 = healthy, 1 = <10 lesions, 2 = 10-25 lesions, 3 = >25 lesions/fruit
*** - Values followed by the same letter are not significantly different based on an analysis of variance and least significant difference (LSD) mean separation ($P > 0.05$).

Table 4: Efficacy of fungicide treatments for management of scab on almond cv. Carmel - Butte Co. 2011

A. Evaluation of petal fall and spring-time treatments for disease control - plot A

			Applications			Dis. Incid. on fruit**		Dis. Sev. on fruit	
No.	Treatments*	Rate (/A)	4-14	5-3	5-24	(%)	LSD^	Lesions	LSD
1	Control	---	---	---	---	72.9	a	2.1	a
2	Bravo WeatherStick	6 pts	@	@	@	36.1	b	0.6	b
3	Ph-D 11.2DF + Bravo	6.2 oz + 6 pt	@	@	@	36.0	b	0.7	b
4	Quash 50WG + Bravo	3.5 oz + 6 pt	@	@	@	38.8	b	0.7	b

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

**- Evaluations for scab on fruit were done on 9-8-11. 50 fruit of each tree were rated for the presence and severity of disease. For severity, a scale was used from 0=no disease, 1=<10, 2=11-20, 3=21-40, 4=>40 lesions/fruit. Dormant treatments did not significantly affect the efficacy of the subsequent petal fall treatments, and thus, dormant treatments combined for each petal fall treatment.

^ Values followed by the same letter are not significantly different based on an analysis of variance and least significant difference (LSD) mean separation *(P* > 0.05) procedures.

B. Evaluation of petal fall and spring-time treatments for disease control - plot B

						Dormant treatment: Bravo WeatherStick				**Dormant treatment: Kocide 3000-Oil**			
			Application			Dis. Incid. on fruit**		Dis. Sev. on fruit		Dis. Incid. on fruit**		Dis. Sev. on fruit	
No.	In-season trt	rate	4-14	5-3	5-24	(%)	LSD^	Lesions	LSD	(%)	LSD^	Lesions	LSD
1	Control	---	---	---	---	63.5	a	1.6	a	60.0	a	1.4	a
2	Syllit 65WSP	30 oz	@	@	@	21.0	b	0.4	b	33.0	b	0.7	b
3	Syllit + Equus	30 oz + 64 fl oz	@	@	@	27.5	b	0.5	b	27.0	b	0.6	b
4	Ph-D + NuFilm	6.2 oz + 8 fl oz	@	@	@	27.5	b	0.7	b	25.0	bc	0.5	b
5	Luna Sensation	5 fl oz	@	@	@	30.0	b	0.5	b	44.0	ab	0.8	b
6	Quadris Top	14 fl oz	@	@	@	19.0	b	0.5	b	26.5	bc	0.5	b
7	Inspire Super	20 fl oz	@	@	@	16.5	b	0.3	b	10.0	c	0.2	b
8	Ziram	8 lb	@	---	---	30.0	b	0.6	b	40.0	ab	0.8	b
	Ph-D + Captan 80WP	6.2 oz + 5 lb	---	@	@								
9	Dithane 45F	4.5 qt	@	---	---	28.0	b	0.5	b	41.5	ab	0.7	b
	Bravo WeatherStick	6 pt	---	@	@								

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

**- Evaluations for scab on fruit were done on 9-8-11. 50 fruit of each tree were rated for the presence and severity of disease. For severity, a scale was used from 0=no disease, 1=<10, 2=11-20, 3=21-40, 4=>40 lesions/fruit.

^ Values followed by the same letter are not significantly different based on an analysis of variance and least significant difference (LSD) mean separation *(P* > 0.05) procedures.

Similar results were obtained at the Kern Co. location on two almond cultivars. Thus, sporulation was most effectively reduced using Bravo in combination with oil (**Table 2**). Only the 4-pt rate of Bravo was evaluated in this trial, and similar results were obtained when applied in late December as compared to mid-January. These results confirm last-year's data and again demonstrate the high efficacy of dormant Bravo-oil as a springtime inoculum-reduction treatment for almond scab and as an alternative for copper-oil. The 6-pt rate of Bravo has the potential of suppressing inoculum production throughout late spring (see the Butte Co. trial above). In November of 2011, Bravo WeatherStik received a Section 2(ee) registration for dormant application between Dec. 1 and Dec. 31, 2011 using the 4-pt rate. Full registration is being pursued through the IR-4 program to change the PHI to 60 days.

Additional non-oil-based treatments were evaluated for their anti-sporulation efficacy in another trial in Colusa Co. on cv. Monterey. In an early-April evaluation, 38.4% of lesions of the untreated control sporulated, whereas 16.7%, 14.3%, and 10.8% of the lesions sporulated in the Catamaran (80 fl oz), Bravo (4 pt), and Manzate (6 lb) treatments, respectively, that were

applied in early February (data not shown). Thus, additional non-oil-based treatments could be explored as possible pre-bloom, anti-sporulation treatments for almond scab.

Spring-time applications for the management of scab were evaluated in three field trials in 2011 (data not available for 2012). Disease pressure was relatively low at all locations. Although the incidence of disease in the untreated control ranged from 55.2% to 72.9%, there was only an average of 1.4 to 3.1 lesions per fruit. In the trial in Butte Co. on cv. Peerless, more recently registered and several experimental fungicides were used. Two applications of anyone fungicide significantly reduced the disease from the control and there was no significant difference among most treatments (**Table 3**).

In two additional trials in Butte Co. with a split-plot design, three-application programs were conducted. Treatments of Bravo, Bravo + Ph-D, or Bravo + Quash were similarly effective for all dormant treatments and thus, data were combined for the dormant treatments (**Table 4A**). Disease was significantly reduced from the untreated control, but overall efficacy was not as high as in the cv. Peerless trial (see above). In the third, trial treatments performed differently between the dormant Bravo Weatherstik and Kocide 3000-oil treatments and thus, data are presented separately (**Table 4B**). With the dormant Bravo application, treatments all significantly reduced the disease. With Kocide-oil, however, only Syllit, Syllit-Equus, Ph-D, Quadris Top and Inspire Super were effective, but not Luna Sensation and two rotation programs.

Our data on scab management indicate that the disease can be effectively managed with currently available fungicides. A highly effective, three-spray program should include dormant applications with chlorothalonil-oil or copper-oil and two petal-fall applications based on twig sporulation. Dormant applications result in a reduced amount of inoculum and this will reduce the risk for selection of fungicide resistance. Effective petal fall treatments are chlorothalonil, DMI fungicides such as Quash or Inspire Super, Syllit, compounds containing SDHIs (Luna Sensation), QoIs (at locations where the pathogen population has not developed resistance), or Ph-D. Treatments containing a DMI compound were very effective, although the incidence of natural resistance against DMIs in *F. carpophilum* is high at some locations (see 2011 Annual Report). Thus, this class of chemicals, as well as others, can be effectively used, but they should be rotated with other classes or FRAC Groups (representing different modes of action) to prevent further selection of insensitivity.

Fungicide evaluations for management of Alternaria leaf spot of almond in 2011. Our research in 2012 is ongoing, we are planning to evaluate our plots in Aug./Sept. Thus, information is presented here for 2011 when trials were conducted in Kern, Butte, and Colusa counties. In 2011, we evaluated programs using single fungicides, mixtures, pre-mixtures, and rotations. Many of the treatments were effective and reduced the disease from that of the untreated control. Disease incidence (based on the

Table 5: Efficacy of fungicide treatments for management of Alternaria leaf spot and rust on almond cvs. Monterey and Fritz - Kern Co. 2011

			Timings			cv. Monterey						cv. Fritz			
						Dis. Incid. leaves		Dis. Sev. leaves		Tree Defoliation		Dis. Incid. leaves		Dis. Sev. leaves	
Program	Treatment	Rate	5-13	6-2	6-23	(%)	LSD^	Rating	LSD	Rating	LSD	(%)	LSD^	Rating	LSD
---	Control	---	---	---	---	99.1	a	2.9	a	1.6	a	73.9	a	1.1	a
Single	EBDC	96 oz	@	@	@	52.4	efghi	0.6	defgh	0.2	d	50.6	b	0.6	b
fungicides	CX10440	3.75 fl oz	@	@	@	68.4	cdefg	0.9	cdefgh	0.3	d	3.0	e	0.0	d
	CX10440	7.5 fl oz	@	@	@	57.6	defghi	0.7	cdefgh	0.2	d	11.0	de	0.1	cd
	Ph-D 11.2DF org. form.	6.2 oz	@	@	@	56.8	defghi	0.6	cdefgh	0.1	d	12.5	de	0.2	cd
	BAS700 (Xemium)	4.5 fl oz	@	@	@	33.8	fghi	0.3	gh	0.0	d	5.0	de	0.1	d
	Quash 50WG	3 oz	@	@	@	64.2	cdefg	0.9	cdefgh	0.5	cd	20.5	cd	0.2	cd
	IKF-5411 400SC	10.5 fl oz	@	@	@	95.6	ab	1.8	b	1.3	ab	22.3	cd	0.2	cd
	IKF-5411 400SC	17 fl oz	@	@	@	87.0	abc	1.7	b	0.9	bc	35.2	bc	0.4	bc
Pre-	Luna Experience	6 oz	@	@	@	28.0	hi	0.3	gh	0.1	d	14.8	cd	0.1	cd
mixtures	Luna Sensation	5 fl oz	@	@	@	40.4	fghi	0.5	efgh	0.0	d	18.7	cd	0.2	cd
	Inspire Super SC	20 fl oz	@	@	@	81.0	bcde	1.0	cdef	0.3	d	10.1	de	0.1	cd
	Quadris Top	14 fl oz	@	@	@	79.4	bcde	1.1	bcd	0.2	d	15.5	cd	0.2	cd
	Pristine 38WG	14 oz	@	@	@	81.0	abcd	1.1	cde	0.1	d	17.4	cd	0.2	cd
	BAS703 (Merivon)	6.8 fl oz	@	@	@	25.2	i	0.3	h	0.0	d	8.1	de	0.1	d
Mixture	Ph-D org. + Quash	6.2 oz + 3 oz	@	@	@	37.1	fghi	0.4	efgh	0.1	d	14.7	d	0.2	cd
Rotations	EBDC	96 oz	@	---	---	61.4	cdefgh	0.8	cdefgh	0.0	d	48.9	b	0.7	b
	Pristine 38WG	14 oz	---	@	---										
	EBDC	96 oz	---	---	@										
	Luna Experience	6 fl oz	@	---	---	83.8	abcde	1.2	bc	0.5	cd	12.2	de	0.1	cd
	Gem 500SC	3.8 fl oz	---	@	---										
	Adament 50WG	6 oz	---	---	@										
	Ph-D org. form.	6.2 oz	@	---	---	53.4	dfghi	0.6	cdefgh	0.4	cd	9.2	de	0.1	d
	Quash 50WG	3 oz	---	@	---										
	Ph-D + Quash	6.2 oz + 3 oz	---	---	@										
	Ph-D org. form.	6.2 oz	@	---	---	69.5	cdef	0.9	cdefg	0.1	d	11.4	de	0.1	cd
	BAS700 (Xemium)	4.5 fl oz	---	@	---										
	Inspire Super SC	20 fl oz	---	---	@										
	Ph-D org. form.	6.2 oz	@	---	---	33.0	ghi	0.4	fgh	0.3	d	6.6	de	0.1	d
	Inspire Super SC	20 fl oz	---	@	---										
	BAS700 (Xemium)	4.5 fl oz	---	---	@										

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A and there were 3 single-tree replications for each treatment.
** - Evaluations for disease were done on 8-17-11. For Alternaria disease incidence on leaves, 30-40 leaves from each of the 3 single-tree replications were evaluated for the presence of disease. For evaluation of disease severity, a rating was used with 0=healthy, 1= 1 lesion/leaf, 2= <50% leaf area diseased,, 3= 75% of leaf area diseased, 4= >75% area diseased. For evaluation of tree defoliation, trees were rated based on a scale from 0= full canopy, 1= up to 25%, 2= 26-50%, 3= 51-75%, and 4=>75% defoliation.
***- For evaluation of leaf rust a severity rating was used with 0=healthy, 1= < 25% of leaves diseased, 2= 25-50%, 3= 50-75%, 4= >75 of leaves diseased.
^ - Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ($P > 0.05$) procedures.

Table 6: Efficacy of fungicide treatments for management of Alternaria leaf spot on almond cv. Carmel - Butte Co. 2011

						Evaluation mid-August				Evaluation early-September			
			Applications			Dis. Incid. leaves		Disease Severity		Disease Severity		Tree Defoliation	
Program	Treatment	Rate	5-3	5-24	6-15	(%)	LSD^	(%)	LSD^	(%)	LSD^	Rating	LSD
	Control	---	---	---	---	76.2	a	0.9	a	2.8	a	3.0	a
Single	Ph-D 11.2DF org. + NF-P	6.2 oz + 8 fl oz	@	@	@	28.5	bc	0.3	bc	1.3	b	1.5	b
fungicides	CX10440	13.4 fl oz	@	@	@	41.8	bc	0.4	bc	1.1	b	1.4	b
Mixture	Ph-D org. + NF-P + Quash	6.2 oz + 8 fl oz + 3.5 oz	@	@	@	21.7	c	0.2	c	1.0	b	0.8	b
Pre-	Luna Experience	6 fl oz	@	@	@	42.4	bc	0.5	bc	0.9	b	0.8	b
mixtures	Luna Sensation	5 fl oz	@	@	@	29.7	bc	0.3	bc	1.4	b	1.6	b
	Inspire Super	20 fl oz	@	@	@	24.9	c	0.2	c	1.3	b	0.9	b
	BAS703 (Merivon)	6.8 fl oz	@	@	@	41.3	bc	0.4	bc	1.0	b	0.9	b
	Q8Y78 240SC	24 fl oz	@	@	@	49.5	b	0.6	b	1.2	b	1.3	b
Rotation	Quadris Top	14 fl oz	@	-	-	35.2	bc	0.4	bc	0.8	b	0.7	b
	Ph-D 11.2DF org. + NF-P	6.2 oz	-	@	-								
	Quash 50WG	3.5 oz	-	-	@								

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. Q8Y78 240SC is a pre-mix of picoxystrobin and penthiopyrad.
** - For evaluations, 30 leaves from each of the 4 single-tree replications were evaluated for the presence of disease. Disease severity was based on a rating scale from 0= no lesions, 1= <25%, 2=25-75%, and 3=>75% of leaf area diseased. For evaluation of tree defoliation, trees were rated based on a scale from 0 (= full canopy) to 4 (>90% defoliation).
^ Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ($P > 0.05$) procedures.

Table 7: Efficacy of fungicide treatments for management of Alternaria leaf spot on almond cv. Carmel - Colusa Co. 2011

A. Three-spray program

Program	Treatments*	Rates (/A)	Applications			Dis. severity leaves		Tree Defoliation	
			5-12	6-1	6-22	(%)	LSD^	Rating	LSD
---	Control	---	---	---	---	3.2	a	3.0	a
Single fungicides	Ph-D 11.2DF org. + NF-P	6.2 oz + 8 fl oz	@	@	@	1.7	ghi	1.3	bcd
	CX10440	3.75 fl oz	@	@	@	1.8	fghi	1.1	bcd
	CX10440	7.5 fl oz	@	@	@	1.9	efgh	1.3	bc
	S-2200	3 fl oz	@	@	@	3.0	ab	3.1	a
	Quash 50WG	3 oz	@	@	@	1.6	ghi	1.2	bc
	Fontelis 1.67SC + NIS	14 fl oz	@	@	@	1.8	ghi	1.4	bc
	Fontelis + NIS	20 fl oz	@	@	@	1.7	ghi	1.2	bc
	YT669 2.08SC (picoxystrobin)	12 fl oz	@	@	@	2.9	abc	2.6	a
	IKF-5411 400SC	10.5 fl oz	@	@	@	2.3	cdef	1.5	bcd
	IKF-5411 400SC	17 fl oz	@	@	@	2.6	bcd	1.6	b
Mixtures	S-2200 + Quash	2.5 fl oz + 2.5 oz	@	@	@	2.4	cde	1.6	bc
	S-2200 + Quash	3 fl oz + 3 oz	@	@	@	2.4	cde	1.6	bc
	Ph-D + NF-P + Quash	6.2 oz + 8 fl oz + 3 oz	@	@	@	1.4	hij	0.7	cd
Pre-mixtures	Luna Experience	6 oz	@	@	@	1.3	ij	0.9	bcd
	Luna Sensation	5 fl oz	@	@	@	1.6	ghi	0.9	bcd
	Pristine 38WG	14 oz	@	@	@	2.1	defg	1.1	bc
	BAS703 (Merivon)	6.8 fl oz	@	@	@	0.8	j	0.3	d
	Q8Y78 240SC	24 fl oz	@	@	@	1.4	hi	0.8	bcd
Rotations	Luna Experience	6 fl oz	@	---	---	2.0	efgh	1.5	bc
	Gem	3.8 fl oz	---	@	---				
	Adament 50WG	6 oz	---	---	@				
	Ph-D org. + NF-P	6.2 oz + 8 fl oz	@	---	---	1.7	ghi	1.4	bc
	Quash 50WG	3 oz	---	@	---				
	Ph-D org. + NF-P + Quash	6.2 oz/8 fl oz/3 oz	---	---	@				

B. One-spray program

Program	Treatments*	Rates (/A)	Applic.	Dis. Severity		Tree Defoliation	
			6-29	(%)	LSD^	Rating	LSD
---	Control	---	---	3.2	a	3.3	a
Single fungicides	Ph-D 11.2DF org. + NF-P	6.2 oz + 8 fl oz	@	1.3	d	0.9	def
	CX10440	7.5 fl oz	@	1.8	bc	1.3	bcd
	Quash 50WG	3 oz	@	1.5	bcd	1.6	bc
Mixture	Ph-D org. + NF-P + Quash	6.2 oz + 8 fl oz + 3 oz	@	1.3	d	1.0	cde
Pre-mixtures	Luna Experience	6 oz	@	1.4	cd	1.1	bcde
	Luna Sensation	5 fl oz	@	1.2	d	0.6	ef
	Quadris Top	14 fl oz	@	1.8	b	1.7	b
	BAS703 (Merivon)	6.8 fl oz	@	0.9	e	0.3	f
	Q8Y78 240SC	24 fl oz	@	1.5	bcd	1.3	bcd

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. Q8Y78 240SC is a pre-mix of picoxystrobin and penthiopyrad. In plot A, rainfall occurred during and immediately after treatments on May 12.

** - Evaluations were done on 9-8-11. For disease severity on leaves, 40-50 leaves from each of the 4 single-tree replications were evaluated based on a rating scale from 0= no lesions, 1 = 1 lesion per leaf, 2 = 2-3 lesions/leaf, 3 = 25% of leaf area, 4 = 50% of leaf area affected. For evaluation of tree defoliation, trees were rated based on a scale from 0 (= full canopy) to 4 (>90% defoliation).

^ Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ($P > 0.05$) procedures.

number of infected leaves) for some treatments were high; however, disease severity and tree defoliation ratings sometimes still demonstrated good efficacy. At the Kern Co. site, most treatments were more effective on the less susceptible cv. Fritz than on cv. Monterey (**Table 5**). Overall for the trials conducted, among the single fungicides, both formulations of polyoxin-D (Ph-D and CX10440 – an organic material), Quash, Fontelis, and Xemium (the SDHI component of Merivon), showed very good efficacy (**Tables 5, 6, 7**). Among the pre-mixtures, Luna Experience, Luna Sensation, Merivon, Inspire Super, Quadris Top, and the new Q8Y78

all resulted in low levels of disease. In the presence of QoI and boscalid resistance in the pathogen populations, the FRAC 7+11 pre-mixtures Merivon, Luna Sensation, and Q8Y78 generally were more effective than Pristine (**Tables 5, 7A**), indicating that the new SDHI sub-groups are more effective than boscalid. Pristine, however, still reduced the amount of disease and was an effective treatment. Resistance to both components of Pristine in *Alternaria* populations is not widespread but limited to selected orchards or areas within the state.

Several rotation programs were also evaluated. Rotations of Quadris Top, Ph-D, and Quash (**Table 6**), or of Ph-D, Inspire Super, and Xemium (**Table 5**) were highly effective. These latter rotations use three to four fungicide classes, and therefore are excellent examples for resistance management programs using fungicide classes currently available.

Interestingly, a single application of selected treatments at the Colusa Co. trial site that was done in late June was similarly effective to the three-spray program that started in mid-May (**Table 7A, B**). Environmental data need to be evaluated to possible identify infection periods. The major infection periods may have occurred late because temperatures in this part of the state are generally lower in the spring than in the southern growing areas. Thus, favorable environments for infection occur later, and under lower disease pressure, a single application may be sufficient for adequate disease control in northern parts of the state. This needs to be further evaluated.

The following are guidelines for management of scab and Alternaria leaf spot with currently registered fungicides:

Guidelines for Scab

- Dormant and delayed dormant treatments with copper-oil or chlorothalonil-oil are highly effective in reducing sporulation of the pathogen on overwintering twig lesions and delays sporulation (e.g., chlorothalonil-oil delays sporulation until May or June. This aligns timing of spring treatments for scab with those for Alternaria leaf spot management.
- Two late-spring/early-summer applications are done with QoI (at locations where the pathogen population has not developed resistance), DMI, SDHI, or chitinase inhibitor (Polyoxin-D) fungicides to prevent new fruit, leaf, and twig infections.
- Effective registered fungicides include Chlorothalonil (M5)– several registrants, Quash (3) - Valent USA, Inspire Super (3/9), Quadris Top (3/11), Quilt Xcel (3/11) - Syngenta Crop Protection, Luna Sensation (7/11), Luna Experience (3/7) - Bayer Crop Science, Syllit - Agriphar, and Ph-D (19) – Arysta LifeSciences. Fungicides pending registration include the guanidine (i.e. Syllit) (U12), Fontelis (7), and Merivon (7/11).
- Rotation and mixture programs need to be done to reduce the development or spread of resistance.

Guidelines of Alternaria leaf spot

- Programs should start with 5-week after petal fall applications that include Rovral and Bravo (performance is variable and depends on the occurrence of favorable conditions).
- Two to three late-spring/early-summer applications (based on the DSV model) are done with QoI, DMI, SDHI, or chitinase inhibitor (Polyoxin-D) fungicides.
- New fungicides (Ph-D – Arysta LifeSciences, Quash - Valent USA, Inspire Super, Quadris Top, Quilt Xcel - Syngenta Crop Protection, Luna Sensation, Luna Experience - Bayer Crop

Science) will have to be strictly used in rotations or mixtures to reduce the development or spread of resistance.

- New highly effective products pending registration include Merivon (BASF) and Q8Y78 (Du Pont).

Common Guidelines for managing both diseases

- An integrated approach in disease management includes cultural practices from planting design to allow air-flow and decreased humidity in the orchard to irrigation systems that provide water in short intervals (e.g., 24-48 hrs). Planting rows in N-S directions or with prevailing winds, adequate planting distances based on varietal architecture, and hedging can dramatic improve air-flow. Pre-plant soil preparation (e.g., ripping) and post-plant practices (e.g. addition of gypsum) for improvement of water penetration, and designing irrigation systems to less frequent and shorter irrigation intervals) are highly critical for management of these diseases.