Epidemiology and Management of Almond Brown Rot, Scab, and Other Foliar Diseases

Project No.: **09-PATH4-Adaskaveg**

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Objectives:

I. Disease management strategies

A. Evaluate new fungicides and develop efficacy data based on spectrum of activity, systemic action, and persistence.
   a. Continue evaluations on brown rot, jacket rot, shot hole, and scab.
   b. Evaluate selected fungicides (e.g., Pristine) and fungicide additives such as BioForge for their effectiveness against diseases, as well as plant growth regulation effects as compared to the use of fungicides alone.
   c. Evaluate persistence and post-infection activity of selected fungicides in field/laboratory studies for management of foliar diseases.
   d. For scab management, evaluate the effect of dormant applications (liquid lime sulfur, copper-oil) on sporulation of infected twig lesions, as well as the fungicides dodine and difenoconazole for in-season use.
   e. Use information on the characteristics of fungicides to develop effective rotation programs for disease management of almond.

B. Develop baseline sensitivities of fungal pathogen populations against new fungicides and determine shifts in fungicide sensitivity.
   a. Characterize baseline sensitivities of *Monilinia, Cladosporium,* and other fungal species against Sterol Biosynthesis Inhibitors (SBI) and other fungicides
   b. Determine extent of strobilurin resistance in populations of *C. carpophilum* and anilinopyrimidine (AP) (e.g., cyprodinil – Vangard) resistance in

Monilinia spp. in CA.

C. Evaluate almond genotype susceptibility to foliar diseases including brown rot and other diseases that develop naturally in the almond variety orchard at UC Davis under simulated rainfall (ongoing collaboration with T. Gradziel).

II. Epidemiology and management of hull rot

A. Cultural practices and fungicide treatments for reducing hull rot.
   a. Evaluate end dates for weed and dust control prior to hull split to prevent hull contamination.
   b. Evaluate the toxicity of fungicides against *Rhizopus stolonifer* and *Monilinia fructicola*.
   c. Evaluate hull split fungicide treatments with different spray volumes.

Interpretive Summary:

In 2009 we conducted field and laboratory studies on the evaluation of new treatments against major foliar and fruit diseases of almond in California. Highly effective single-fungicides and pre-mixtures were identified for the management of brown rot blossom blight, gray mold, shot hole, scab, rust, and hull rot. We also evaluated several natural products and a biocontrol as alternatives to synthetic fungicides. This arsenal of treatments will help to prevent the selection and build-up of resistant pathogen populations when applied in rotation or mixture programs. Resistance to date has not been found in almond populations of *Monilinia laxa* (brown rot), *Botrytis cinerea* (gray mold), *Wilsonomyces carpophilus* (shot hole), or *Rhizopus stolonifer* (hull rot), but is common in *Cladosporium carpophilum* (scab) and in *Alternaria* spp. against the strobilurin QoI class fungicides and in *Alternaria* spp. against carboxamide fungicides. In addition, we initiated studies on the management of hull rot, a disease with an increased occurrence in recent years. An update on our research on Alternaria leaf spot is presented in a separate report (Project 09-PATH3-Adaskaveg).

A. Brown rot blossom blight management. In a Solano Co. trial on cv. Drake, we evaluated of single treatments, new pre-mixtures, and several rotation programs. All registered and experimental pre-mixtures were similarly highly effective against brown rot (**Table 1**).

Table 1: Efficacy of fungicide programs for management of brown rot and shot hole of Drake almonds at the UC Davis experimental orchard 2009**.**

							Brown rot**		Shot hole on fruit***			
			Product	Applications			Strikes		Incidence		Severity	
No.	Program	Treatment*	Rate (/A)	2-25	3-4	3-20	per tree	LSD^	(%)	LSD	lesions/fruit	LSD
1	---	Control	---	---	---	---	44.2	a	80.1	a	4.0	a
2	Single treatments	Actinovate + Breakthru	12 oz / 6 fl oz	@	@	@	27.8	b	63.6	ab	2.6	b
3		USF 2015B SC	4 fl oz	@	@	@	4.2	d	24.8	cd	0.7	cde
4		Enable 2F	6 fl oz	@	@	@	10.0	cd	24.0	cde	0.4	cde
5		Syllit 3.4FL	48 fl oz	@	@	@	17.4	c	1.6	g	0.0	e
6	Pre-mixtures	Adament 50WG	3 oz	@	@	@	3.4	d	42.4	bc	1.4	c
7		Adament 50WG	6 oz	@	@	@	5.8	d	32.0	cd	1.0	cd
8		USF 2016A SC	4 fl oz	@	@	@	5.4	d	16.0	def	0.4	cde
9		Inspire Super EW	10 fl oz	@	@	@	4.8	d	12.8	def	0.3	de
10		Inspire Super EW	14 fl oz	@	@	@	4.8	d	24.8	cd	0.5	cde
11		Inspire Super EW	20 fl oz	@	@	@	4.6	d	8.0	fg	0.2	de
12		A15909C	14 fl oz	@	@	@	4.8	d	12.8	defg	0.4	cde
13		A15909C	21 fl oz	@	@	@	5.8	d	8.8	efg	0.2	de
14		Inspire XT (A8122B) EC	7 fl oz	@	@	@	5.2	d	10.4	defg	0.3	de
15	Rotations	Scala 600SC	12.8 fl oz	@			7.6	d	25.7	cd	0.9	cde
		USF 2016A	4 fl oz		@							
		Rovral 4F	16 oz			@						
16		Quash 50WG	2.5 oz	@			30.6	b	10.4	fg	0.3	de
		Abound 2F	12.3. fl oz		@	@						
17		Quash 2DC	5 fl oz	@			17.2	c	7.0	fg	0.3	de
		Abound 2F	12.3 fl oz		@	@						

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. For the third application, Breakthru (6 oz) was added to the Enable treatment.

** - For brown rot evaluation, the number of brown rot strikes per tree was counted on 5-7-09 for each of five single-tree replications.

***- Shot hole was evaluated on 4-23-09. Disease incidence was based on the number of fruit with shot hole lesions of a total of 25 fruit evaluated for each replication. Disease severity is the number of shot hole lesions per fruit.

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

Disease was reduced from 44.4 strikes/tree in the control to 3.4 to 5.8 strikes/tree in the pre-mixture treatments Adament, Luna Sensation (USF2016), Inspire Super, Quilt Xcel (A15909C), and Inspire XT. Both Quash-Abound rotations were not as effective as the Scala-USF2016-Rovral rotation. Luna Privilege (USF2015-fluopyram) was the best single-treatment. The biocontrol/fermentation product Actinovate significantly reduced the disease, but was less effective than most of the fungicide treatments.

In the trial on cv. Butte where disease pressure was lower than on cv. Drake, we confirmed the high efficacy of Luna Privilege (USF2015) against brown rot blossom blight (**Table 2**). Treatments with several different natural products all significantly reduced the incidence of disease. Efficacy of these treatments was sometimes similar to that of some fungicides. Numerically, the registered Regalia was the most effective natural product.

Table 2: Efficacy of treatment programs with fungicides, natural products, and a biocontrol for management of brown rot of cv. Butte almond at the UC Davis experimental orchard 2009.

No.	Program	Treatment*	Product Rate (/A)	Application 2-25 (PB)	Application 3-19 (FB)	Brown rot** Strikes per tree	Brown rot** LSD^
1	---	Control	---	@	@	7.0	a
2	Single treatments	Cerebrocide L***	0.50%	@	@	2.7	bcde
3		Regalia	1%	@	@	1.5	cdef
4		MOI 106B	1%	@	@	3.0	bcd
5		MOI 106C	0.25%	@	@	3.3	bcd
6		Actinovate****	12 oz	@	@	2.3	bcde
7		Indar 2F****	6 fl oz	@	@	0.5	efg
8		USF 2015B SC	4 fl oz	@	@	0.0	g
9		Polyoxin-D 11.2DF***	20 g ai	@	@	2.0	bcde
10		Polyoxin-D 11.2DF***	30 g ai	@	@	0.8	defg
11		Polyoxin-D 11.2DF***	40 g ai	@	@	2.8	abc
12	Mixtures	Polyoxin-D 11.2DF + Cerebrocide L***	20 g a.i. - 0.5%	@	@	4.8	ab
13		Actinovate + Indar 2F****	12 oz - 6 fl oz	@	@	3.8	abc
14	Rotation	Indar 2F****	6 fl oz	@	---	0.2	fg
15		Pristine 38WG	14.5 oz	---	@		

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A.
Trees were inoculated with *Monilinia laxa* on 2-27-09 using a backpack sprayer.

** - For brown rot evaluation, the number of brown rot strikes per tree was counted on 4-15-09 for each of four single-tree replications.

***- Used with Nufilm-17 at 16 fl oz/100 gal.

****- Used with Breakthru at 6 fl oz/100 gal.

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

In laboratory tests on the evaluation of the pre- and post-infection activity of selected treatments, Syllit and Ph-D (Polyoxin-D) were the least effective among the fungicides (data not presented). Luna Privilege (USF2015), Quash, Inspire Super, Luna Sensation (USF2016), and Quilt Xcel (A15909C) effectively protected blossoms from infections with the brown rot pathogen that occurred one day before or after treatment. The natural products were not very effective in these laboratory studies under high disease pressure conditions.

B. Shot hole management. Syllit was highly effective against shot hole and reduced the incidence and severity of the disease to the lowest ratings among all treatments (**Table 1**). Other very efficacious treatments included the high rates of Inspire Super and Quilt Xcel (A15909C), as well as the Quash DC-Abound rotation program.

C. Gray mold management. The efficacy of field fungicide treatments against gray mold was evaluated in a laboratory blossom petal assay. Flowers that were treated with selected materials at full bloom in the field were collected and their petals were evaluated after incubation at 20 C, 100% RH. With the exception of Syllit, all fungicides significantly reduced the incidence and severity of gray mold. Adament, Inspire Super, Inspire XT, Luna Privilege (USF2015), and the experimental pre-mixtures Luna Sensation (USF 2016) and Quilt Xcel (A15909C) reduced the disease to the lowest levels (**Table 3**).

Table 3: Efficacy of fungicide programs for management of gray mold of Drake almonds, UC Davis experimental orchard 2009.

No.	Program	Treatment*	Product Rate (/A)	Applic. 3-4	Gray mold** Incidence (%)	LSD^	Severity % Area	LSD
1	---	Control	---	---	85.4	a	2.4	ab
2	Single treatments	Actinovate + Breakthru	12 oz - 6 fl oz	@	86.1	a	2.6	a
3		USF 2015B SC	4 fl oz	@	29.1	e	0.3	f
4		Enable 2F	6 fl oz	@	56.1	c	1.2	de
5		Syllit 3.4FL	48 fl oz	@	76.9	ab	1.9	bc
6		Abound 2F	12.3 fl oz	@	70.8	b	1.8	cd
7	Pre-mixtures	Adament 50WG	3 oz	@	42.7	cde	0.8	ef
8		Adament 50WG	6 oz	@	42.9	cde	0.7	ef
9		USF 2016A SC	4 fl oz	@	34.8	de	0.7	ef
10		Inspire Super SC	10 fl oz	@	37.9	de	0.7	ef
11		Inspire Super SC	14 fl oz	@	44.1	cd	0.9	ef
12		Inspire Super SC	20 fl oz	@	31.9	de	0.5	f
13		A15909C	14 fl oz	@	36.1	de	0.6	f
14		A15909C	21 fl oz	@	28.7	e	0.4	f
15		Inspire XT (A8122B) EC	7 fl oz	@	40.7	de	0.6	f

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

**- Gray mold was evaluated on flower petals that were collected on 3-5-09 and incubated on moist vermiculite in the laboratory. Incidence of gray mold was based on ca. 50 petals for each treatment replication. Severity was evaluated using a rating scale: 0=0, 1=<25%, 2=26-50%, 3= 51-75%, 4=76-100% petal area diseased.

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

D. Yield effects of bloom and petal fall fungicide treatments. An additional field trial was done in a commercial orchard in Kern County on cv. Carmel almond trees (16 yrs old) to evaluate the effect of bloom fungicide applications on yield. An orchard was chosen that did not produce maximum yields in previous years so that potential increases in yield could be more clearly observed. There was no significant difference in yield between single full bloom Pristine or Vangard treatments followed by petal fall treatments of ziram (kernel weights/A 12.2 and 12.4 kg/tree, respectively). A full bloom application of Vangard that was followed by a 20-day after petal fall application with Pristine resulted in a kernel weight of 11.6 kg/tree. Although the full bloom application of Vangard followed by a 20-day after petal fall application of Gem had a lower average yield (9.7 kg kernel weight/tree), no significant difference was observed between treatments. Field trials conducted in the 2008 and 2009 seasons indicate that almond trees treated at full bloom with Pristine or Vangard or at petal fall with Pristine had similar yields. Thus, these large-scale replicated trials cannot support general statements that yields are improved with the use of Pristine over other fungicides.

E. Scab management. Two trials were conducted on the management of scab. A study in Butte County also included the evaluation of dormant treatments to reduce the production of primary inoculum in the springtime from overwintering twig lesions on previous year's growth. Sporulation was first observed on lesions occurring on shoots from previous year's late summer/fall growth, as opposed to lesions on spring/summer growth, indicating that vigorous tree growth in late summer/fall before dormancy can lead to the production of highly susceptible host tissue and thus, should be avoided. Delayed-dormant (Jan 19, 2009) applications with copper or copper-oil were most effective in delaying twig lesion sporulation. In an evaluation in late April, 54% a, 54.1%

a, 7.8% b, and 15.9% b of lesions on trees of the untreated control, oil, copper, and copper-oil treatments, respectively, were sporulating. In a late-May evaluation 73.5% a, 79.7% a, 45.7% b, and 46.8% b of the lesions in the same treatments, respectively, were sporulating. Thus, dormant applications can be highly effective inoculum reduction treatments. They should be included into any scab management program, also because a reduced amount of inoculum will reduce the risk for selection for fungicide resistance.

Table 4: Efficacy of fungicide treatments for management of scab on almond cv. Carmel - Butte Co. 2009

A. Evaluation of dormant treatments

			Applic.	No. of	Dis. Incid. on fruit**		Dis. Sev. on fruit**	
No.	Treatments*	Rate (/A)	Jan.	trees	(%)	LSD***	rating	LSD
1	Control	---	---	50	45.1	a	0.59	a
2	Oil	4 gal	@	50	40.5	a	0.52	ab
3	Kocide 2000	6 lb	@	50	40.2	a	0.51	ab
4	Kocide 2000 + Oil	6 lb - 4 gal	@	50	32.6	b	0.40	b

B. Evaluation of petal fall treatments

			Applications		No. of	Dis. Incid. on fruit**		Dis. Sev. on fruit**	
No.	Treatments*	Rate (/A)	4-2	4-22	trees	(%)	LSD***	rating	LSD
1	Control	---	---	---	32	81.2	a	1.24	a
2	Ziram 76WDG	8 lb - 7 lb	@	@	32	41.0	b	0.46	b
3	Syllit 3.4FL	3 pts	@	@	32	32.5	c	0.35	c
4	Maneb 75WDG	8 lb	@	@	32	31.3	c	0.36	c
5	Captan 80WP	8 lb	@	@	32	28.4	c	0.31	c
6	Echo 720	6 pts	@	@	32	12.7	d	0.13	d

* Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. Ziram was used at 7 lb on 4-22-09.

** Evaluations were done on 6-19-09. 25 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=11-25%, 3=26-50% of fruit surface diseased.

*** Petal fall treatments did not significantly affect the efficacy of the dormant treatments, and thus, all petal fall treatments were combined for each dormant treatment. Similarly, 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.

These dormant treatments were also evaluated as part of fungicide management programs for scab that included treatments after petal fall. In this trial, petal fall treatments did not interact with the efficacy of the dormant treatments. Thus, in **Table 4A** the incidence and severity of scab were calculated based on all after-petal-fall treatments for each of the dormant treatments. The data presented indicate that copper-oil treatments performed better than the other dormant treatments evaluated.

After-petal-fall treatments were timed after twig infections started to sporulate. Because dormant treatments did not interact with the efficacy of the after-petal-fall treatments, the efficacy of these latter treatments was based on the combined dormant treatments. As shown in **Table 4B**, all treatments significantly reduced scab. Chlorothalonil (Echo 720) was most effective in reducing the incidence and severity of scab. Syllit, Maneb, and Captan also performed very well, whereas Ziram had an intermediate efficacy.

In another field trial in Butte County with a much lower disease pressure all single-fungicide, mixture and pre-mixture, as well as rotation programs reduced disease incidence to very low levels and no differences among treatments were observed (**Table 5**).

Table 5. Efficacy of fungicide programs for management of scab of cv. Peerless almonds Butte Co. 2009.

No.	Program	Treatments*	Product Rate (/A)	Application dates 4-19 (1 wk APF)	Application dates 5-5 (5 wk APF)	Incidence of scab** (%)	LSD***
1	---	Control	---	---	---	12	a
2	Single	Syllit 3.4FL	48 fl oz	@	@	1	b
3	fungicides	Polyoxin-D 11.3WDG	6.2 oz	@	@	0	b
4		Orbit 3.6EC	6 fl oz	@	@	1	b
5		Enable 2F	6 fl oz	@	@	1	b
6		USF2015 SC	4 fl oz	@	@	0	b
7	Mixtures	Polyoxin-D 11.3WDG + Captan 4F	6.2 oz + 16 fl oz	@	@	0	b
8	and	Adament 50WG	8 oz	@	@	1	b
9	pre-mixtures	Inspire Super SC	20 fl oz	@	@	0	b
10		USF2016 43F	4 fl oz	@	@	0	b
11	Rotations	Inspire Super SC	20 fl oz	@		1	b
		A15909	25 fl oz		@		
12		USF2017 SC	5 fl oz	@		1	b
		Adament 50WG	8 oz		@		
13		Pristine 38WG	14.5 oz	@		0	b
		Indar 2F/Dithane F45	6 fl oz/192 fl oz		@		

* - 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 of four single-tree replications from each treatment.
*** - Values followed by the same letter are not significantly different based on an analysis of variance and least significant difference (LSD) mean separation ($P > 0.05$).

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 copper-oil and two after-petal-fall applications with chlorothalonil (e.g., Echo, Bravo, Equus), Maneb (or in the future mancozeb), or Captan. All these active ingredients are multi-site mode of action fungicides that have a low potential of resistance development. Because maneb fungicides have been voluntarily canceled (2008/2009), mancozeb (e.g., Dithane) fungicides are being tested and are planned for future registrations. The single-site mode of action fungicides Indar, Ph-D (polyoxin-D), and Syllit (dodine), as well as the pre-mixtures Inspire Super, Quilt Xcel, and Luna Sensation, all represent new almond scab fungicides.

F. Rust management. Almond rust can have a serious impact on crop production but due to its sporadic occurrence and unpredictability, it is difficult to manage with high efficacy. The first application with a fungicide should be done at the very first occurrence of disease symptoms in the spring and early summer to prevent additional infections. In a field trial in Colusa County on the management of rust, treatments were applied after the occurrence of disease symptoms in early June. All treatments were effective except Luna Privilege (USF2015). New shoot growth was most effectively protected from infections by the SBI Quash and the QoI Abound, whereas Ph-D (polyoxin-D) and Inspire were less effective (**Table 6**). Because Quash, Inspire, Ph-D, and Abound are also very effective against Alternaria leaf spot, and timings of some applications for these two diseases usually overlap, these fungicides could be integrated into an Alternaria-rust management program (provided that no resistance against QoI fungicides is present in the *Alternaria* spp. populations at the specific location).

Table 6: Efficacy of fungicide treatments for management of almond rust on cv. Carmel - Colusa Co. 2009

			Applications		Dis. Incid. on leaves**		Dis. Severity. on leaves**	
No.	Treatments	Rates (/A)	6-9-09	6-30-09	(%)	LSD***	lesions/leaf	LSD
1	Control	---	---	---	100.0	a	3.39	a
2	USF2015 SC	4 fl oz	@	@	100.0	a	3.36	a
3	Inspire EC	7 fl oz	@	@	73.5	b	1.16	b
4	Polyoxin-D 11.2DF	6.2 oz	@	@	59.6	b	0.71	bc
5	Abound 2F	12.5 fl oz	@	@	39.9	c	0.43	c
6	Quash 50WG	3.5 oz	@	@	26.5	c	0.27	c

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

** - Evaluations for disease were done on 7-28-09. For disease incidence on leaves, 25 leaves from each of the 4 single-tree replications were evaluated for the presence of disease.

***- 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.

***G. Hull rot management with fungicides*.** Results obtained from laboratory and field experiments provided new insights for the management of hull rot caused by *Rhizopus stolonifer*, the main cause of hull rot. In three field studies, the efficacy of six fungicides was evaluated. In all three trials, there was no significant difference in efficacy among timings, number of applications, and application volumes used (see footnote of **Table 7**). Thus, for each trial, data were combined for these parameters. All compounds, including Abound, Gem, Quash, Scholar, Quadris Top, and Luna Privilege (USF2015), significantly reduced the incidence of hull rot and there was no consistent ranking in efficacy among the fungicides tested (**Table 7**). Grower trials where applications of Gem and wettable sulfur were evaluated demonstrated a similar level of efficacy for Gem but not wettable sulfur.

Laboratory studies indicated that almond hulls are susceptible to infection by *R. stolonifer* only during a brief period of nut development. As a wound pathogen the pathogen requires injuries (i.e., splitting of the hull) but additionally, we found that the physiological state of the tissue is critical. The highest incidence of infection of detached almond fruit was observed at hull split stage b2 (*see* UCIPM for Almonds, second edition, Page 7 [ANR Publication 3308]) when only a very small crack of the hull is present. Later stages resulted in significantly fewer infected fruit, no infections occurred at stage f, when the hull is completely split and partially rolled up. These differences in susceptibility of the hull to infection by *R. stolonifer* are likely due to differences in the moisture content of the hull.

Table 7: Efficacy of fungicide treatments for management of hull rot on cv. Winters - Colusa Co. 2009
Applications done at different timings and application volumes

				Orchard 1		Orchard 2		Orchard 3	
				Total disease**					
No.	Program	Treatments*	Rates (/A)	Strikes/tree	LSD***	Strikes/tree	LSD	Strikes/tree	LSD
1	---	Control	---	60.9	a	75.9	a	15.0	a
2	Single	Abound 2F	12.5 fl oz	38.3	b	44.2	b	5.1	c
3	fungicides	Gem 500SC	3 fl oz	30.2	bcd	32.7	c	5.2	c
4		Quash 50WG	3.5 oz	29.9	bcd	26.4	bc	4.3	c
7		Scholar 50WP	6 oz	26.8	cd	36.8	bc	4.5	c
5	Pre-mixtures	Quadris Top SC	14 fl oz	37.1	bc	33.5	bc	6.0	bc
6		USF2016 SC	4 fl oz	24.8	d	34.4	bc	8.2	b

* - In orchard 1, single treatments were applied using an air-blast sprayer on 7-20-09 at 100 or 200 gal/A, or 2 applications were done on 7-20 and 8-11 at 100 gal/A. In orchard 2 single treatments were done on 7-20, 8-11, or 8-28-09 at 100 gal/A. In orchard 3, treatments were done on 7-20 or 8-13-09 at 150 gal/A. Hull split stages were b1 on 7-20, b3 on 8-11, and c on 8-28-09.

** - Evaluations for disease were done on 9-11-09 and the number of hull rot twig strikes was counted on each of the 4 single-tree replications.

***- There were no significant differences in treatment efficacies among timings, number of applications, and application volumes for each orchard. Thus, data for each fungicide treatment were combined for these parameters. 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.

Based on these laboratory studies, the most important timing of a hull rot fungicide application would be during the very early hull split stage. Possibly, we did not see differences in application timings in our field trials because of the long hull split duration within an orchard where a similar number of nuts was in the susceptible stage at each fungicide timing. Consequently, for the most effective integrated management of hull rot, hull split should be induced simultaneously with proper water management (i.e., deficit irrigation) and should proceed as quickly as possible to shorten the highly susceptible period. A fungicide could then be applied most effectively during the stages when susceptibility is high.

Interestingly, in our field trials there was no significant difference in hull rot between orchard rows that were either herbicide treated before hull split or that were mowed. Hull rot management guidelines suggest that orchard activities that create excess dust be avoided during hull split because dust-borne pathogen inoculum from the orchard is spread into the tree canopy. Despite our data that do not support this mechanism of infections, these guidelines should still be followed. Possibly, the mowing practices in our trial sites did not create a high level of dust or were done before the highly susceptible early stages of hull split for hull rot infection occurred.

H. Susceptibility of almond varieties against brown rot blossom blight. The natural host resistance was again evaluated in the UC Davis variety plot. There was a wide range of susceptibilities among early-, mid-, and late-blooming accessions. Whereas observations for some varieties were consistent with previous data, others performed differently from previous evaluations (**Table 8**). In 2009, less rainfall occurred during bloom than in 2008. This emphasizes the importance of varying environmental conditions over the years on the host-pathogen interaction and disease development. These ongoing studies on natural host resistance will help growers to select cultivars and breeders to design new selections for different growing areas with different micro- or regional climates.

Table 8: Susceptibility of almond varieties against brown rot blossom blight - UCD 2009

A. Early-blooming varieties

No.	Variety	No. strikes*	LSD**
1	Aldrich	5.0	b
2	Peerless	6.8	b
3	Winters	7.0	b
4	NePlus Ultra	8.5	b
5	Rosetta	9.8	b
6	Sonora	27.8	ab
7	1-87	36.4	a

B. Mid-blooming varieties

No.	Variety	No. strikes	LSD
1	F7, 1-1	3.4	d
2	Price	4.5	cd
3	Chips	8.5	cd
4	Nonpareil	9.5	cd
5	Jenette	11.8	cd
6	F10D, 3+4-25	18.0	bcd
7	Sauret No. 1	18.4	bcd
8	Johlyn	20.5	bc
9	Alamo	33.1	b
10	Wood Colony	110.0	a

C. Late-blooming varieties

No.	Variety	No. strikes	LSD
1	Carmel	5.0	d
2	Ruby	11.0	cd
3	Plateau	17.0	bcd
4	LeGrand	17.0	bcd
5	Monterey	17.3	bcd
6	2-19E	19.0	bcd
7	Ferragnes F7,4-7	20.0	bcd
8	Fritz	22.0	bcd
9	Merced	24.0	bcd
10	Butte	32.0	bc
11	Livingston	37.0	bc
12	Mission	43.0	b
13	25-75	98.0	a
14	Padre	112.0	a

* - For evaluation, the number of brown rot strikes per tree was counted in April 2009.

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