Epidemiology & Management of Almond Brown Rot, Jacket Rot, Shot Hole, Rust, and Hull Rot in California

Project No.: **13-PATH4-Adaskaveg**

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Objectives:

I. **Disease management strategies: Evaluate new fungicides and develop efficacy data based on spectrum of activity, systemic action, and persistence.**
   a. Continue evaluations of new products against brown rot, jacket rot, and shot hole, in experimental orchards at UC Davis and KARE (as well as rust if the disease occurs during the season).
      - Evaluate new fungicides, fungicide pre-mixtures, and adjuvants: fluxapyroxad – Xemium (Sercadis), penthiopyrad - Fontelis, metconazole - Quash, polyoxin-D - Ph-D or Oso, dodine - Syllit, Luna Experience, Luna Sensation, Quadris Top, Quilt Xcel, Inspire Super, Merivon, as well as biologicals (Fracture, Serenade Optimum, Botector).
      - Evaluate persistence and post-infection activity of selected fungicides in laboratory studies for management of brown rot.
   b. For hull rot management, evaluate timing and new fungicides.
      - Susceptibility of almond fruit to *M. fructicola* at different stages of development.
      - QoIs, DMIs, SDHIs, polyoxin-D, and experimental fungicides, as well as selected pre-mixtures as above.

II. **Develop baseline sensitivities of fungal pathogen populations against new fungicides and determine potential shifts in fungicide sensitivity.**
   a. Characterize baseline sensitivities of *Monilinia* species against SDHIs (boscalid, penthiopyrad, fluxapyroxad, fluopyram, isofetamid) and Fracture.
   b. Determine fungicide sensitivities in locations where disease was not satisfactorily managed after fungicide treatments

III. **Establish a new almond variety orchard at UC Davis under simulated rainfall in collaboration with T. Gradziel and farm advisors and evaluate an existing orchard with a limited number of genotypes for susceptibility to foliar diseases including brown rot and other diseases that develop naturally in the springtime.**

IV. **Studies on the etiology of a powdery mildew-like disease of almond fruit**

a. Inoculate almond fruit with *Acremonium* sp. and observe symptoms (Koch's postulates).

At the time of preparing this annual report, we can only include 2014 data for the springtime diseases brown rot, shot hole, and gray mold. Trials on summer diseases including hull rot are ongoing, and thus, 2013 data are presented for these objectives.

Interpretive Summary:

In 2013-14, we conducted field and laboratory studies on the evaluation of new treatments against major foliar and fruit diseases of almond in California. New fungicides evaluated belong to new (BAS750) and existing classes (e.g., DMIs – FRAC 3, SDHIs – FRAC 7, anilinopyrimidines – FRAC 9, QoIs – FRAC 11, polyoxins – FRAC 19, phosphonates – FRAC 33, isophthalonitriles – FRAC M5, and guanidines – U12). Additionally, several pre-mixtures and rotation programs as well as a natural product were evaluated. FRAC 7 fungicides (boscalid, isofetamid, fluopyram, fluxapyroxad, penthiopyrad) are assigned to three sub-groups that differ in their anti-fungal activity due to differences in the target binding site. This reduces cross-resistance among some of the sub-groups; however, cross resistance is still possible because the target site (i.e., succinate dehydrogenase) is the same. In vitro studies were conducted to characterize this cross-resistance in some of the main almond pathogens. With awareness and fungicide stewardship, the arsenal of available fungicide treatments will help prevent the selection and build-up of resistant pathogen populations when applied in rotation or mixture programs. The use of pre-mixtures is a resistance management strategy, and additionally, the spectrum of activity is generally expanded so that several diseases can be targeted by a single treatment. In our research, highly effective single-fungicides and pre-mixtures were identified for the management of brown rot blossom blight, gray mold, and shot hole.

Brown rot, shot hole, and gray mold incidence was generally very low in the spring of 2014. For management, single-fungicides of several classes, and especially several pre-mixtures and rotation programs provided excellent disease control. A new variety block was established at UC Davis for evaluation of disease susceptibility of new varieties of almond in the coming years. Studies on the management of hull rot were conducted in orchards with *Rhizopus stolonifer, Monilinia fructicola,* or both pathogens as the causal agents. We confirmed previous studies, that hull rot caused by *R. stolonifer* can be managed with a single application during early hull split. For hull rot caused by *Monilinia* species, applications should be done earlier (e.g., early to mid-June). Because the pathogen population causing hull rot is generally not known for a particular orchard site and because both pathogens are usually present at varying frequencies among locations and years, a 2-spray program with one treatment in early/mid-June and another one at early hull split is recommended. The most effective treatments include fungicides in FG 3+7, 3+9, 7+11, 3+11, and 3+19. For the most effective integrated management of hull rot, fungicides should be used together with proper water management (i.e., deficit irrigation) and nitrogen fertilization.

Materials and Methods:

***Fungicide evaluations for management of brown rot, gray mold, and shot hole in experimental orchards – 2014 Research*.** Field trials were conducted at UC Davis on cvs. Drake, Butte, and Sonora, and at the Kearney Agricultural Research and Extension (KARE) Center on cvs. Wood Colony and Sonora. Treatments were done as single-fungicide, pre-mixture, or rotation programs with applications at UC Davis at pink bud, full bloom, and petal fall. Only a single application was done at

KARE using an air-blast sprayer at a rate of 100 gal/A and was followed by two 8-h simulated rain applications. For brown rot evaluation, the number of strikes per tree was counted for each of four or six single-tree replications. All fungicides were also evaluated in laboratory studies on detached blossoms that were inoculated with conidia of *M. laxa* (20,000 conidia/ml) either 20 h before or after treatment. The incidence of stamen infections was then determined after 5 days of incubation at 20^{o}C. For efficacy against gray mold, field-treated flower petals were collected after the full bloom spray and incubated on moist vermiculite for 5-6 days at 20^{o}C for the development of natural incidence of the disease. For shot evaluation, a random sample of 15-25 fruit was collected on May 1 and examined for shot hole lesions. Disease incidence was based on the number of fruit infected of the total number collected and disease severity was based on the number of lesions and using a rating scale.

***Fungicide evaluations for management of hull rot - 2013 Research*.** Field trials were conducted in cv. Nonpareil orchards in Butte, San Joaquin, and Fresno Co. where hull rot was mostly caused by *R. stolonifer* and in Colusa, San Joaquin, and Stanislaus Co. where *R. stolonifer* and *M. fructicola* were involved as pathogens. Treatments to evaluate fungicide efficacy were done as single treatments between early suture split and 10-20% hull split or immediately after a rain event in late June and at early hull split. In timing studies in Stanislaus and San Joaquin Co. where both pathogens were present, two or three treatments were applied between May 9 and July 17. Hull rot was evaluated by counting the number of shoot infections per tree.

Develop baseline sensitivities of fungal pathogens from hull rot-infected fruit against different fungicide classes – 2013-14 Research. Isolates of *M. fructicola, R. stolonifer,* and *B. cinerea* were obtained from almond fruit with hull rot in the summer of 2013. In vitro fungicide sensitivities were determined for four isolates each for difenoconazole, metconazole, fluopyram, fluxapyroxad, trifloxystrobin, and pyraclostrobin using the spiral gradient dilution method as described previously (Forster et al., Phytopathology 94:163-170).

Planting of a new variety orchard in spring 2014. A new variety block was established at UC Davis for evaluation of disease susceptibility of new varieties of almond in the coming years. Twenty-eight varieties on two rootstocks were planted in a randomized block design.
***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 version 9.2.

Results and Discussion:

***Brown rot blossom blight and gray mold management – 2014 Research*.** With low rainfall in the spring of 2014, brown rot incidence in the UC Davis field trials on Butte, Drake, and Sonora was very low. In the untreated control, the incidence was approximately 2%, and no disease was found in all treatments. No supplemental irrigation (simulated rain) was applied in this plot due to the high levels of disease in previous years.

Most of the field treatments were also evaluated in laboratory studies on detached blossoms. Most treatments, especially the mixtures and premixtures (Luna products, Merivon, Inspire Super, Quadris Top), showed high pre- and post-infection activity (treatments done 20 h before or after inoculation). The new DMI Rhyme and the DMI-phosphite fungicide Viathon performed similarly to registered DMI fungicides (e.g., Indar, Quash); whereas Fontelis was similar to other SDHI fungicides. Catamaran (pre-mixture of chlorothalonil and potassium phosphite) was the only one without post-infection activity (treatments applied 20 h after inoculation) (**Table 1A**). Overall, Syllit (dodine) and isofetamid were also less effective treatments. The biological (e.g., biocontrols and natural products) and exempt from tolerance (K-phite - potassium phosphite) treatments mostly also reduced the incidence of stamen infections, but they were generally less effective than the synthetic fungicides (**Table 1B**). Serenade Optimum and Botector resulted in numerically the lowest disease values for the post- infection activity, and Serenade Optimum and K-phite had the lowest values for the pre-infection activity.

Table 1. Evaluation of the pre- and post-infection activity of treatments for control of brown rot blossom blight of cvs. Drake and Wood Colony in laboratory studies 2014.

A. Synthetic fungicides

				cv. Drake				cv. Wood Colony			
				Post-inf. activity*		Pre-inf. activity**		Post-inf. activity		Pre-inf. activity	
			Product Rate	Incid. stamen inf.		Incid. stamen inf.		Incid. stamen inf.		Incid. stamen inf.	
No.		Fungicide	(100 gal/A)	%	LSD^	(%)	LSD	%	LSD	(%)	LSD
1	---	Control	---	81.8	a	65.9	a	75.4	a	45.0	a
2	Single	Syllit	1.5 lb	28.2	b	7.6	c	6.4	b	14.2	b
3	fungicides	Indar 2F + surf.	4 + 8 fl oz	3.1	cde	8.2	c	1.5	bc	4.3	bcde
4		Rhyme	5 fl oz	1.3	cde	0.9	e	4.8	bc	0.0	e
5		Quash	3 oz	1.6	cde	0.9	de	2.4	bc	4.9	bcd
6		Isofetamid	17 fl oz	8.8	c	21.4	b	2.7	bc	8.1	bc
7		Fontelis	20 fl oz	3.7	cde	9.8	c	0.0	c	0.6	de
8		BAS750	5.14 fl oz	3.3	cde	6.6	cd	1.6	bc	7.0	bcd
9	Mixtures	BAS750 + Headline	3.43 + 5.48 fl oz	1.9	cde	2.7	cde	2.7	bc	9.9	bcd
10		BAS750 + Sercadis	3.43 + 4.57 fl oz	0.0	e	3.8	cde	0.0	c	2.4	cde
11	Pre-	Luna Experience + surf.	6 + 8 fl oz	0.9	cde	2.4	cde	0.9	c	0.0	e
12	mixtures	Luna Sensation + surf.	5 + 8 fl oz	2.1	cde	3.4	cde	1.2	bc	1.9	cde
13		Inspire Super + surf.	20 + 16 fl oz	2.8	cde	2.5	cde	0.0	c	3.4	bcde
14		Quadris Top + surf.	14 + 16 fl oz	1.2	cde	4.9	cde	0.1	c	1.3	cde
15		Merivon	5.5 fl oz	1.6	de	7.0	c	2.1	bc	0.0	e
16		Viathon	32 fl oz	6.2	cd	4.0	cde	0.0	c	3.7	cde
17		Catamaran	64 fl oz	73.1	a	7.6	cd	not done			

B. Biological treatments - cv. Drake

			Post-inf. activity*		Pre-inf. activity**	
		Product Rate	Incid. stamen inf.		Incid. stamen inf.	
No.	Fungicide	(100 gal/A)	%	LSD^	(%)	LSD
1	Control	---	81.8	a	65.9	a
2	Fracture + surf.	30 + 16 fl oz	53.3	ab	30.3	bc
3	K-Phite + surf.	96 + 4 fl oz	40.3	b	13.8	cd
4	Taegro	5 oz	39.4	b	23.3	bcd
5	Serenade Optimum	16 fl oz	28.2	b	5.2	d
6	Botector + surf.	10 oz + 16 fl oz	23.6	b	43.1	ab

* For evaluation of the post-infection activity, blossoms were inoculated with conidia of *M. laxa* (20,000 conidia/ml) and treated after 20 h using a hand sprayer. There were 8 blossoms in each of 3 replications

** For evaluation of the pre-infection activity, blossoms were first treated, air-dried and then inoculated with *M. laxa* after 20 h. The incidence of stamen infections was evaluated after 5 days of incubation at 20^{o}C.

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

In the trial at Kearney Ag Center with a single full bloom application and two overhead irrigations after application, an average of 8.2 strikes was observed on cv. Wood Colony and 3.6 strikes on cv. Sonora control trees. All treatments significantly reduced the amount of disease (**Table 2**). On cv. Sonora the disease incidence was lower and a single treatment was highly effective; whereas on cv. Wood Colony, a cultivar highly susceptible to brown rot, an additional application would be needed to reduce the incidence of disease to commercially acceptable levels.

Table 2. Efficacy of fungicides for management of brown rot of cvs. Sonora and Wood Colony almonds at KAC, Fresno County, 2014.

				Average number of brown rot strikes**			
				Sonora		Wood Colony	
No.	Code	Treatment	Rate/A	No.	LSD^	No.	LSD
1	---	Control	---	3.6	a	8.2	a
2	Single	Ph-D	10 oz	0.8	b	4.4	b
3	treatments	Indar (Enable 2F) + Breakthru	4 + 16 fl oz	0.2	b	4	b
4		Rhyme	7 fl oz	0.2	b	3.2	b
5		Rhyme	5 fl oz	0.8	b	2.4	b
6		Fontelis + Latron B-1956	20 + 7 fl oz	0.4	b	2.2	b
7		BAS750	5.14 fl oz	1.6	b	2.2	b
8	Mixtures	Syllit + Tilt	1.5 lb + 4 fl oz	0.8	b	2	b
9		BAS750 + Headline	3.43 + 5.48 fl oz	1.2	b	3.6	b
10		BAS750 + Sercadis	3.43 + 4.57 fl oz	1.2	b	2.6	b
11	Pre-mixtures	Quadris Top + Dyne-Amic	14 + 16 fl oz	0.4	b	3.8	b
12		Inspire Super + Dyne-Amic	20 + 16 fl oz	1	b	4.6	b
13		Luna Experience	6 fl oz	1.4	b	3.8	b
14		Luna Sensation	5 fl oz	1	b	3	b
15		Merivon	5.5 fl oz	0.4	b	3	b
16		Viathon	2 pts	0.8	b	2.4	b

* Treatments were applied using an air-blast sprayer at a rate of 100 gal/A at 40% bloom (2-12-14) to cv. Sonora and at 50% bloom (2-19-14) to cv. Wood Colony. 8 h of overhead sprinkler irrigation was applied to the orchard one and two days after application.

** For brown rot evaluation on 4-8-14, the number of brown rot strikes per tree was counted for 1.5 min for each of five single-tree replications.

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

The efficacy of field fungicide treatments against gray mold was evaluated in a blossom petal assay on cv. Drake. The lowest levels of disease occurred using Quash, Luna Experience, the new BAS750, mixtures of BAS750 with Headline or Sercadis, and Viathon (used in rotation with Catamaran during petal fall) (**Table 3**). Luna Sensation, isofetamid, and the mixture of isofetamid and IB18111 (10.3+5.57 rates) had an intermediate performance; whereas, Rhyme, Fontelis, and propiconazole were least effective in this assay.

Shot hole management – 2014 Research. The incidence of shot hole was high in the untreated control in 2014, but disease severity was low with an average of four lesions per fruit. All treatments evaluated were very effective and significantly reduced incidence and severity to similar levels (**Table 3**).

Thus, although disease levels of springtime diseases were very low in 2014 due to very dry weather conditions, some efficacy data could be obtained. Among new compounds, BAS750 (FRAC group not disclosed) is a promising treatment with high efficacy against brown rot, gray mold, and shot hole. For brown rot, Rhyme and Viathon and selected mixtures of isofetamid and IB18111 are also promising new materials. The registered premixtures (FRAC Groups 7/11, 3/11, and 3/7) are all highly effective against the major spring time diseases brown rot, gray mold (jacket rot), and shot hole. Our data also indicate that some biologicals can have a role in the management of springtime diseases.

Table 3. Efficacy of fungicide programs for management of gray mold and shot hole of cv. Drake almonds at UC Davis, 2014.

			Application											
		Product	PB	FB	PF	PF	**Gray mold****				**Shot hole on fruit*****			
Program	Fungicide*	Rate (/A)	2/14	2/20	3/5	3/24	Inc. (%)	LSD^	Severity	LSD	Inc. (%)	LSD	Severity	LSD
---	Control	---	---	---	---	---	87.4	a	2.7	a	69.6	a	4.0	a
Single	Rhyme	7 fl oz	@	@	@	@	19.1	e	0.4	ef	0.0	c	0.0	b
	Quash	3 oz	@	@	@	@	4.3	h	0.1	g	2.0	bc	0.0	b
	Fontelis	20 oz	@	@	@	@	68.1		1.5	b	4.7	bc	0.1	b
	Isofetamid	17 fl oz	@	@	@	@	26.7	de	0.6	de	2.0	bc	0.0	b
	BAS750	5.14 fl oz	@	@	@	@	12.3	f	0.2	fg	3.3	bc	0.1	b
Mixtures	BAS750 + Headline	3.43 + 5.48 fl oz	@	@	@	@	8.2	fgh	0.2	fg	0.0	c	0.0	b
	BAS750 + Sercadis	3.43 + 4.57 fl oz	@	@	@	@	5.9	g	0.1	g	2.0	bc	0.0	b
	Isofetamid + IB18111	8.6 + 4.63 fl oz	@	@	@	@	43.0	c	0.6	d	0.7	c	0.0	b
	Isofetamid + IB18111	10.3 + 5.57 fl oz	@	@	@	@	31.2	d	0.6	d	3.3	bc	0.1	b
	Isofetamid + IB18121	8.6 + 13.7 fl oz	@	@	@	@	68.0	b	1.6	b	6.0	b	0.1	b
	Isofetamid + IB18121	10.3 + 11 fl oz	@	@	@	@	44.5	c	1.0	c	2.7	bc	0.1	b
	Luna Experience + surf	6 + 6 fl oz	@	@	@	@	8.0	fgh	0.1	g	3.4	bc	0.1	b
	Luna Sensation + surf	5 + 6 fl oz	@	@	@	@	32.8	d	0.5	de	2.0	bc	0.0	b
Rotations	Viathon	2 pt	@	@	---	---	10.7	fg	0.2	fg	2.0	bc	0.0	b
	Catamaran	4 pt	---	---	@	@								
	Propiconazole	4 fl oz	@	@	@	@	43.4	c	0.5	de	0.7	c	0.0	b
	Syllit	1.5 lb	---	@	@	@								

* 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 after the full bloom spray (2/21) 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.

*** Shot hole was evaluated on 5-1-14. Incidence was based on the number of fruit with shot hole lesions of a total of 25-30 fruit evaluated for each of four single-tree replications. Severity is the number of shot hole lesions per fruit. The incidence of brown rot in the non-treated control was less than 2% and no disease was found on all treatments.

^ Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean.

Table 4. Efficacy of fungicide treatments for management of hull rots of cv. Nonpareil almond caused mainly by Rhizopus stolonifer - Butte County, 2013.

No.	Treatment*	Rate	Application 7/16/13*	Incidence of hull rot (%)	LSD^
1	Control	-----	-----	28.3	a
2	Ph-D + Quash	6.2 oz + 3 oz	@	12	b
3	Quadris Top + Dyne-Amic	14 fl oz + 16 fl oz	@	14.5	b
4	Merivon	6.5 fl oz	@	8.5	b
5	Luna Experience	10 fl oz	@	10	b

* Treatments were applied on 7/16/13 at early suture opening using an air-blast sprayer at a rate of 100 gal/A.

** Evaluations for disease were done on 8/27/13 and the incidence of hull rot twig strikes was assessed based on the evaluation of 300 spurs for each of the 4 single-tree replications.

^ 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.

Table 5. Efficacy of fungicide treatments for management of hull rots of cv. Nonpareil almond caused mainly by Rhizopus stolonifer - Fresno County, 2013.

No.	Treatment*	Rate	Application 7/19/13*	Incidence of hull rot (%)	LSD^
1	Control	---	---	16.3	a
2	Quash 50WG	2.5 oz	@	9.6	b
3	Inspire Super + DyneAmic	20 fl oz	@	9.0	b
4	Ph-D + Quash 50WG	6.2 oz + 2.5 oz	@	8.8	b
5	Quadris Top	14 fl oz	@	8.8	b
6	Luna Sensation	5 fl oz	@	7.9	b
7	Merivon	6.8 fl oz	@	7.7	b
8	Ph-D 11.3DF	6.2 oz	@	6.7	b

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

** Evaluations for disease were done on 8/23/13 and the incidence of hull rot twig strikes was assessed based on the evaluation of 120 spurs for each of the 4 single-tree replications.

^ 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.

Still, the incidence of disease was not reduced to very low levels, indicating that perhaps *M. fructicola* was present at higher incidence than thought. This was substantiated by timing studies. These latter studies, as in previous years, demonstrated that early applications are beneficial when *M. fructicola* is causing hull rot. In two trials, there was little difference in efficacy between a two-spray program (6/5 and 6/18/14) and a three-spray program (an additional treatment on 7/17/14). In the trial presented in **Table 6**, hull rot was reduced from 15.7 or 17.0% in the control to 2 or 2.8% by the most effective treatment (i.e., a mixture of Ph- D and Quash) in the two timings, respectively.

Table 6. Efficacy of selected timings for management of hull rot of cv. Nonpareil almond in Stanislaus County, 2013 - Hull rot caused by Monilinia fructicola and Rhizopus stolonifer.

			Applic. 6/5, 6/18, 7/17/13		Applic. 6/5, 6/18/13	
No.	Treatment*	Rate/A	Incidence of hull rot (%)**	LSD^	Incidence of hull rot (%)	LSD^
1	Control	-----	15.7	a	17.0	a
3	Custodia	17.25 fl oz	7.7	b	9.3	bc
2	Quadris Top + Dyne-Amic	14 fl oz + 16 fl oz	6.7	bc	9.8	ab
5	Inspire Super + Dyne-Amic	20 fl oz + 16 fl oz	5.3	bcd	6.2	bcd
6	Luna Sensation	5 fl oz	3.5	cde	4.5	bcd
7	Merivon	6 fl oz	2.7	de	4.3	cd
4	Ph-D 11.3DF + Quash 50WG	6.2 oz + 3 oz	2.0	e	2.8	d

* Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. The application on 7/17 was at early suture opening to 1% hull split.

** Evaluations for disease were done on 8/15/13 and the incidence of hull rot twig strikes was assessed based on the evaluation of 150 spurs for each of the 4 single-tree replications.

^ 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.

***Hull rot management – 2013 Research*.** The incidence of hull rot was very high again at some orchard sites. Incubation of diseased fruit indicated that in addition to *Rhizopus stolonifer* and *Monilinia fructicola, Botrytis cinerea* may have a role in this disease complex at some locations. Studies on the management of hull rot were conducted in orchards with *R. stolonifer, M. fructicola,* or both pathogens as the causal agents. In comparisons of different treatments using a single application at early hull split in locations where *R. stolonifer* was considered the main pathogen, all fungicides were statistically similarly effective in reducing hull rot strikes (**Tables 4, 5**).

Table 7. Efficacy of fungicide treatments for management of hull rot of cv. Nonpareil almond caused by Monilinia fructicola and Rhizopus stolonifer - Colusa County, 2013.

			Applications*			
No.	Treatment*	Rate	'6/26/13	7/16/13	Incidence of hull rot (%)	LSD^
1	Control	-----	-----	-----	17.8	a
2	ARY 0951-001	54 fl oz	@	@	11.3	ab
3	Pristine	14.5 oz	@	@	10.7	ab
4	Ph-D + Quash + NuF-P	6.2 oz + 3 oz + 8 fl oz	@	@	10.0	b
5	Luna Experience	10 fl oz	@	@	8.8	b
6	Inspire Super + Dyne-Amic	20 fl oz + 16 fl oz	@	@	8.5	b
7	Quadris Top + Dyne-Amic	14 fl oz + 16 fl oz	@	@	6.8	b
8	Merivon	6.5 fl oz	@	@	5.8	b

* Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. The first application was done immediately after a rain event (0.5 in.) to manage Monilinia hull rot. The second application was at early suture opening for managing Rhizopus hull rot.

** Evaluations for disease were done on 8/16-/13 and the incidence of hull rot twig strikes was assessed based on the evaluation of 150 spurs for each of the 4 single-tree replications.

^ 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.

In the trial presented in **Table 7**, two applications were made, one immediately after a rain on 6/26/13 and the second one at early suture split on 7/16/13. Hull rot was reduced from 17.8% in the control to 5.8% by the most effective treatment (i.e., Merivon).

In summary, for *Rhizopus* hull rot, applications should be done at early hull split when host susceptibility is high (*R. stolonifer* generally infects injured - hull split or senescent tissues). In this case, fungicides are applied most effectively with NOW treatments. For *Monilinia* hull rot**,** applications should be done earlier in late spring (*M. fructicola* infects immature and mature hull tissues). Because the pathogen population causing hull rot is generally not known for a particular orchard site and because both pathogens are usually present at varying frequencies among locations and years, a 2-spray program with one treatment in early/mid-June and another one at early hull split is recommended. The most effective treatments include fungicides in FG 3+7, 3+9, 7+11, 3+11, and 3+19. For the best integrated management of hull rot, fungicides should be used together with proper water management (i.e., deficit irrigation) and nitrogen fertilization.

Table 8. In vitro sensitivities of three hull rot pathogens against fungicides of three FRAC groups.

	EC_{50} values for mycelial growth (mg/L)					
Pathogen	difenoconazole	metconazole	fluopyram	fluxapyroxad	trifloxystrobin	pyraclostrobin
R. stolonifer	0.09-0.30	0.08-0.14	0.30-0.50	0.85-1.50	0.001-0.003	0.001-0.005
M. fructicola	0.002	0.001	0.01-1.04	0.01-0.37	0.11-0.44	0.002-0.037
B. cinerea	0.02- 0.05	0.11-0.19	0.05-0.25	0.10-0.47	0.01->30	0.03->30

Difenoconazole and metconazole belong to FRAC group 3, fluopyram and fluxapyroxad belong to group 7, and trifloxystrobin and pyraclostrobin belong to group 11. EC_{50} values were determined using the spiral gradient dilution method.

Develop baseline sensitivities of fungal pathogen populations against new fungicides and determine potential shifts in fungicide sensitivity - 2013/2014 Research. Baseline sensitivity studies were initiated for the hull rot pathogens for representative fungicides in FRAC groups 3, 7, and 11. *B. cinerea* was isolated consistently from some samples in 2013, and thus, this fungus may be another hull rot pathogen and was included in these tests. Average values for four isolates of each species are shown in **Table 8**. The pathogens varied widely in their sensitivity to the fungicides. Additionally, a wide range of sensitivities was found for some pathogen-fungicide combinations such as for *M. fructicola* and the SDHIs (FRAC 7) and for *B. cinerea* and the QoIs (FRAC 11). Comparisons with additional isolates will determine if high values are part of the baseline or are an indication of resistance.

Planting of a new variety orchard in Spring 2014. A new variety block was established at UC Davis for evaluation of disease susceptibility of new varieties of almond. Twenty-eight varieties (many numbered accessions) on two rootstocks (Krymsk 86 and Nemaguard) were planted in a randomized block design. Standard cultivars such as Nonpareil, Winters, and Wood Colony were included. The orchard will not receive foliar fungicides and will be evaluated for foliar diseases from spring to fall in the each of coming years (e.g., first leaf, second leaf, etc.).