

Determining the Causes, Development and Management of Lower Limb Dieback and Canker Diseases of Almonds

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BACKGROUND:

We continued monitoring canker diseases, including band canker, and lower limb dieback (LLD) throughout almond orchards in California in 2009 & 2010 seasons. For more details, please check the completed report in 2009-10 Annual Report on CD or on the web (after January 2011) at AlmondBoard.com/ResearchReports.

A. Lower Limb Dieback (LLD):

Pathogens and irrigation management may both play a factor in development of lower limb dieback. This project deals with the role of the pathogens while the project 10-PATH6-Lampinen led by Bruce Lampinen is investigating the role of irrigation management.

Table 1. Frequency of isolations of fungi from almond limbs with LLD and without LLD symptoms collected in 2009

Orchard	Cultivar	With LLD		Without LLD	
		Botryosphaeria	Phomopsis	Botryosphaeria	Phomopsis
Butte 1	Nonpareil	0	1	0	0
	Aldrich	0	36	1	0
Butte 2	Nonpareil	0	5	5	1
	Carmel	0	14	0	1
Butte 3	Butte	0	2	0	0
	Aldrich	0	12	1	0
Stanislaus 1	Butte	2	1	0	0
	Padre	1	25	2	1
Stanislaus 2	Butte	0	5	0	1
	Padre	6	1	2	0
Stanislaus 3	Butte	0	18	1	0
	Padre	0	17	0	0

Samples from 10 trees per orchard.

Although *Botryosphaeria* and *Phomopsis* spp. are frequently isolated from limbs with LLD symptoms, these fungi alone did not reproduce the symptoms of LLD when healthy branches of almonds were inoculated with them. Furthermore, in some years, the frequency of isolation of these fungi even from limbs with no LLD symptoms is as high as that from limbs with LLD.

Removal of trees with LLD to examine the roots (Figures 1 & 2):

In early 2010, we removed four blown over trees in 2 orchards in Stanislaus Co. and sectioned their roots. To our surprise, cortical tissues of some of the roots were severely stained (Figure 2) and isolations were made to determine any putative pathogens.



Figure 1. Removal of a tree showing LLD in Stanislaus County to examine sections of roots, trunk, and limbs with symptoms.

Figure 2. After taking the tree down and cutting the trunk a severe staining was found. The staining was also present in some of the roots of these trees, continued into the trunk, and the branches that showed the LLD symptoms and the longitudinal canker (also see Figure 3).

Herbicide drift experiments:

We performed four herbicide experiments to test the hypothesis whether herbicide drift could cause symptoms of LLD.

To date field studies to determine if herbicide drift causes LLD symptoms are inconclusive, but the trees will be followed.



OBJECTIVES:

A. Lower Limb Dieback (LLD):

- Survey orchards for LLD and determine common characteristics
- Conduct experiments to determine if herbicide drift could be a factor

B. Canker Diseases:

- Survey orchards statewide from canker resulting from pruning wounds
- Determine susceptibility of wounds to canker caused by *Botryosphaeria* fungi
- Perform band canker control experiments in the field



Figure 3. Roots of a Padre almond tree with brown stain in the cortex area of the root (upper row and middle left) and dark brown stain in the trunk (middle right), in the limb (bottom left), and in branches leading to LLD cankers (lower right).

Table 2. Isolations from almond trees from Stanislaus County with severe LLD symptoms which were sampled in the spring of 2010 after removal with a backhoe. Interior of lower scaffolds and roots had dark staining (Figure 3).

Location	Tissue	Stain	Incidence (%)		
			Phomopsis	Acremonium ^a	Cylindrocarpum
Orchard 1 Tree 1	Roots	+	0	53	20
	Shoots	-	5	0	0
Orchard 2 Tree 1	Limb	-	100	0	0
	Limb	+	29	44	0
	Roots	+	0	42	0
	Limb	+	0	0	0
Orchard 2 Tree 2	Roots	+	0	47	0
	Limb	+	0	0	0
Orchard 2 Tree 3	Limb	+	0	0	0
	Roots	+	0	49	0

B. Canker Diseases:

Survey orchards for cankers:

Isolations made from samples submitted by consultants, farm advisors, and growers and those collected by us represented 24 orchards in 2009 and 25 orchards in 2010. Isolations are made on acidified PDA, the plates are incubated at 25°C for 5 days when the fungal colonies are determined. Results are presented in Table 3. In a large number of these samples, cankers by *Botryosphaeria* fungi were initiated from pruning wounds.

Table 3. Isolations from almond samples received from consultants and cooperative extension personnel in 2009 and 2010.

Year	County	Number of orchards	Incidence (%)				
			Botryosphaeria	Phomopsis	Eutypa	Acremonium	Cylindrocarpum
2009	Colusa	2	0	0	0	0	0
	Fresno	13	15	0	0	0	0
	Glenn	1	100	0	0	0	0
	Kings	4	0	0	0	0	0
	Merced	4	25	25	0	0	0
	Stanislaus	2	0	0	0	0	0
2009 Total	26	15	4	0	0	0	
2010	Colusa	4	50	50	0	0	0
	Fresno	3	67	0	33	0	0
	Glenn	4	50	50	0	0	0
	Kern	3	0	0	0	0	0
	Madera	2	0	50	0	0	0
	Merced	7	14	0	29	29	29
	Stanislaus	1	0	0	0	0	0
	Yolo	1	0	0	100	0	0
	2010 Total	25	28	20	16	8	8

In an orchard in Mendota, Fresno County, the fourth leaf trees had more *Botryosphaeria* than the fifth leaf trees. However, the older trees had some *Eutypa* (Table 4). The trunks and/or broken scaffolds due to band canker suggest that *Eutypa* can colonize the wounded tissues as a secondary. Another fungus that colonized a trunk split in half due to band canker was *Schizophyllum commune*, a wood-decay fungus (Figure 5A).

Band Canker:

Table 4. Isolations from Padre almond trees near Mendota with band canker resulting from infected pruning wounds made while selecting primary scaffolds (collected on July 26, 2010).

Location/orchard	Incidence (%)		
	Botryosphaeria	Phomopsis	Eutypa
South block/ fourth leaf	55.3	0.3	0.0
North block/ fifth leaf	11.2	0.0	4.0



Figure 5. A. A sixth leaf Nonpareil tree split due to band canker and has been colonized by the wood decay fungus *Schizophyllum commune* (white fungus on the surface of split) in an orchard in Glenn Co. (2010). B. A fifth leaf tree snapped in half due to band canker.

Susceptibility of pruning wounds to Botryosphaeriaceae fungi:

Pruning wounds were inoculated with isolates of *Botryosphaeriaceae* at the Kearney Ag Center experimental almond orchard (Figure 6).

Infections will be recorded in the summer or fall of 2011. Since inoculations of pruning wounds were done at different dates after the pruning, an expected outcome from this experiment will be determining of the duration pruning wounds remain susceptible to infection by these *Botryosphaeriaceae* fungi. Another expected outcome will be whether a fungicide application directly on the pruning wound as soon as the cut is made could prevent infection.



Figure 6. Pruning wound inoculated with *Botryosphaeria dothidea* and covered with parafilm in an experimental Nonpareil orchard at Kearney Agric. Center

Distribution of band canker in an orchard:

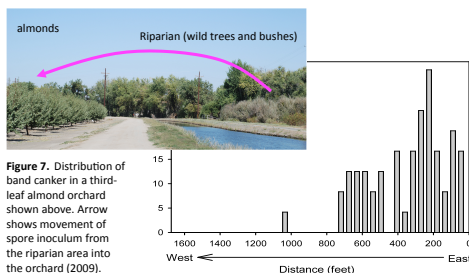


Figure 7. Distribution of band canker in a third-leaf almond orchard shown above. Arrow shows movement of spore inoculum from the riparian area into the orchard (2009).

Band canker control experiment in the field:

Fungicide treatment of young trees in an orchard where band canker symptoms were low did not reduce existing symptoms or protect trees from further infection (data not shown). Fungicides were painted on with latex paint. As the trees age, they have naturally become more resistant to disease.

CONCLUSIONS

A. Lower Limb dieback (LLD):

- ✓ Pathogen and irrigation may both play a factor in development of LLD (see Bruce Lampinen's project on irrigation/LLD).
- ✓ Some xylem inhabiting fungi (i.e., *Acremonium*, *Phaeoacremonium*, and *Cylindrocarpum*) have been isolated from four trees with LLD symptoms after their removal.
- ✓ Herbicide drift experiments to determine if drift causes LLD symptoms are inconclusive.

B. Canker Diseases:

- ✓ Survey of 24 and 25 orchards in 2009 and 2010, respectively, revealed cankers caused by *Botryosphaeriaceae* > *Phomopsis* > *Eutypa* > *Acremonium* > *Cylindrocarpum*.
- ✓ Band canker in the crotch of trees results in trunk splitting and invasion by wood decay fungi such as *Eutypa*, and *Schizophyllum commune*, etc...
- ✓ Riparian areas provide inoculum for infection of almond by *Botryosphaeriaceae* fungi.
- ✓ Fungicide treatments by painting on even small cankers are not effective.

ATTENTION!

Growers who have blown over trees with LLD symptoms are encouraged to contact their farm advisors so that the trees can be sampled.