Etiology, Epidemiology, and Management of Lower Limb Dieback and Band Canker of Almonds

Project No.: **09-PATH5-Michailides**

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Objectives:

Lower limb dieback (LLDB)
1. Survey orchards in Stanislaus, Butte, Glenn, and Kern Counties for LLDB and determine common characteristics.
2. Select 4 orchards and arrange with the growers to measure herbicide drift on the tree canopy.

Band canker
3. Inoculate almonds at Nickels Soil Lab orchard with the five species of *Botryosphaeria* to determine relevant virulence of each species in the field.
4. Determine sensitivity of the five *Botryosphaeria* species to currently registered fungicides.
5. Perform band canker control experiment in the field.

Interpretive Summary:

We continued monitoring band canker and lower limb dieback throughout almond orchards in California in 2008 - 2009 season. For more details, please see the completed report in 2008 – 2009 Final Reports on CD included with the Proceedings (Project 08-PATH5-Michailides).

Isolations from limbs of trees with symptoms of LLDB and without symptoms in March, June, and October again revealed both *Botryosphaeria* and *Phomopsis* species present

in these limbs. Frequency of isolation was greater for *Botryosphaeria* than *Phomopsis* in 2008. The opposite was true in 2009 sampling. In general the frequency of isolation of *Phomopsis* spp. was higher in the limbs with symptoms than those with no symptoms for all the isolation dates and it was higher than the frequency of isolation of *Botryosphaeria* species, which was very low in 2009. The results suggest that the frequency of isolation of these fungi depends on the year, and this is another reason why the results thus far suggest that these fungi are not directly involved in LLDB. Although both *Botryosphaeria* and *Phomopsis* spp. were isolated from woody tissues of limbs, with the exception of one sample, these fungi were not isolated from the bark of the limbs, suggesting that these fungi are truly found inside the woody tissues and they are not just contaminants of the bark. However, the question remains whether these fungi enter the woody tissues as primary invaders or secondary colonizers of tissues that have been stressed due to other factors (abnormally wet soils, herbicide drift, shading and weakening of limbs, etc.).

In samples collected in October 2009, there was no increase of isolation frequency of either *Botryosphaeria* or *Phomopsis* spp. in plated tissues from either symptomatic or asymptomatic tissues (data not shown). However, generally isolation of *Phomopsis* was higher from LLDB symptomatic tissues than from asymptomatic tissues (**Tables 1 and 2)**. Inoculations of almond shoots with either *Botryosphaeria* or *Phomopsis* isolates did not reproduce the typical cankers that are found in limbs with LLDB symptoms.

We performed four herbicide experiments to test the hypothesis whether herbicide drift could cause symptoms resembling LLDB. In three commercial orchards where the grower was ready to apply an herbicide spray, squash plants were set up at different heights to measure herbicide drift. Although symptoms of LLDB have not developed in these orchards, we are hesitant to reject this hypothesis just in case tree symptoms in these experiments may take longer to develop. The squash plants that were placed on the soil and definitely received herbicide drift were killed, suggesting that these plants can be used as good indicators of herbicide drift.

In the mean time, more and more samples of both band canker and LLDB continue to be submitted by farm advisors and PCAs from various locations. Blighted shoots and putative LLDB limbs from 14 orchards in Sacramento and the Southern San Joaquin Valleys had *Botryosphaeria* spp. but not *Phomopsis* spp. The frequency of isolation of tree trunk samples collected from 5 orchards in Sacramento Valley revealed 100% *Botryosphaeria* while trunk samples from 19 orchards in Southern San Joaquin Valley had only produced only 16% *Botryosphaeria.* In a large number of these samples, we noticed that band cankers and other Botryosphaeria cankers were initiated from pruning cuts. For instance, in a 3- to 4-year-old orchard in Fresno County where the grower had lost 7% of trees due to infection by *Botryosphaeria,* we noticed that cankers on the trunk of these young trees were initiated from major pruning cuts (**Figure 1**) made to develop the canopy and from cracking trunks at the crotch of the trees. These cankers grew very fast surrounding the pruning wound and killed the trees. A similar type of infections was also reported in Merced Co. (David Doll, Farm Advisor, UC Coop. Extension, Merced Co., personal communication). In the orchard in Fresno Co., more disease was present closer to the riparian area (east) where willow, cottonwood, volunteer figs, and

blackberries were found to bear pycnidia and pseudothecia of *Botryosphaeria* spp. Disease declined with distance from the riparian area from east to west of the field (**Figure 2**).

As in previous years, these findings suggest that riparian sources of *Botryosphaeria* spp. can serve as inoculum for almond infection. To control band canker, an experiment was set in Glenn Co. where symptoms of band canker were light with the thinking that perhaps management of the disease may be more successful when disease symptoms were not severe. The fungicides azoxystrobin, Pristine (pyraclostrobin+boscalid), Captan, and the biopesticide Plant Shield mixed with latex paint were applied on to the trunks of trees. In addition, a set of healthy-appearing trees was treated similarly in order to protect them from infection. The fungicide treatments were not successful in restricting canker size nor protected the healthy trees from new infections during the season when treatments were applied. This plot will be again evaluated in spring to 2010 to determine whether these applications have an effect in protecting the trees from entirely new infections in the following growing season.

Among the five species of *Botryosphaeria* isolated from band canker and limbs with LLDB symptoms, *Botryosphaeria parva* was the most virulent species followed by *Neofusicoccum mediterraneum*. Cankers produced from these inoculations were typical Bot cankers but differed from cankers associated with LLDB symptoms.

Table 1. Frequency of isolations of fungi from almond limbs[1] **with lower limb dieback symptoms** collected in June 2009.

Orchard	**Cultivar**	***Botryosphaeria* species (%)**	***Phomopsis* species (%)**	***Aspergillus* species**	***Alternaria species* (%)**
Butte 1	Nonpareil	0	1	1	18
	Aldrich	0	36	0	34
Butte 2	Nonpareil	0	5	14	32
	Carmel	0	14	15	11
Butte 3	Butte	0	2	28	14
	Aldrich	0	12	20	7
Stanislaus 1	Butte	2	1	10	37
	Padre	1	25	18	6
Stanislaus 2	Butte	0	5	7	16
	Padre	6	1	3	25
Stanislaus 3	Butte	0	18	8	13
	Padre	0	17	10	11

[1] Samples were collected from limbs **with LLDB symptoms** from 10 trees per orchard.

Table 2. Frequency of isolations of fungi from almond limbs[1] **without lower limb dieback symptoms** collected in June 2009.

Orchard	Cultivar	*Botryosphaeria species* (%)	*Phomopsis* species (%)	*Aspergillus* species	*Alternaria species* (%)
Butte 1	Nonpareil	0	0	27	10
	Aldrich	1	0	2	9
Butte 2	Nonpareil	5	1	5	7
	Carmel	0	1	20	13
Butte 3	Butte	0	0	45	39
	Aldrich	1	0	3	6
Stanislaus 1	Butte	0	0	4	43
	Padre	2	1	8	2
Stanislaus 2	Butte	0	1	3	15
	Padre	2	0	8	23
Stanislaus 3	Butte	1	0	3	5
	Padre	0	0	3	2

[1] Samples were collected from **asymptomatic** limbs from the same 10 trees that were used in **Table 1**.

Figure 1. A third-leaf orchard with severe band canker whose infections were initiated mainly from pruning cuts made to develop the tree's main scaffolds. (Note the running of canker above and below the pruning cut in both cases.)

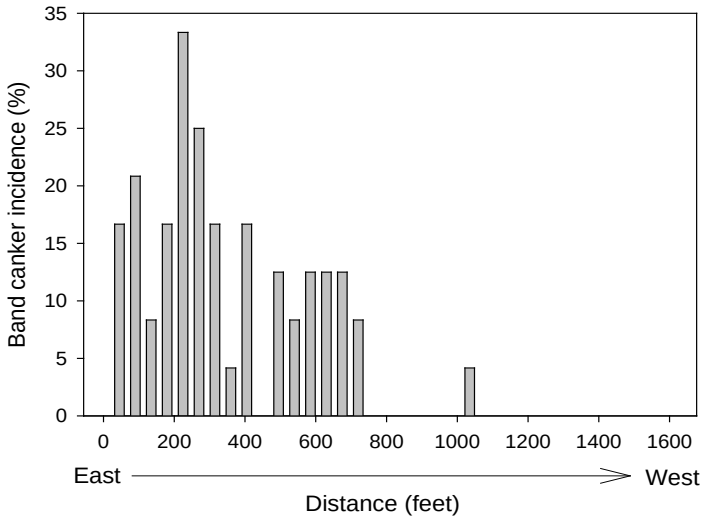

Figure 2. Distribution of almond band canker in a third-leaf almond orchard (bars = average of eight rows) in Fresno County (East side had the riparian area); Padre and Butte cvs. in a 1:1 ratio, with the Padre severely infected).