Lower Limb Dieback in Almond

Project No.: **08-PATH6-Lampinen**

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Objectives:

Growers in the Sacramento and San Joaquin Valleys have been noticing increasing dieback of lower limbs on almond trees. Beginning in late April, lower canopy leaves on affected branches begin to yellow and drop off while some leaves dry and remain hanging on the affected shoots. Eventually, entire limbs dieback and by late summer significant death of lower canopy wood can occur. Necrotic brown lesions can occur under the bark, primarily on the tops of the limbs around lenticels. Frequently wedgeshaped cankers are also visible on cross sections of affected limbs. Isolations from samples of the affected tissues were collected in two years (2005 and 2006) and, in some cases, indicated the presence of both *Botryosphaeria dothidea* and *Phomopsis* spp. These fungi have been reported to cause canker diseases on almond in California and in Europe, Australia, and South America. Although both fungi have been isolated at incidences up to 50 to 70%, isolations from lower limb dieback-affected shoots were not consistent among all affected orchards monitored in several counties.

Lower Limb Dieback (LLDB) seems to be most pronounced on the Butte and Padre varieties but has also been observed on Aldrich, Fritz, NePlus Ultra, Nonpareil, Sonora and other varieties to a lesser degree. Growers in Stanislaus County suggest the problem usually starts when Butte/Padre orchards reach about 7 to 8 years of age and continues to get worse as the orchard ages. Several growers have indicated that the problem is worse in heavily shaded blocks although this does not always seem to be the case, particularly in Butte County orchards.

The objectives of the current study are to investigate lower limb dieback, determine the causative factors and develop methods to overcome the problem.

Interpretive Summary:

Plans and Procedures

In 2008, three orchards in Stanislaus County and two orchards in Butte County, all with a history of lower limb dieback, were monitored. Stanislaus orchards #1, #2 and #3 were all flood irrigated Butte/Padre plantings. Stanislaus orchard #1 was the only orchard that was also studied last year. Both Butte County orchards had both microsprinkler and doubleline drip systems. The microsprinkler systems were mainly for frost protection but were used extensively for irrigation in the Butte County orchard #2 in 2008. Butte County orchard #1 consisted of Aldrich, Butte, Nonpareil and Peerless. All four varieties were monitored in this orchard. Butte County orchard #2 consisted of Butte, Carmel, Nonpareil, NePlus Ultra and Sonora and all varieties were monitored in this orchard as well.

Midday stem water potential was measured on bagged-lower-canopy-shaded leaves between 1:00 and 3:30 pm. Overall orchard midday light interception and light interception under the tree canopies were measured with an Accupar light bar (Decagon Devices, Pullman, WA 99163 USA) within 1 hour of the time the sun was directly overhead. Overall, 100 measurements were taken with the Accupar light bar around each target tree, and the values were compared to full-sun readings taken outside the orchard to estimate the percentage of mid-day light intercepted by the orchard. Mid-day light interception under the tree canopy was measured by taking 25 measurements in a circular pattern within the drip-line of the target tree and comparing these measurements to full sun readings taken outside the orchard. Mid-day stem water potential and light measurements were done approximately weekly early in season when symptoms were increasing and approximately monthly later in the season when symptoms generally were subsiding.

All trees were rated for lower limb dieback symptoms on each day that water potential and midday light interception were measured. A rating of zero indicated no lower limb dieback was observed, a one indicated one limb of approximately one inch in diameter was exhibiting symptoms (or a number of smaller limbs that added up to the same leaf area as a one inch diameter limb), a two indicated two limbs were impacted, etc. Ratings only indicated new occurrence of lower limb dieback symptoms (i.e. branches that already had brown leaves were not counted).

All three of the Stanislaus orchards tended to be wetter than the normal range of water potentials we would expect in almond, particularly during the April to June period (**Figure 1**). Moisture monitoring also showed that all of the orchards were running above field capacity at this time during the season (**Figure 2**). Lower limb dieback symptoms were most severe over the season in the wettest orchard in Stanislaus County (orchard #1). All three of the Stanislaus County orchards had midday light interception near 80%

which is about the point where shading related dieback usually starts to occur in almond so there may have been a synergistic effect between shading and wet conditions.

These results again suggest that excessively wet conditions early in the season could potentially have played a role in lower limb dieback. It is unusual to see orchards in the -6 to -7 bar midday stem water potentials that we observed in Orchards #1 and #2 in this study. It should also be noted that these are both flood irrigated orchards and water potential was measured at some random point in between irrigation events. The initial measurement in Orchard #1 was done about 10 days after the first irrigation had occurred suggesting conditions would have been much wetter immediately following irrigation. The symptoms also tended to get less severe as the season progressed and midday stem water potentials dropped into, and eventually below, the normal expected range (Fig. 1a, 1b). Field inoculation tests suggested that trees that were healthier were more resistant than less healthy trees to *B. dothidea* and *Phomopsis* spp. It is possible that the excessively wet conditions that occurred in many of the affected orchards might lead to better conditions for infection by these organisms. It is well known in the literature that any kind of stress can predispose woody plants to infection by *Botryosphaeria* spp.

Results and Discussion:

Results from isolations taken from symptomatic and non-symptomatic limbs are presented in the report for the complimentary project presented by Themis Michailides (Project 08-PATH5-Michailides).

Midday stem water potential and light interception

Stanislaus County Orchards

Midday stem water potentials in all three Stanislaus County orchards ran significantly wetter than the fully watered baseline during the April and May measurements (**Figure 1**). Stanislaus County orchard #1 continued to run wetter than the baseline throughout most of the season. It also had the most severe lower limb dieback symptoms of any of the orchards and they continued throughout the season until August (Fig. 1). Soil moisture readings in all three orchards show that the soil was excessively wet through the April to June period at all depths with only the shallowest sensors showing any drying between irrigation cycles (**Figure 2).**

Butte County Orchards

Butte County orchard #1 was excessively wet through the end of July based on soil moisture (**Figure 2**) and plant water potential (**Figure 1**) measurements. Below the two foot depth, the soil only began drying below field capacity during August (**Figure 1**). This orchard was irrigated by double line drip with the emitters some distance out from the tree and this, combined with its relatively lower midday canopy light interception (about 70% versus 80% for the other orchards in this study) may explain why it had relatively few lower limb dieback symptoms. The author has observed that orchards with double line drip placed some distance out from the tree row can be operated with relatively wet soil conditions without damaging trees, likely due to a dry area above the

two drip lines down the center of the tree row where roots can access water from below but still receive adequate soil oxygen from dry soil above. The roots in this situation would likely be concentrated in the top one foot of the soil (above all of our soil moisture sensors since the shallowest one was at the one foot depth).

Butte County orchard #2 was near the fully water baseline (slightly above and below; **Figure 1**) during the period from April through early July. After June 1st, the wetting during the irrigation cycles did not reach below the one foot sensor with the 2, 3, 4, 5, 6 and 7 foot sensors successively becoming drier (in order) as the season progressed (**Figure 2**). All of the varieties were moderately to severely stressed by August based on midday stem water potential measurements (**Figure 1**).

Overall Summary:

These results suggest a hypothesis that water management plays a role in development of lower limb dieback, but confirming this relationship will require experimental verification by manipulating soil and tree water status as a treatment variable. None of the orchards was a model for water management with all five orchards having periods, particularly early in the season when the trees were wetter than the fully irrigated baseline. The Stanislaus orchard #1 and Butte orchard #1 was the wettest overall based on soil moisture readings (**Figure 2**). The Stanislaus orchard #1showed the most symptoms of lower limb dieback (**Figure 1**) and although the Butte orchard #1 also showed symptoms (**Figure 1**), the severity may have been limited by the double line drip irrigation system as describe earlier.

All five of these orchards would likely benefit from improved water management practices, particularly during the April through June period. Excessively wet conditions early in the season likely played a role in lower limb dieback. It is unusual to see orchards running substantially above the baseline as we saw in all of these orchards at some point during the season. It should also be noted the water potential measurements were generally done towards the end of the irrigation cycle (particularly in the flood irrigated orchards) so they likely went through wetter periods than we recorded. The initial measurement in Stanislaus orchard #1 was done about 10 days after the first irrigation had occurred suggesting conditions would have been much wetter immediately following irrigation. It should also be noted that most of these orchards had the dead lower limbs removed throughout the season so there was likely additional lower limb dieback occurring than was recorded.

Between the three orchards investigated under this project in 2007 and the additional four orchards investigated in 2008, all of the orchards could benefit from improved water management. Six of the seven orchards were excessively wet during the April-June period and the seventh orchard had severe water management problems (excessively stressed by mid-summer with a wet soil suggesting root damage). Before spending any time looking for causes of lower limb dieback, almond growers should first address any water management related problems with the orchard.

In 2009, measurements are continuing on the same orchards in both Stanislaus and Butte County. In addition, one additional orchard has been added in Stanislaus County. Planned differential irrigation treatments were not initiated due to the difficulty in managing them with the growers' infrequent irrigation schedules and the fact that orchards became stressed extremely rapidly when irrigation was withheld, most likely due to shallow rooting resulting from excessively wet conditions early in the season most years.

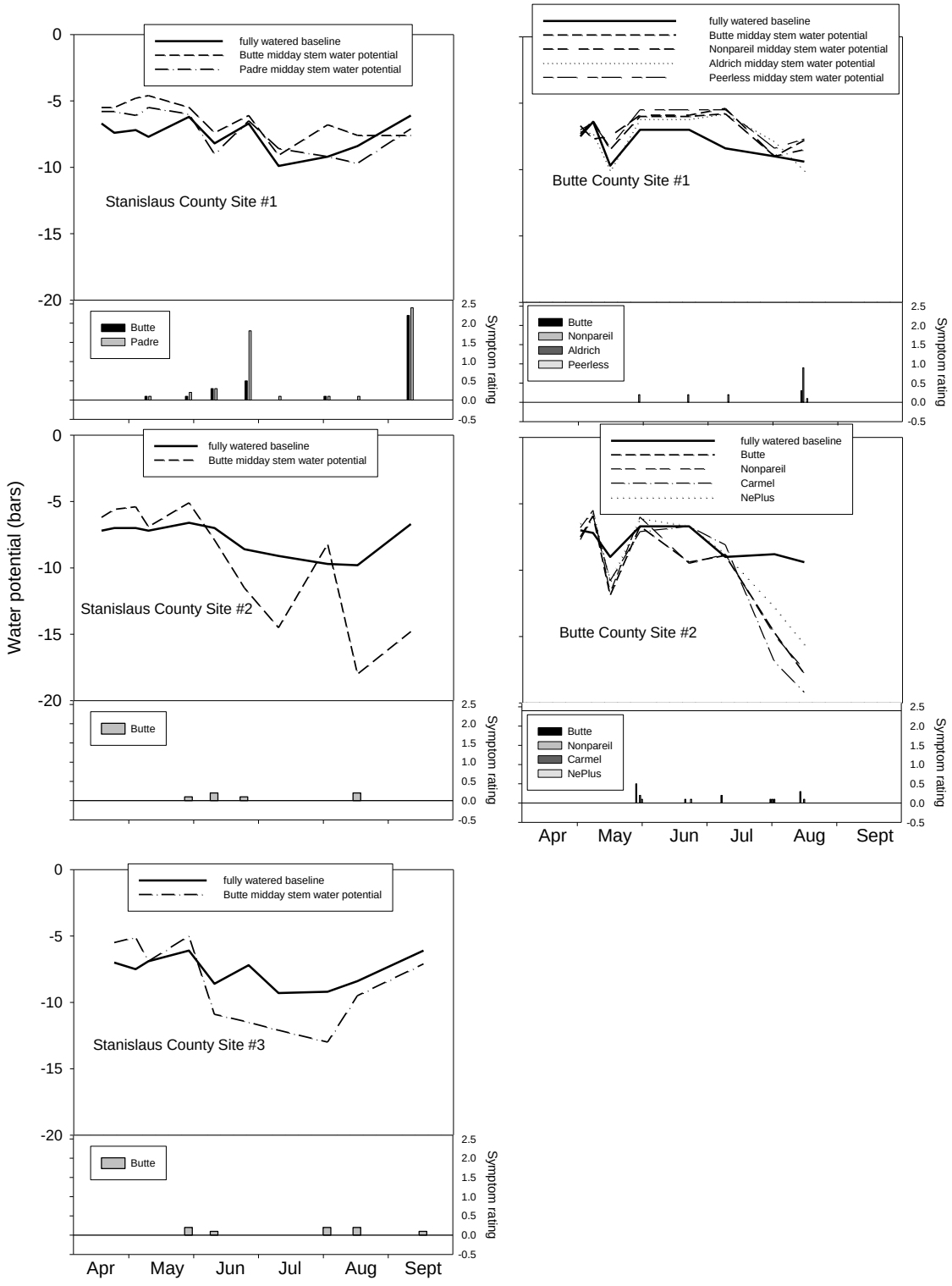

Figure 1. Midday stem water potential and symptom ratings (bar graphs) by orchard and variety for Stanislaus and Butte County sites in 2008. The solid line is the fully watered baseline on the day of measurement.

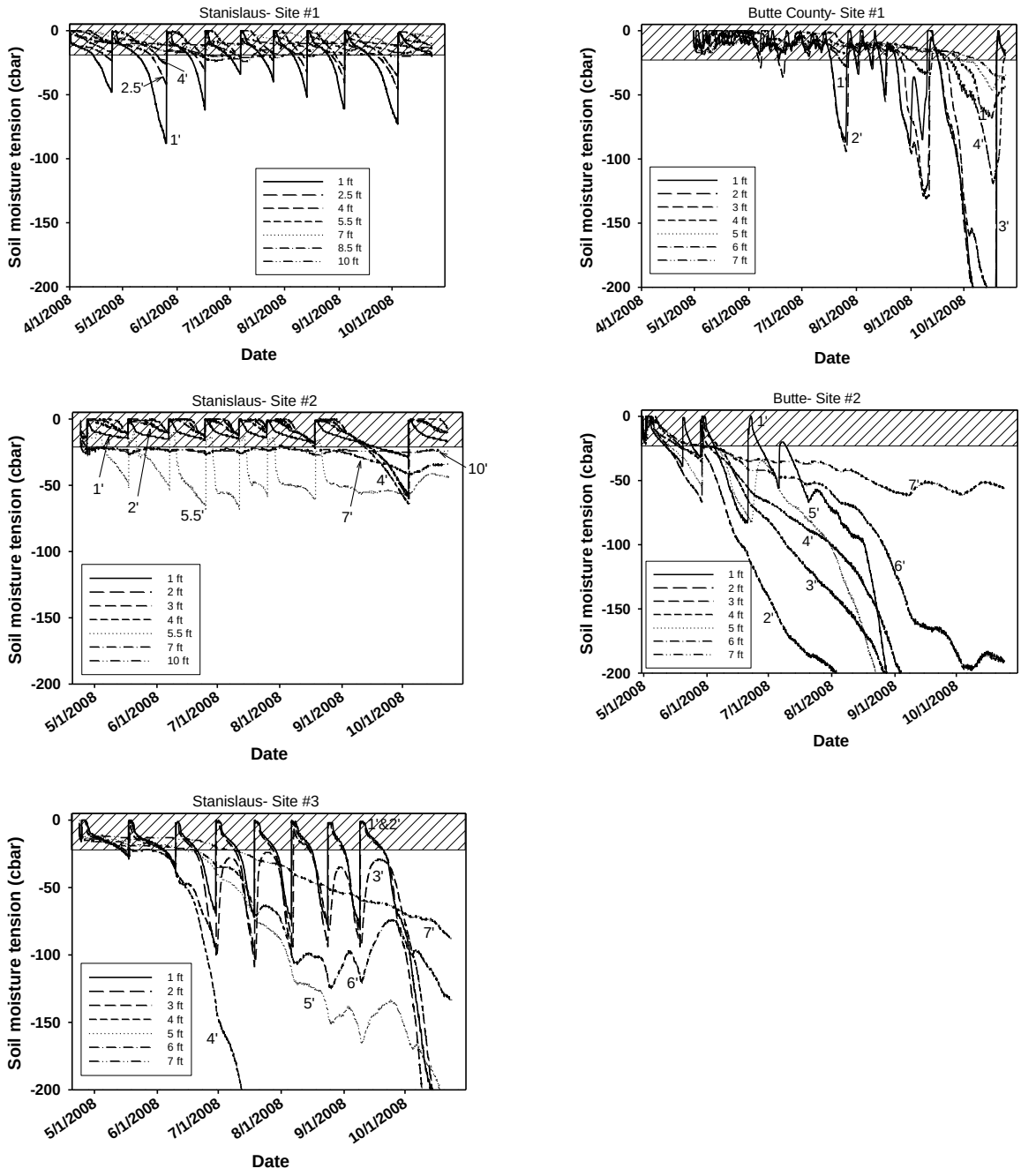

Figure 2. Soil moisture tension (in centibars) by orchard for Stanislaus and Butte County sites in 2008. Shaded area at top of each graph indicates approximate area above field capacity.