Lower Limb Dieback in Almond

Project No.: **10-PATH6-Lampinen**

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Objectives:

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

Background:

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 have, in some cases, indicated the presence of both *Botryosphaeria dothidea* and *Phomopsis* spp. These fungi have been reported to cause canker and other 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 have not been consistent among all affected orchards monitored.

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.

Interpretive Summary:

In 2009, three orchards in Stanislaus County and two orchards in Butte County, all with a history of lower limb dieback, were monitored. All of the Stanislaus County orchards were flood irrigated Butte/Padre plantings. Stanislaus orchards #1, #2 and #3 were also studied last year. Butte County orchard #1 has both microsprinklers and a doubleline drip system while Butte orchard # 2 has solid set sprinklers. The microsprinkler system in orchard #1 is used mainly for frost protection. Both Butte County orchards were also monitored 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, NePlus Ultra, Nonpareil and Sonora. 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. Orchard midday light interception was not monitored in 2009 since data collected in 2008 suggested it was not a major causative factor.

All trees were rated for lower limb dieback symptoms on five of the days when water potential was measured (indicated at the top of **Figure 1**). 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).

In 2010, the goal was to differentially irrigate two orchards in Stanislaus County to help determine the role of water management in the phenomena of lower limb dieback. Both of the study orchards in Stanislaus County in 2010 had moderate to severe lower limb dieback symptoms. However, problems with the irrigation systems and dataloggers in the 2010 season led to inconclusive results.

Materials and Methods:

In 2010, differential irrigation sections were set up in two orchards in Stanislaus County. The goal was to attempt to alleviate or minimize lower limb dieback symptom expression by minimizing stress cycles. The first trial was in Stanislaus Orchard #1 (the same used in previous years) and the second was in Stanislaus Orchard #4 (a new site) which is also a flood irrigated Butte/Padre orchard with a history of severe lower limb dieback symptoms. Differential irrigation (and soil moisture monitoring using logging Watermark sensors) was set up in the Padre rows at Stanislaus Orchards #4 and in both varieties at Orchard #1. All trees were rated for lower limb dieback symptoms through the season. A rating of zero indicated no lower limb dieback was observed and a rating of one indicated one limb of approximately one inch diameter was exhibiting symptoms

Results:

2009

Stanislaus County Orchards

Midday stem water potentials in all three Stanislaus County orchards ran significantly wetter than the fully watered baseline during the April to June period (**Figure 1**). Stanislaus County orchard #1 continued to run wetter than the baseline through July in 2009 as it did in 2008. Soil moisture readings in all Stanislaus Orchards showed 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**). Even though the average midday stem water potential stayed substantially above the baseline in these orchards early in the season, individual trees within the trial showed rapid drops in midday stem water potential (data not shown). Because of the rapid drying in the upper soil moisture levels between irrigation cycles (**Figure 3 - Stanislaus Site #2 and Figure 4 – Stanislaus Site #1**) and the fact that soil moisture monitoring showed rapid drops in upper level soil moisture, the differential irrigation was not imposed since severe stress would have likely resulted at the ends of the flood irrigation cycles.

Butte County Orchards

Midday stem water potentials in the Butte County orchard #1 were equal to or wetter than the baseline through early June (**Figure 1**) when a rapid decline in water potential occurred and trees were moderately to severely stressed through the rest of the season. Soil moisture readings in this orchards suggested that there was a substantial dry down in the shallower sensors beginning in the end of April followed by a rewetting of the shallow profile in mid-May (**Figure 2**). After June 1, the wetting during the irrigation cycles did not reach the one foot sensor and all sensors became progressively drier as the season progressed (**Figure 2**). The trees were moderately to severely water stressed from August on based on midday stem water potential measurements (**Figure 1**). Expression of lower limb dieback symptoms was minor on the monitored trees in this orchard in 2009 (**Figure 1**).

Midday stem water potential in Butte County orchard #2 was wetter than the fully watered baseline during the period from April through early June (**Figure 1**). During the summer, soil moisture fluctuated between 0 and -100 centibars approximately in this orchard (**Figure 2**) and midday stem water potentials showed that the trees tended to become progressively more stressed from late July through September (**Figure 1**).

The common characteristic to all of the orchards monitored for lower limb dieback to date has been that the orchards have been running wetter than the fully watered baseline early in the season and tend to fluctuate well below the fully watered baseline during the summer period. Soil moisture measurements also confirm that the orchards are wet early in the season since they have generally been running wetter than field capacity during this period. During the summer period, these orchards have generally had rapid fluctuations in shallow soil moisture levels from above field capacity to well below field capacity. These fluctuations have been more pronounced than the authors have seen in orchards that do not show lower limb dieback symptoms. Because our

water potential measurements have typically not been frequent enough to correctly document the short term variations associated with the soil moisture cycles, we cannot definitely say that these fluctuations are related to the incidence of lower limb dieback.

2010

Stanislaus Orchard #1

The micro-irrigation system was installed in early spring and the first irrigation was carried out on 5/12/10. The first yellowing of lower canopy leaves appeared the week before the micro-irrigation system was started. By early July, it became very difficult to keep up with plant needs with the micro-sprinkler system. This was due to a number of factors including an inadequately sized fuel tank used to power the pump, the need to make many visits to the site during each irrigation cycle to add fuel and maintain the system, and difficulty in meeting plant demands with the abrupt switch from flood to micro-sprinkler irrigation. This resulted in a severe drop in soil moisture levels in the upper soil profile (white arrow– East microsprinkler irrigation in **Figure 5**) and an increase in LLDB symptom expression in this area (late June date, **Figure 8**). The decision was made to flood the entire orchard in early July and abandon the micro-irrigation system. Symptom expression over the season was not significantly different between the flood and microsprinkler irrigated sections except on the late June evaluation date when the symptom expression was significantly worse on the microsprinkler irrigated section (**Figure 8**). This again, indicates a relationship of lower limb dieback with irrigation and suggests that it is the stress cycles rather than the overly wet cycles that cause the symptoms.

Stanislaus Orchard #4

In Stanislaus orchard #4, stress levels were excessive and even with supplemental irrigation, the trees still developed significant stress in May, June and July (see midday stem water potential data in **Figure 7**). Further investigation of soil moisture data from this site is needed determine if this is due to shallow rooting (i.e. deeper water is present but not available to tree due to shallow rooting) or actual water shortages. Unfortunately, the dataloggers had problems a number of times so there are gaps in data, particularly at Stanislaus Orchard #4 in 2010 (**Figure 6**). There were no significant differences in symptom expression between irrigation treatments in Stanislaus Orchard #4 in 2010 (**Figure 7**).

Overall Summary:

Both of the study orchards in Stanislaus County in 2010 had moderate to severe lower limb dieback symptoms. However, problems with the irrigation systems and dataloggers in the 2010 season lead to inconclusive results during this period. However, the results again suggest a role of stress cycles in lower limb dieback symptom expression since the symptom expression was different with the flood compared to microsprinkler irrigated sections at Stanislaus Orchard #1 in 2010.

Overall, these results continue to support a hypothesis that water management plays a role in development of lower limb dieback. All of the orchards had excessively wet conditions (indicated by midday stem water potentials wetter than the fully watered

baseline) early in the season. In some cases, particularly in Butte County, this may have been due to spring rainfall and hence would be beyond the control of the grower. Of the five orchards, all except Stanislaus Orchard #2 were wetter than the fully watered baseline through May. This is a situation which is likely to lead to shallow rooting and stress sensitivity as the season proceeds. We do not commonly see orchards running substantially above the baseline as we saw in these orchards early in the season. It should also be noted the water potential measurements were generally done in the middle and end of the irrigation cycle (particularly in the flood irrigated orchards) so the orchards went through wetter periods than we recorded. It should also be noted that most of these orchards had the dead lower limbs removed throughout the season so there was likely more lower limb dieback occurring than was recorded. Limited measurements done during at the points where rapid drops in shallow soil moisture occurred suggest that trees in these orchards tend to become stressed at soil moisture levels that would normally be considered adequate (**Figures 3, 4**). This was particularly pronounced in Stanislaus orchard #2 where soil moisture remained above field capacity in the 1 to 4 foot levels yet trees showed moderate to severe stress levels of -3 to -8 bars below the baseline (midday stem water potentials of -12 to -17 bars or so) suggesting that a concentration of roots shallower than one foot was likely causing stress.

It is likely that the rapid drops in water potential that occur due to the shallow rooting conditions is a causative factor for lower limb dieback. Since water management has been a problem in all of the lower limb dieback orchards, it is prudent that before spending any time looking for other causes of lower limb dieback growers should first make sure that water management is not a problem with the orchard. It is important to point out that it would be difficult to manage water optimally in these orchards without a combined approach using soil and plant based measurements.

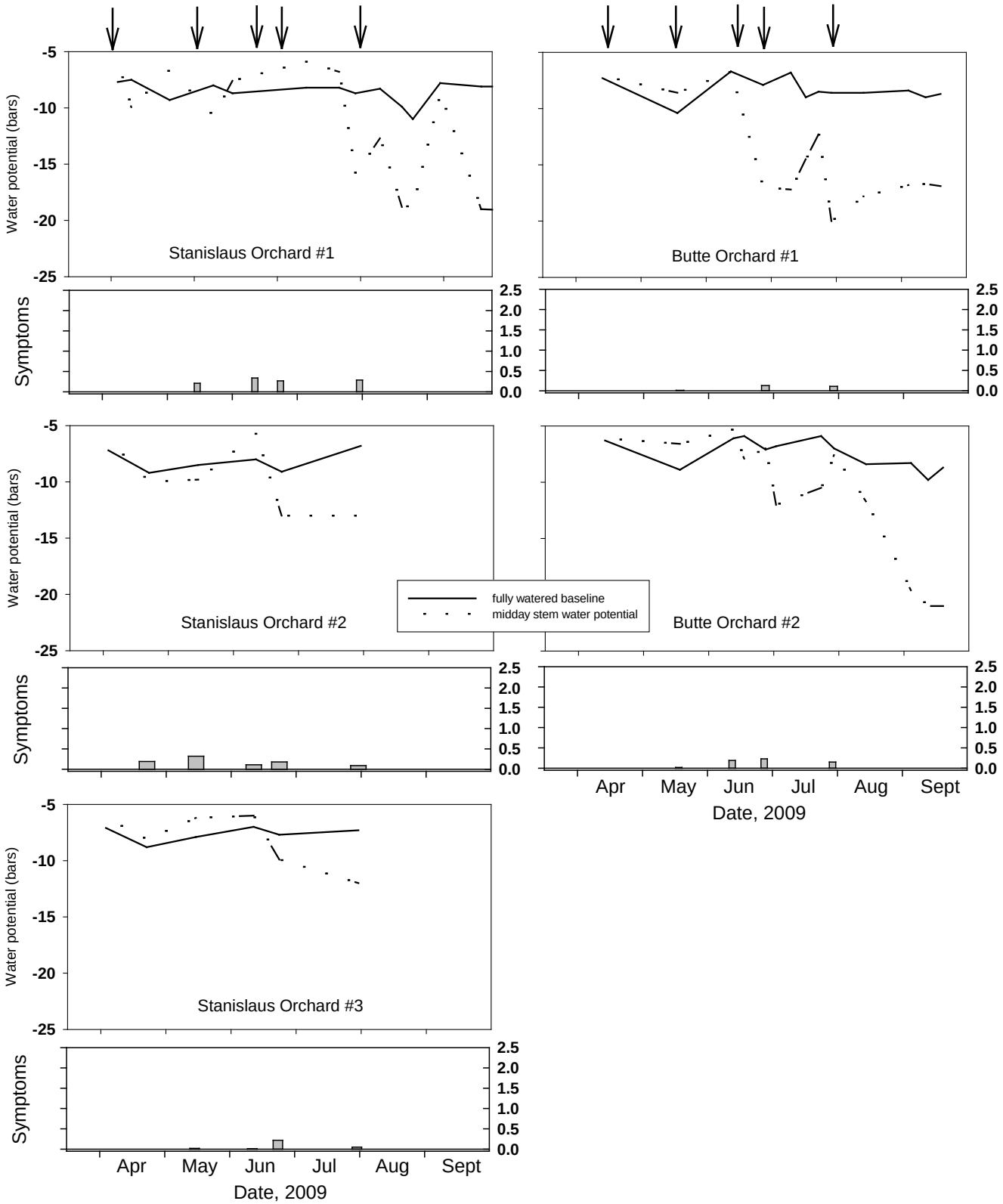

Figure 1. Midday stem water potential and symptom ratings (bar graphs) by orchard and variety for Stanislaus and Butte County sites in 2009. Arrows at top of figure indicate dates when symptom ratings were taken.

The solid line is the fully watered baseline on the day of measurement.

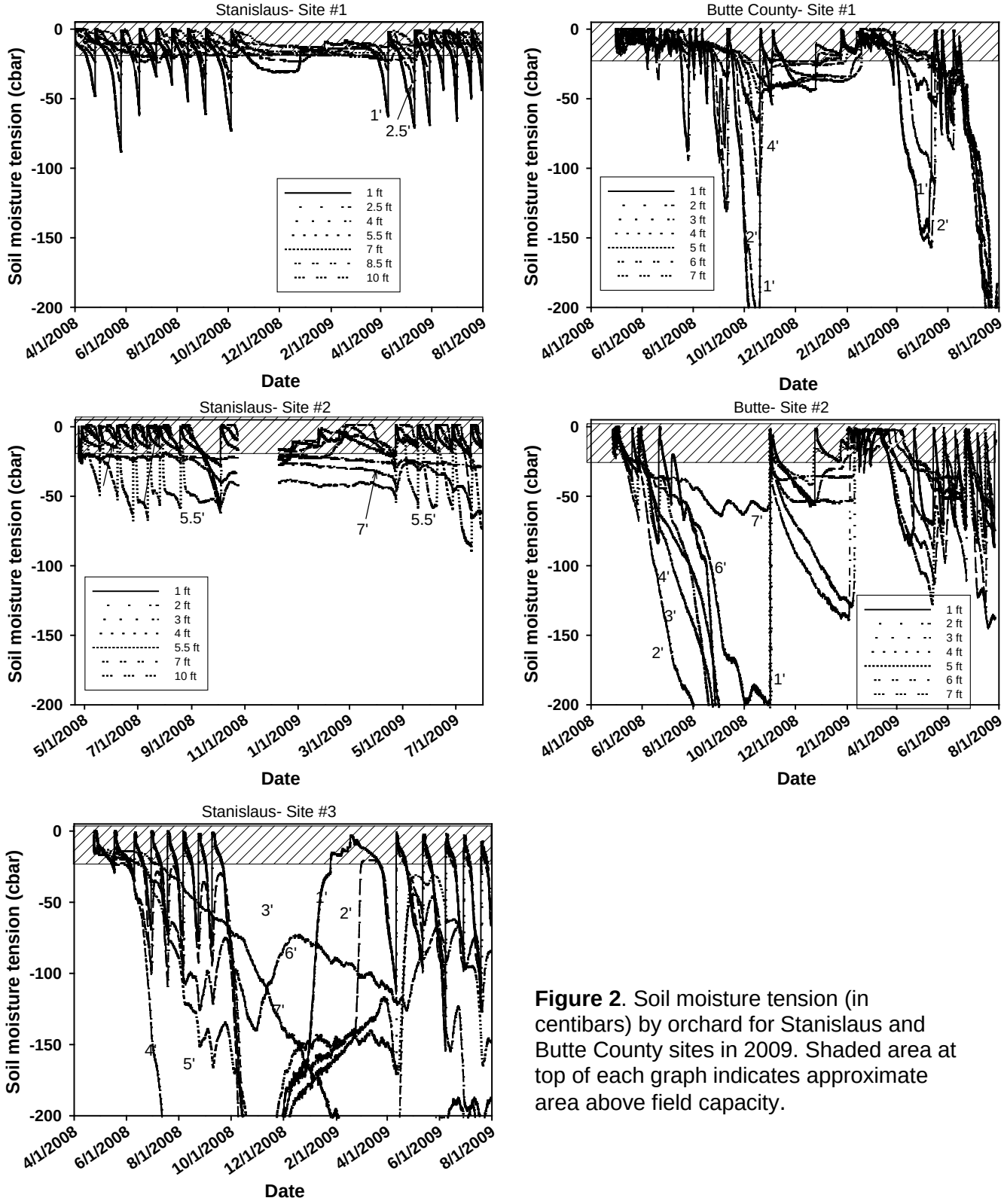

Figure 2. Soil moisture tension (in centibars) by orchard for Stanislaus and Butte County sites in 2009. Shaded area at top of each graph indicates approximate area above field capacity.

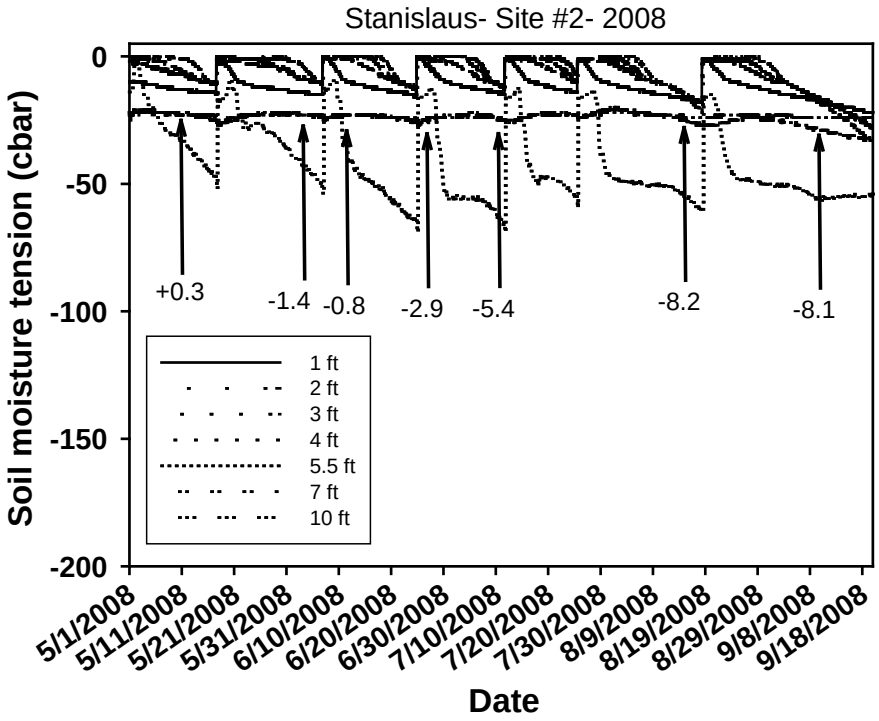

Figure 3. Soil moisture tension over 2008 season at Stanislaus Site #2. Arrows with number indicate difference from fully watered level. More negative number indicates more severe stress and positive number indicates excessively wet conditions. Note that a -8.2 in the graph would indicate a midday stem water potential in the -16 bar range which would be moderately to severely stressed.

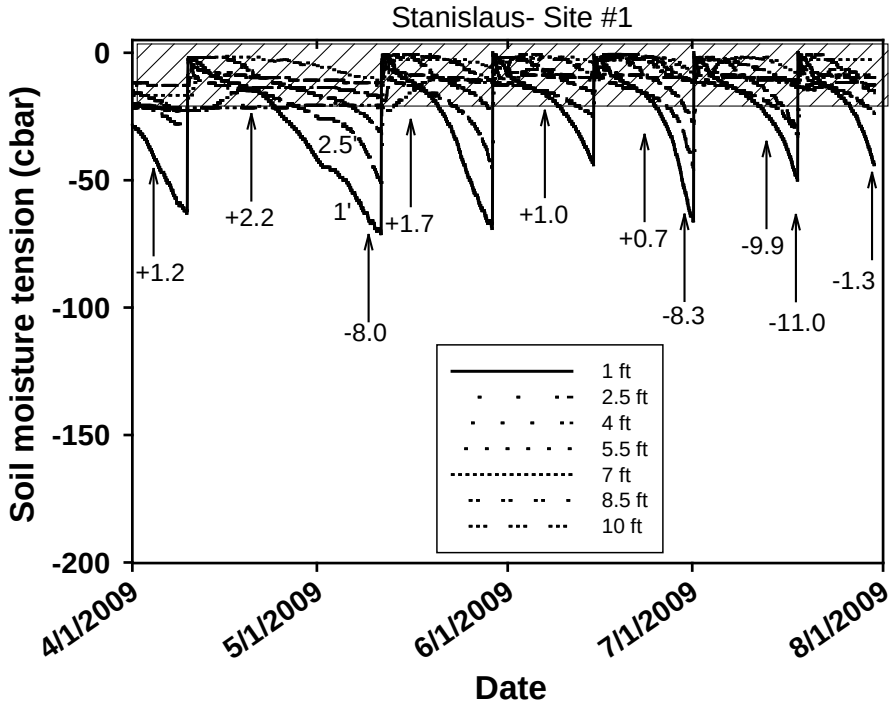

Figure 4. Soil moisture tension over 2009 season at Stanislaus Site #1. Arrows with number indicate difference from fully watered level. More negative number indicates more severe stress and positive number indicates excessively wet conditions.

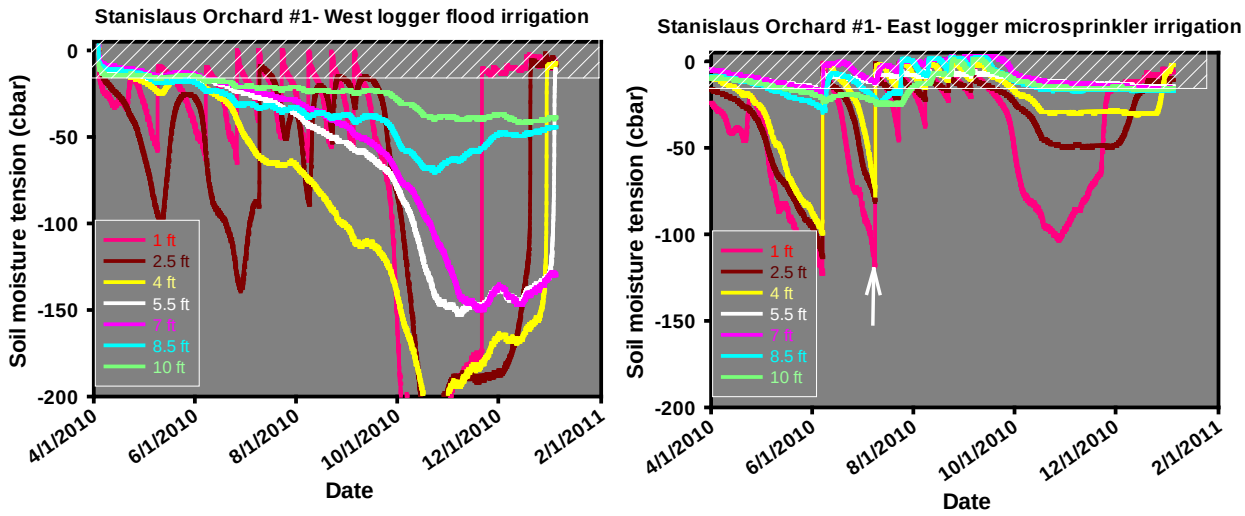

Figure 5. Soil moisture tension over 2010 season for Stanislaus Orchard #1 flood (left) and microsprinkler irrigated sections. The microsprinkler irrigated orchard was returned to flood irrigation in early July 2010. Drying down of upper soil levels in late June/early July in microsprinkler irrigated section resulted in tree stress and increase in LLDB symptom expression in late June (see **Figure 8**). Differences in soil moisture conditions from July onward between the two areas of the orchard suggest there are soil differences among the areas.

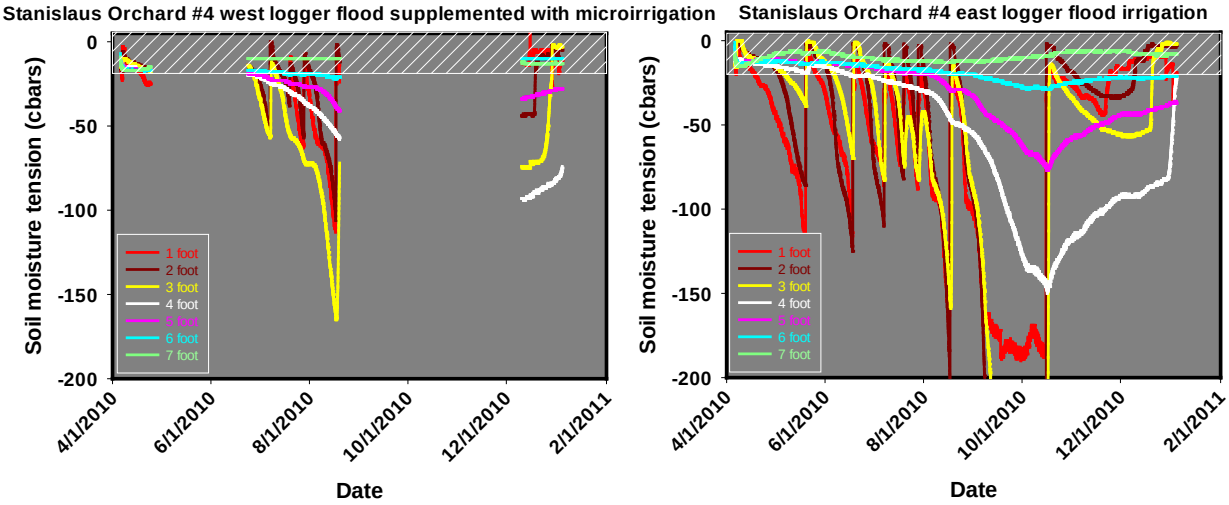

Figure 6. Soil moisture tension over 2010 season for Stanislaus Orchard #4 flood supplemented with microsprinkler irrigated section (left) and flood irrigated section (right).

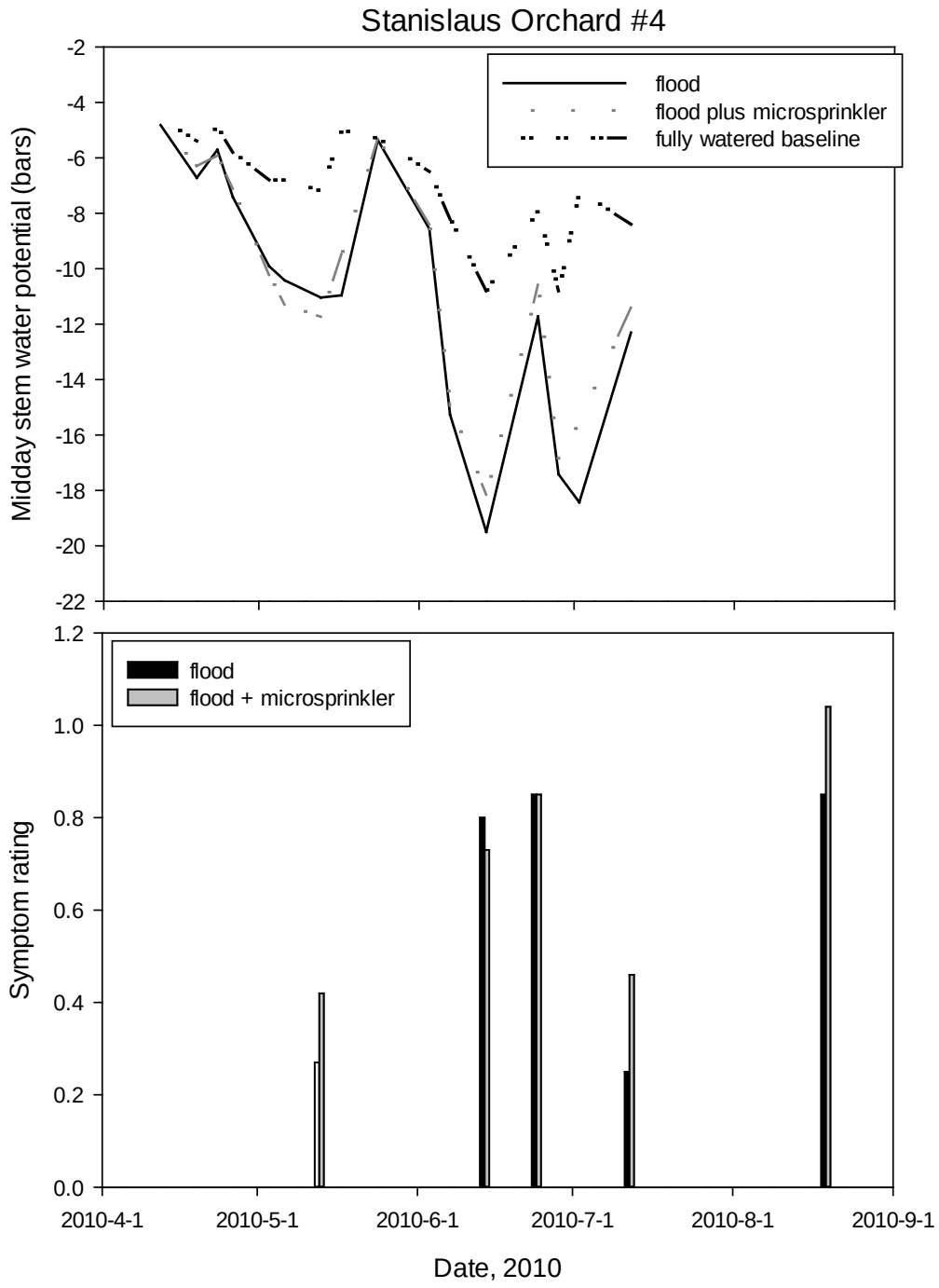

Figure 7. Midday stem water potential (top) and lower limb dieback symptom expression (bottom) for the differentially irrigated Stanislaus orchard site #4 in 2010.

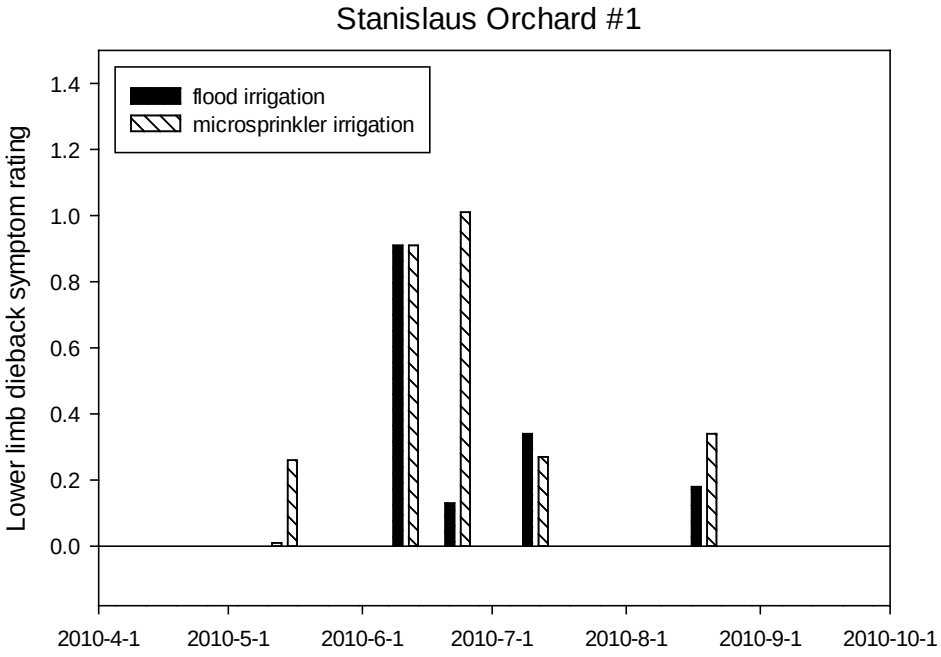

Figure 8. Lower limb dieback symptom expression for differentially irrigated Stanislaus Orchard #1 for the 2010 season.