MANAGING HEAT AT BLOOM IN 'FRENCH' PRUNE, 2010

F. Niederholzer
R. Buchner
C. DeBuse
W. Krueger

PROBLEM AND ITS SIGNIFICANCE

Excessive heat at bloom is linked to significantly reduced prune production in key California growing regions in three of the last six crop years (2004, 2005, and 2007). Total grower economic losses in Sutter and Yuba Counties – with 40% of the prune acres in the state -- were in the range of $240 million for those three years, based on county ag commissioners' data. Overall economic damage to the regional economy was probably 1.5x that loss -- $360 million. As the probability of heat in March appears to be increasing (Rick Snyder, personal communication), California prune growers must develop management strategies to mitigate heat damage at bloom to remain economically viable.

Recent research results show that temperatures >75^{o}F begin to negatively affect pollen tube growth rate and viability, but research has not identified 1) temperature thresholds for actual crop damage and 2) practices to improve set once orchard temperature approaches those thresholds.

Prune growers currently use irrigation water as the most cost-effective means of modifying orchard temperature. Freezing of water releases energy that is used to protect crops from temperatures below 32^{o}F. Evaporative cooling is a common practice in apple production to reduce sunburn, and appears to be the most cost-effective approach to reducing temperatures in prune orchards when hot weather occurs at bloom.

Research must answer three questions:

1. What is/are the threshold temperature(s) that affect prune set and crop yield?
2. Can orchard temperatures be lowered using irrigation water?
3. Can one or more nutrients and/or plant growth regulators be used to improve set when orchard temperatures reach above 75^{o}F?

OBJECTIVES

- Determine bloom-time temperature thresholds above which crop damage occurs.
- Evaluate under-tree orchard cooling with micro-jet sprinklers for improving prune set during hot weather at bloom.
- Test commercially available spray materials to assess their potential for improving prune fruit set under warm orchard conditions.

PROCEDURES

Glenn, Tehama, Yolo and Sutter Counties:

Temperature and relative humidity sensors were placed in commercial orchards in each county. Sensors were located at 5-6' feet off the ground in exposed sites between trees in the tree row. They were not placed in tree canopies. In a few locations, sensors were placed at 5' and 10' in the same location in an effort to evaluate affect of sprinkler cooling on orchard temperatures. Temperatures in each block were continually recorded during bloom at all sites.

Bloom progression was measured by counting open flowers on short branches at roughly 6' height around 3 trees in each orchard. Initial set was measured in May.

Irrigation Test: One study orchard (Sutter Co.) uses movable pipe sprinkler irrigation. The growers applied irrigation water between 10 AM and 4-5 PM on March 18-22. They left 5 rows, up wind, without irrigation for an untreated control. A single temp/RH logger was placed at 5' and 10' on a single pole within the tree row between trees in a row (not in the canopy) and temp and RH recorded at 5 minute intervals. Fruit set was determined in the irrigated section and the non-irrigated section.

Spray Trials: To assess the potential for certain spray materials – nutrient, plant growth regulators, etc. – to improve prune fruit set at bloom, a replicated, complete blocked design experiment was established in Sutter County. Materials, rates and timings appear in Table 2. Five blocks with single reps of seven treatments was established in March, 2010. Treatments were applied by gas-powered, backpack sprayer. Reasoning for including each treatment in the trial are as follows:

Retain: A plant growth regulator that inhibits ethylene formation, Retain can increase set in walnuts and other crops at bloom.
Boron: An essential mineral nutrient, boron may increase set ps when applied early in bloom.
Calcium: Another essential mineral nutrient, calcium is reported to be a key factor in flower biology and may help increase fruit set. Calcium and boron are often purported to work together to improve fruit set.
SeaWeed extract(s): Reported to improve set, these materials are often blended with essential mineral nutrients including nitrogen, boron, and calcium in a commercial package.

RESULTS AND DISCUSSION

Warm temperatures (72-78^{o}F) at full bloom across the state's prune growing regions had no negative effect on fruit set (Table 1). Figure 1 graphs the temperatures in each county March 16-31. The duration of heat at bloom is one of the factors that seems to be very important not just the highest temperature. This year the amount of time the temperatures were above 75°F was minimal during the full bloom in all counties. Two and a half hours was the longest duration of temperatures above 75°F for one Tehama orchard all other orchards did not even experience this

amount.

Fruit set in all test orchards was above 20% with the highest set in Yolo # 2 orchard of 60% (heavy bee activity in that orchard may have enhanced set). Mid-summer fruit set was counted in all counties except Glenn to see if 'June drop' would decrease final yields. Only a small reduction in fruit set percentage was found at these later dates (Figures 2-5). County average fruit set ranged from 29%-49% (Figure 6). The desired fruit set for a healthy orchard to produce large fruit size is considered between 12-20% depending on orchard. The heavy 2010 set indicated high yields and possible need for fruit thinning to reduce crop and increase fruit size. In Tehama County, the fruit set of 2009 compared to 2010 shows that both years set well (Figure 7).

Irrigation Test: The irrigation test in Sutter County showed minimum differences in temperatures between the 5 ft. sensor and the 10ft. sensor. The difference between irrigated and non-irrigated at 5 feet ranged from -2.5 to 1.7 (Figure 8). An unusually low spike appears in Figure 8 when irrigation water hit the temperature sensor.

Sutter County Bloom Sprays: Limited advantage or disadvantage was provided by any of the treatments relative to the untreated control. Wide ranges of set per branch data were recorded for all treatments. Average and median set for each treatment, along with max and min percent set for each treatment appear in Figure 9.

CONCLUSIONS

These data indicate that trees at full bloom under conditions where maximum daily temperatures range between 75-79^{o}F can set commercially viable crops when duration of time at these high temperatures is short.

Field data from the 2005 and 2007 bloom seasons, when very low set levels were observed, show that maximum temperatures at full bloom were between 80-85^{o}F for 2-3 consecutive days. In those years, flowers were exposed to 11 (2007) or 13 (2005) total hours of temperatures over 80^{o}F, with continuous exposure to >80^{o}F temperatures ranged from 3-6 hours per day.

Our results over the years suggest that risk to commercial prune production may be greater when flowers are exposed to 10 or more hours of temperatures over 80^{o}F compared to less than 5 hours over 80 ^{o}F. More work is needed to confirm this idea.

Irrigation water can provide some reduction in temperature, but this benefit is limited to 1-2^{o}F under most conditions. The actual benefit to the crop from irrigating during bloom will depend on the high temperatures that day.

Material choices for sprays intended to improve fruit set may tend to improve or inhibit fruit set. Growers should select and use these products with care after limited, on-farm testing.

Table 1. Average prune fruit set, full bloom dates, and maximum temperatures in orchard at full bloom for individual orchards in Yolo, Solano, Sutter, Glenn and Tehama Counties, 2010.

Orchard	Date of Full bloom	Maximum Temperature at 80-100% full bloom	% Fruit Set (mid-May)
Tehama-Red Bluff	March 24	76	28%
Tehama-Los Molinos	March 24	76	27%
Tehama-S. Los Molinos	March 24	76	24%
Tehama-South Corning	March 24	76	20%
Tehama-East Corning	March 25	75	54%
Tehama-W. Red Bluff	March 25	74	41%
Tehama-Tehama	March 24	76	32%
Tehama-S. Red Bluff	March 24	75	54%
Tehama- Jelly's Ferry	March 24	77	59%
Glenn #1	March 24	74	22%
Glenn #2	March 24	78	33%
Glenn #3	March 24	78	39%
Glenn #4	March 22	78	22%
Sutter #1	March 21	71	56%
Sutter #2	March 21	72	46%
Sutter #3	March 21	71	46%
Yolo/Solano- Winters #1	March 22	77	41%
Yolo/Solano- Winters #2	March 22	77	46%
Yolo/Solano- Winters #3	March 21	77	46%
Yolo/Solano- Yolo #1	March 24	75	60%
Yolo/Solano- Yolo #2	March 26	72	43%

Table 2. Materials, rates, and timings for prune bloom spray trial to test materials for improving prune fruit set.

		----------Application timing----------				
Treatment material	Rate for each application	Green bud	Popcorn	30% bloom	Full Bloom	2 weeks after full bloom
Retain	333 gm/acre		**X**			
5% Ca poly amine	1 qt/acre			**X**	**X**	
3% B poly amine	1 qt/acre			**X**	**X**	
3% B poly amine & 5% Ca poly amine	1 qt/acre + 1 qt/are			**X**	**X**	
BM86	3 pints/acre			**X**	**X**	**X**
Solubor	2 lb/acre	**X**				
untreated control						

Figure 1. Bloom time temperatures for individual orchards in Yolo, Solano, Sutter, Glenn and Tehama Counties, 2010.

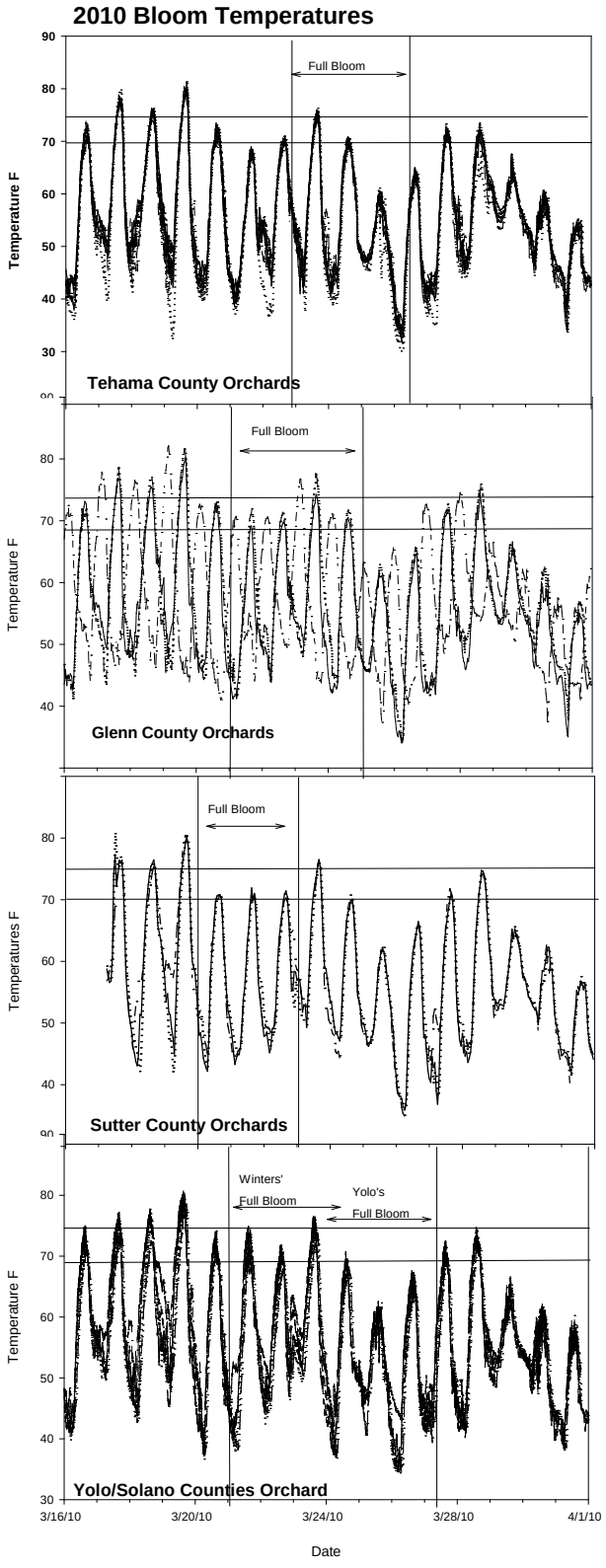

Figure 2. Percentage fruit set on three dates in Tehama County orchards, 2010.

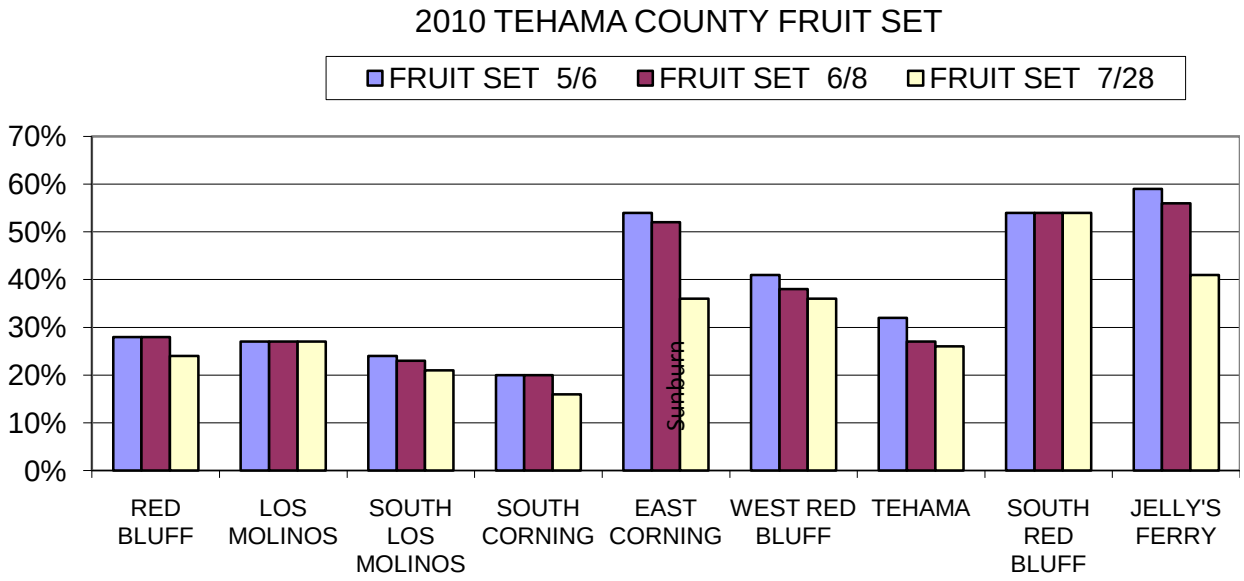

Figure 3. Percentage fruit set in Glenn County orchards. May, 2010

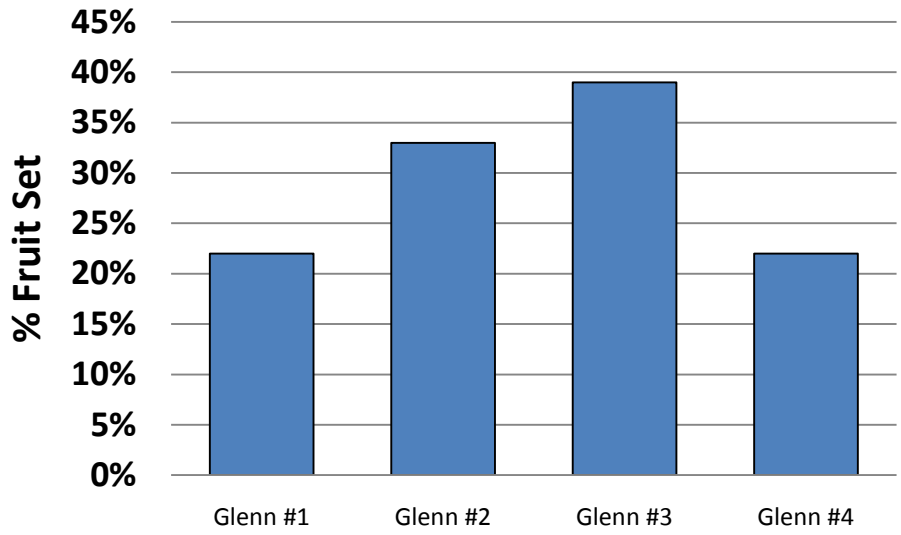

Figure 4. Percentage fruit set on two dates in Sutter County orchards 2010.

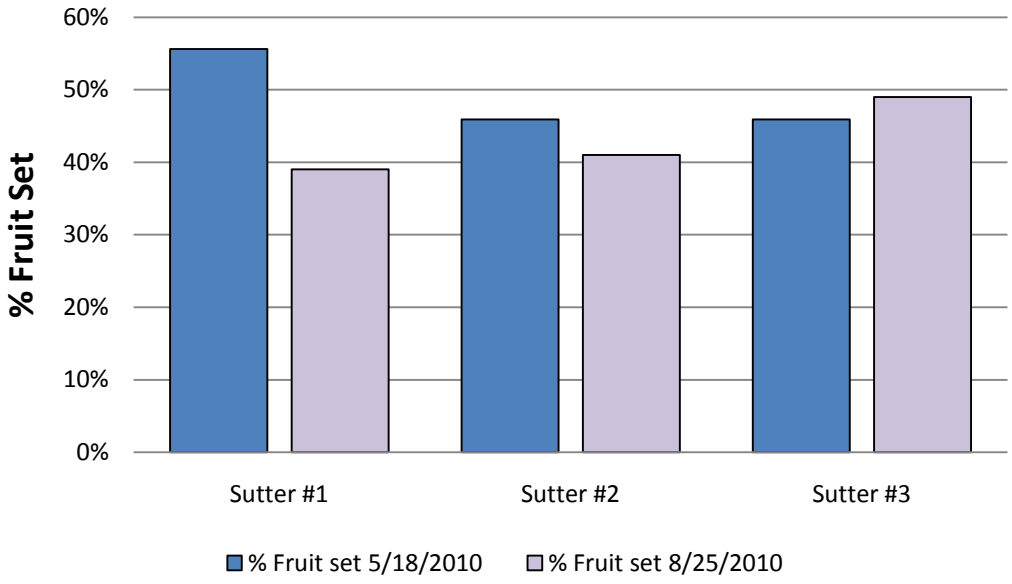

Figure 5. Percentage fruit set in Yolo/Solano Counties' orchards 2010.

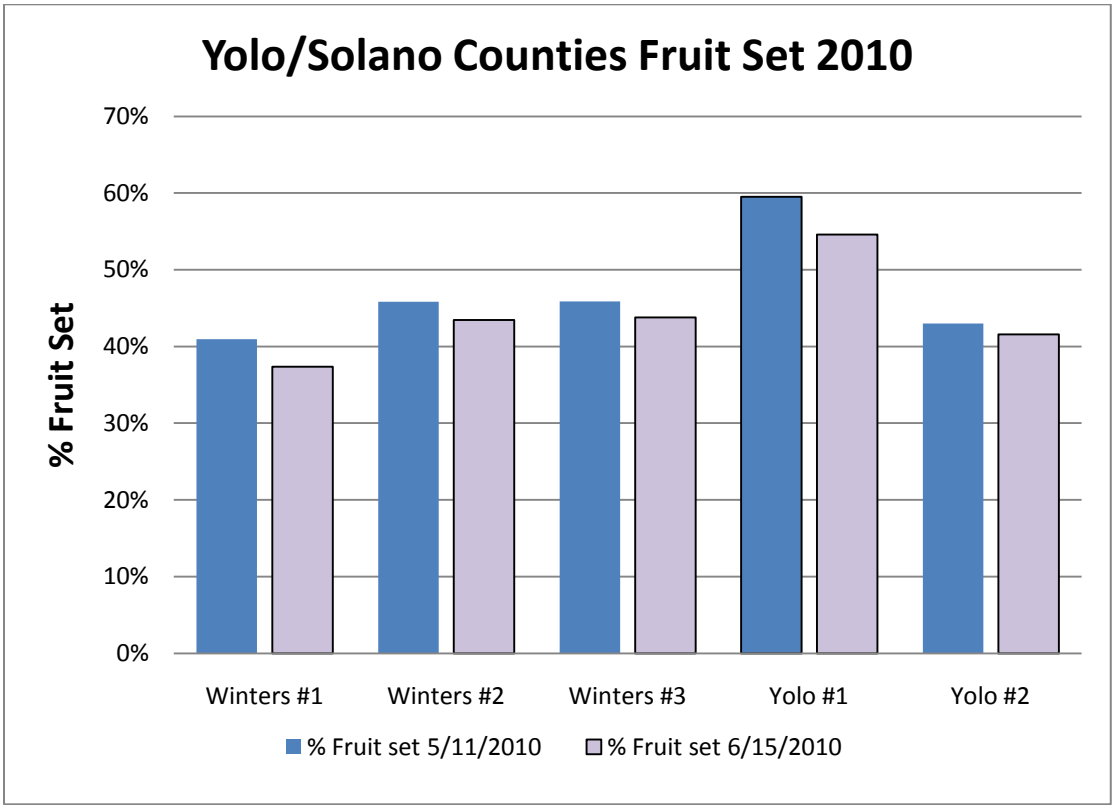

Figure 6. Average fruit set by county in 2010

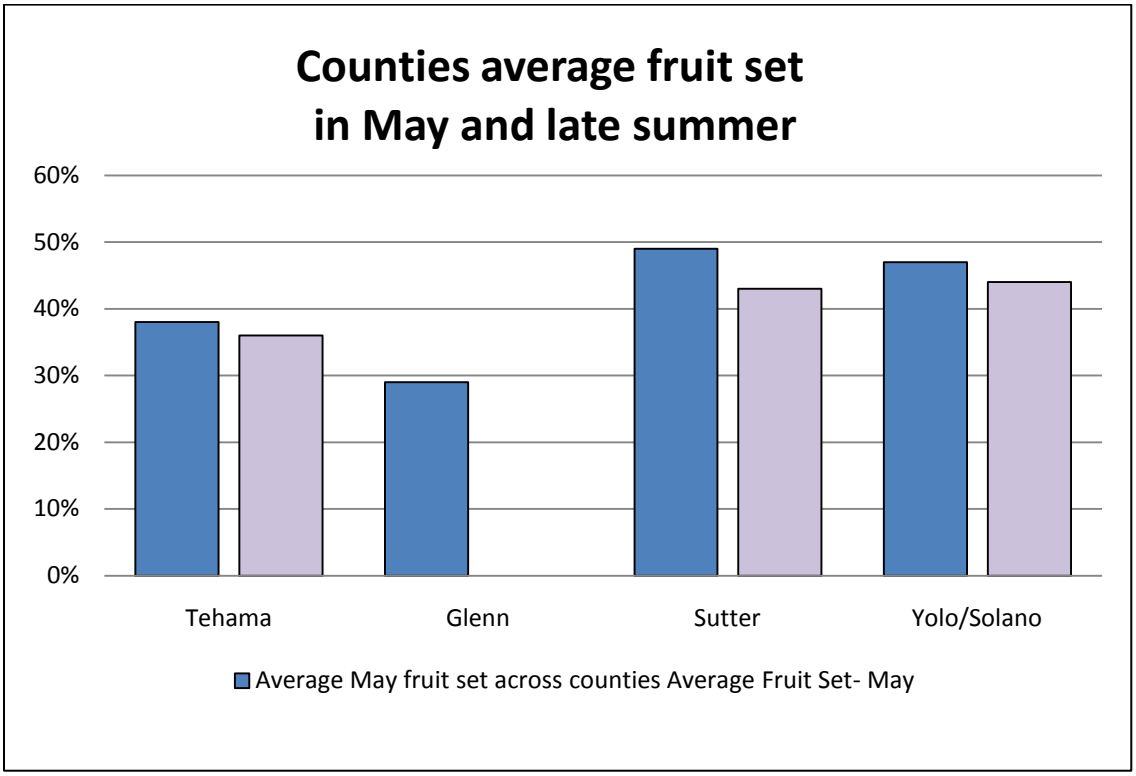

Figure 7. Tehama County Fruit set comparing 2009 to 2010 in the same orchards.

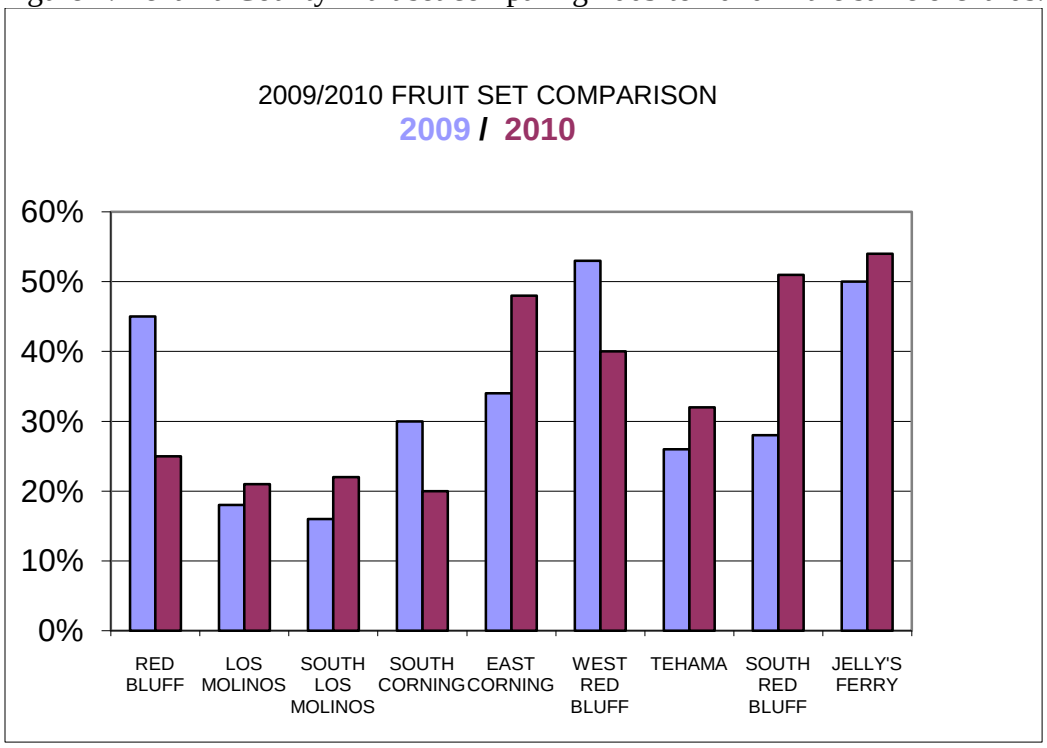

Figure 8. Temperature differences between the irrigated and non irrigated orchards measured at 5 ft above the ground March 17-23, 2010. (Sutter County)

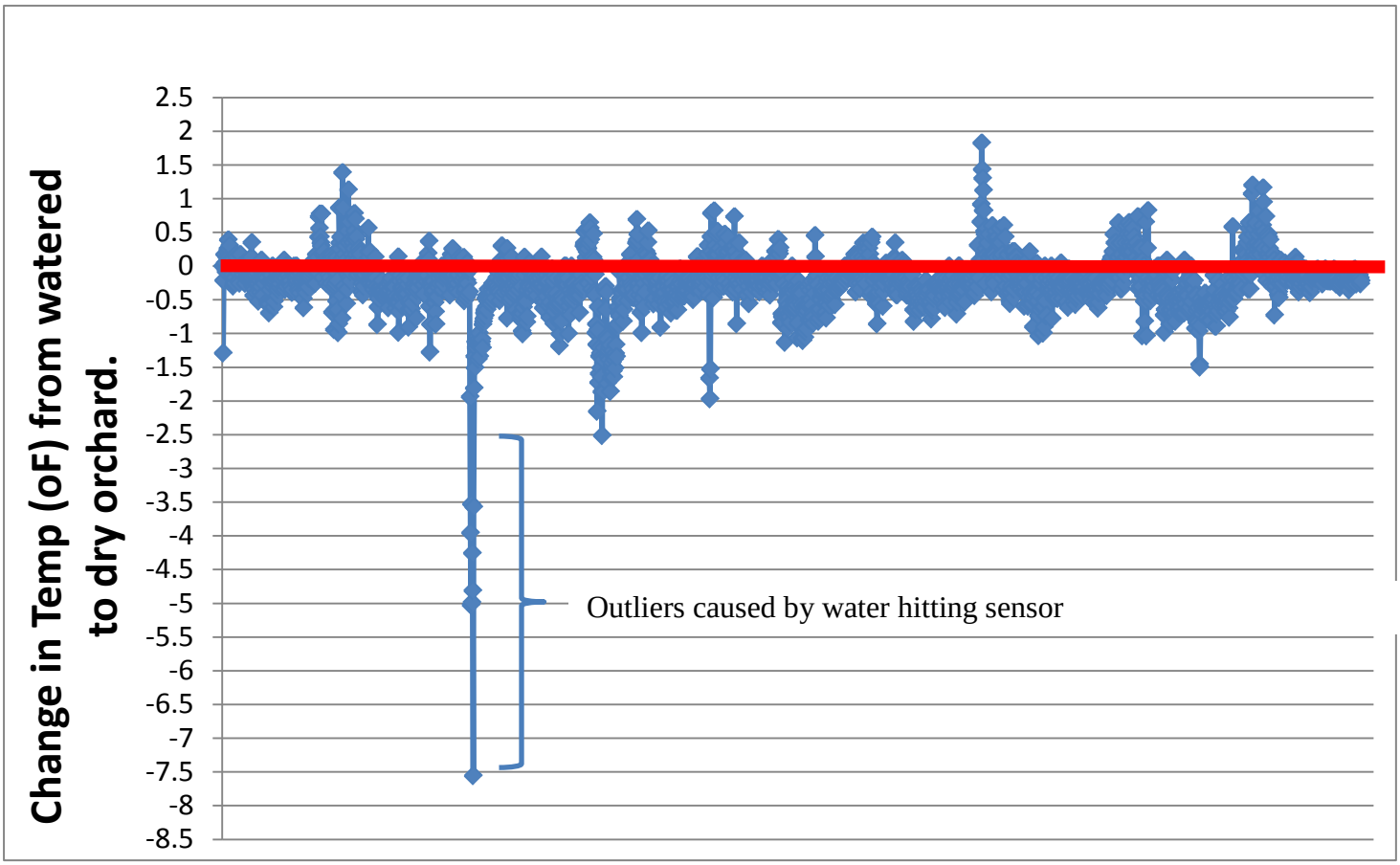

Figure 9. Maximum, minimum, average and median values for all shoots in the experiment treatments to evaluate materials to improve prune fruit set.