MANAGING HEAT AT PRUNE BLOOM

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PROBLEM AND ITS SIGNIFICANCE

Heat at bloom has significantly reduced prune production in key California growing regions in three of the last four crop years (2004, 2005, and 2007). Total grower economic losses in Sutter and Yuba Counties – with 40% of the prune acres in the stat -- 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 reduce orchard temperature once those thresholds have been reached. In addition, the interaction of flower nutrition and bloom temperature has not been assessed. 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. How can orchard temperatures be lowered using irrigation water?
3. Does flower nutrient level play a role in reduced set under high temperatures at bloom?

OBJECTIVES

1. Determine bloom-time temperature thresholds above which crop damage occurs.
2. Evaluate under-tree vs over-tree orchard cooling with micro-jet sprinklers for improving prune set during hot weather at bloom.
3. Measure and compare flower nutrient analysis in two different prune growing regions.

PLANS AND PROCEDURES

1. A study to assess the impact of heat on prune bloom set was established at the University of California's Wolfskill Experimental Orchard in Winters, CA during bloom. Two 6-

foot tall patio heaters were placed approximately 2 feet from blooming trees. Temperature sensors were placed near blooming flowers. The patio heaters were turned on in the afternoon, when ambient temperatures were highest, and turned off near 5PM. Open flowers were counted and all unopened flowers removed to make sure that the affect of heat on opened flowers was measured. Percent fruit set was measured by counting set fruit in June/July. Three separate experiments were conducted March 18-20, 2008, with a final total of 2200 flowers on 46 branches counted at bloom.

2. The affect of under-tree microsprinkler irrigation on orchard temperatures were measured in three counties in the Sacramento Valley: Tehama, Yolo, and Sutter. These measurements were done during late spring/summer. Temperature sensors were located in mature orchards either within or outside the canopies. In all counties, sensors were placed at 4-5’ from the ground. Additional sensors were placed 10’ off the ground in Sutter County.

3. Flower nutrient analysis was conducted on flowers from orchards in Yolo (2), Sutter (5), Glenn (2), and Yuba (1) Counties. One hundred newly opened flowers were taken from around the perimeter of tree canopies, dried at 55^{o}C and submitted for nutrient analysis to the UC ANR lab at UC Davis.

RESULTS AND DISCUSSION

1. Increasing flower exposure to hours of heat above 75^{o}F generally decreased final set (Figure 1). These results are consistent with field data from 2005 and 2008. However, the fruit set decrease with increasing hours was not as dramatic as we had anticipated. Dr. Vito Polito, UC Davis Plant Sciences Department, suggests that longer heat intervals for more days should be used in future research.

2. In all counties where late spring or summer irrigation was monitored to decrease orchard temperatures, temperature decreases ranging from 1-5^{o}F and increases in relative humidity from 0-20% were measured. An example of temperature changes with irrigation is shown in Figure 2. Larger differences were measured when ambient orchard temperatures were higher, and when irrigation was begun in the morning and shut off in the evening or run for several days continuously. There was little influence on orchard temperature when irrigation was run from the late afternoon through the next morning.

   Results are summarized in Table 1. In general, under-tree irrigation decreased temperatures 1-3^{o}F and increased relative humidity 1-6% compared to non-irrigated sites. Irrigation influence on temperature and RH decreased as the distance from the orchard floor increased.

3. All flower analysis results appear in Tables 2 and 3. There appear to be no apparent difference in flower nutrient levels between growing regions that might explain stark differences in prune production between Glenn and Sutter/Yuba counties in 2005 and 2007.

Figure 1. The affect on fruit set of hours above 75°F at bloom. Data points are from three separate experiments conducted March 18-20, 2008 Winters, CA.

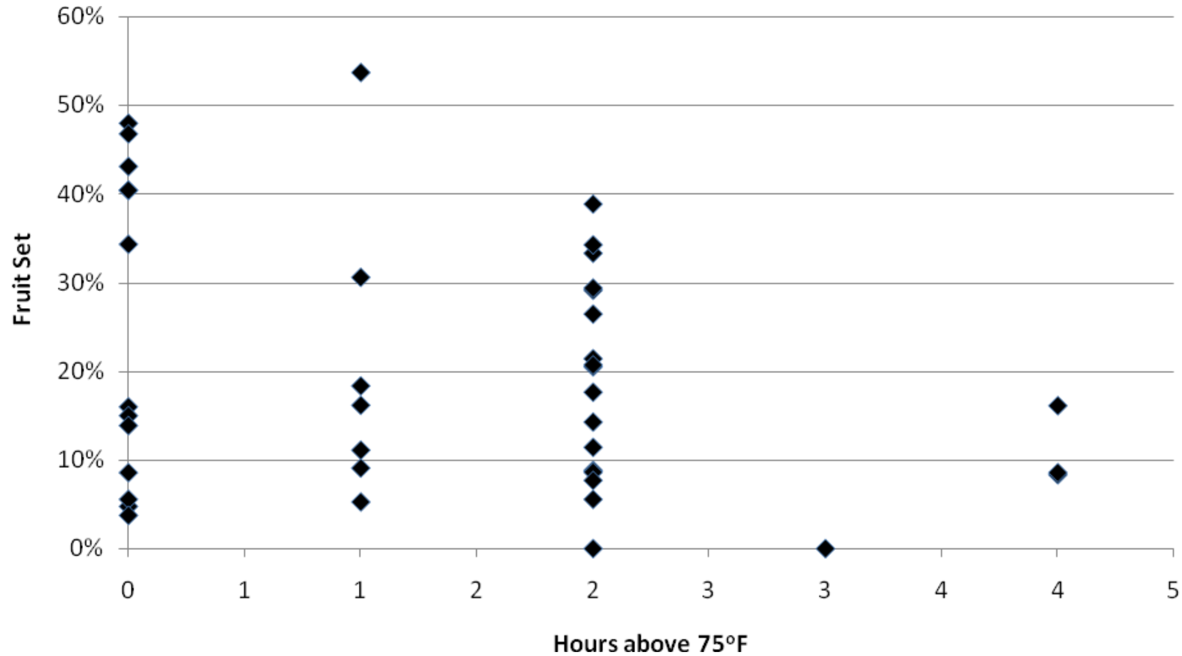

Figure 2. Temperatures at 4' high in two prune trees on June 5, 2008 in Tehama County. One trees was in a section of the orchard irrigated from 8AM to 11PM (dotted line), the other was in a part of the orchard that received no irrigation during this time (solid line). At 4PM the maximum difference between locations (3.4°F) occurred.

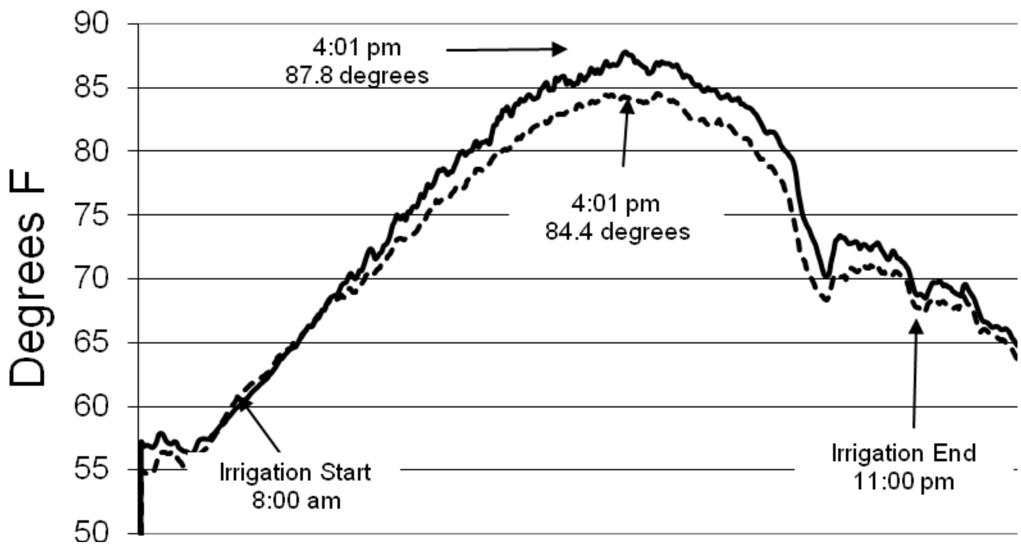

Table 1. Summary of trials to evaluate the affect of under-tree microsprinkler irrigation on orchard temperatures. Sensors were set up in portions of an orchard that were irrigated and in portions that were not irrigated and the difference in temperatures and relative humidity were noted when the pumps were on.

Region	Date(s)	Maximum air temperature/ Minimum %RH	Water On-off timings	Sensor in or outside canopy?	Maximum temp reduction with water	Maximum %RH increase with water
Solano	May 28	73.0°F/41.1%	On: 12:00 Off: 15:45	Outside	@ 5' -1.1°F @10' -1.2°F	@ 5' +5.4% @10' +1.7%
Solano	May 29	74.5°F/40.1%	On: 12:00 Off: 15:45	Outside	@ 5' -1.8 °F @10' -1.9°F	@ 5' +6.0% @10' +4.0 %
Solano	June 4	78.2°F/20.9%	On: 12:00 Off: 15:45	Outside	@ 5' -1.7°F @10' -0.9°F	@ 5' +2.6% @10' +1.2%
Sutter	June 22	93.9°F/19.6%	See note*	Outside	@ 5' -9.3°F @10' -1.2°F	@ 5' +29.4% @10' +1.8%
Tehama	May 15-May 16	100.1°F/--	On: 09:00 Off:06:00	Inside	@ 4' -3.6°F	
Tehama	June 5	87.8°F/---	On: 09:00 Off:23:00	Inside	@ 4' -3.4°F	
Tehama	June 12-June 13	94.8°F/--	On: 14:45 Off: 14:25	Inside	@ 4' -3.0°F	
Tehama	July 1-July2	91.1°F/--	On: 15:30 Off: 09:00	Inside	@ 4' -2.3°F**	
Tehama	July 2-July3	89.5°F/--	On: 16:00 Off: 09:00	Inside	@ 4' None	

*irrigation began several days before measurements, and there was standing water under irrigated trees. The large difference in temperature and RH between irrigated and non-irrigated was for a 1-2 hour period early in the morning. The average difference in temperature was similar for other sites: about 3-4°F.
**Largest temperature reduction was measured on July 2, 6 hours after irrigation was shut off.

Table 2. Nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), sodium (Na), and chloride (Cl) concentrations in newly opened French prune flowers from ten orchards in three counties in the Sacramento Valley. 2008. Micro nutrient levels from the same sites appear in Figure 3.

County	%N	%P	%K	ppm S	%Ca	%Mg	ppm Na	%Cl
Solano/Yolo1	3.07	0.38	1.64	1950	0.303	0.24	73	0.02
Solano/Yolo2	2.94	0.39	1.8	1700	0.321	0.24	36	0.02
Sutter/Yuba1	3.48	0.53	2.13	2010	0.25	0.21	25	0.02
Sutter/Yuba2	2.93	0.38	1.81	1900	0.325	0.2	24	0.02
Sutter/Yuba3	2.76	0.37	1.82	1730	0.287	0.21	26	0.01
Sutter/Yuba4	2.88	0.37	1.69	1720	0.297	0.2	26	0.03
Sutter/Yuba5	3.26	0.4	1.78	2020	0.38	0.18	15	0.02
Glenn1	2.74	0.35	1.83	1850	0.332	0.21	68	0.02
Glenn2	2.92	0.37	1.88	1880	0.365	0.19	22	0.01
Glenn3	3.13	0.39	1.95	1940	0.382	0.18	17	0.02

Table 3. Boron (B), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu), molybdenum (Mo), and nickel (Ni) concentrations in newly opened French prune flowers from ten orchards in three counties in the Sacramento Valley. 2008. Macro nutrient levels from the same sites appear in Figure 2.

County	ppm B	ppm Zn	ppm Mn	ppm Fe	ppm Cu	ppm Mo	ppm Ni
Solano/Yolo1	103	147	26	50	12.7	<0.1	2
Solano/Yolo2	79	30	24	63	9.6	<0.1	1
Sutter/Yuba1	75	50	48	89	14.5	<0.1	2
Sutter/Yuba2	63	33	23	53	10.1	<0.1	<1
Sutter/Yuba3	92	99	28	54	10.1	<0.1	2
Sutter/Yuba4	85	44	26	53	12.6	<0.1	3
Sutter/Yuba5	76	48	29	55	13.5	<0.1	2
Glenn1	85	59	24	53	15.2	0.1	1
Glenn2	85	44	27	47	11.1	<0.1	2
Glenn3	101	36	23	46	13.2	<0.1	1