Irrigation Effects on Walnut Kernel Quality as Affected by Nut Temperatures Throughout the Season

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ABSTRACT

Heat-related injury manifested by dark kernel color is thought to be influenced by numerous factors, including irrigation. Presumably, water deprivation results in elevated kernel temperature due to reduced water loss from the hull and/or higher temperatures in the canopy as the result of diminished leaf transpiration. A study was undertaken in 1987 as part of our deficit irrigation project on hedgerow cv. Chico trees to evaluate the relationship between irrigation-related nut temperature throughout the season and the development of pelicle color. Continuously recording thermocouples were inserted into the packing tissue when the nuts were 0.75 to 1.0 inch in diameter. Thermocouples were also affixed to the hulls. Weekly nut samples were taken, cracked out, and visually rated for sunburn and pelicle color.

We found large differences throughout the season in kernel temperature (commonly 6 to 7°C) between well watered and stressed nuts. Peak kernel temperatures of sun-exposed nuts regularly exceeded 40°C. However, little effect on nut quality was observed. RLI at harvest was 52.4, 52.5, and 50.2 for the 100, 66, and 33% ET irrigation regimes, respectively. This indicates the cv. Chico is relatively insensitive to heat related injury.

We believe that the methodology developed in this study is sound and that the question of how irrigation-related nut temperature affects kernel quality is important. Accordingly, we anticipate repeating this work on more heat sensitive cultivars (Vina and Ashley) next season.

OBJECTIVE

To evaluate the relationship between nut temperature throughout the season and the time-course development of pelicle color in cv. Chico walnuts.

PROCEDURE

This study was conducted as part of the deficit irrigation project on the hedgerow planting at the Kearney Agricultural Center (see site description in the report entitled, "Second Year Effects of Deficit Irrigation on Walnut Tree Performance").

Hull and kernel temperature measurements were taken throughout the season on nuts in western, sun-exposed and fully shaded areas of the canopies. Temperature was measured nearly continuously (once per minute) and averaged over 15 minute intervals. When the nuts were 0.75 to 1.0 inch in diameter, 36 gauge thermocouple wire (chromel-constantan) was inserted approximately 0.5 cm into the suture, resulting in the tip, or location of measurement, being in the packing tissue. This measurement is hereafter referred to as the kernel temperature. The installation procedure for this internal measurement was the
same for both sun-exposed and shaded nuts. However, for the measurement of hull temperature, care was taken to ensure that the location of the thermocouple on sun-exposed nuts was such that it would receive the maximum direct radiation at midday, in order to monitor maximum hull temperature. In the shade, hull temperatures were made at random on the nut surface. The thermocouples were affixed to the hulls with non-conducting, non-phytotoxic cement. Eight sun-exposed nuts and seven shaded nuts in a single replication for each irrigation were instrumented. A multiplexing relay with 32 channels was used at each plot to expand the capability of a single datalogger for recording and averaging thermocouple readings. Additionally, ambient air temperature and relative humidity at 6 ft above the ground were measured in the canopy between two trees in which the nut temperature data was collected in each irrigation regime.

Manual readings of kernel and hull temperatures in shade and sun-exposed nuts were also taken weekly at midday beginning June 24 with a hand-held temperature probe. The manual measurements were taken for comparison with the continuous recordings. The walnuts from the manual measurements were collected and removed to the laboratory for quality analysis (10 from each exposure in each treatment; 60 in total). Visual quality ratings of the hulls were as follows: 1 = green, 2 = light yellow, 3 = tan, and 4 = brown. The kernels were rated as: 1 = normal, 2 = slight browning, 3 = moderate browning, 4 = severe browning, 5 = shrivel, and 6 = speckled.

RESULTS AND DISCUSSION

Much effort was expended in this project to precisely measure hull and kernel temperatures of nuts on the tree from mid-June through late September. This was accomplished using both continuously-recording temperature measuring devices and with midday measurements from a hand-held probe. Our goal was to correlate some aspect of these measurements, possibly peak daily readings or the duration of time that temperatures exceeded a certain threshold value, with nut quality that was assessed weekly. However, little, if any, real differences in pelicle color were observed for the different irrigation levels and overall nut quality was relatively good. This is reflected by harvest RLI values of 52.4, 52.5, and 50.2 for the 100, 66, and 33% ET irrigation regimes, respectively. This was achieved even though large differences in nut temperatures were recorded. The following data is provided to illustrate these differences as well as to indicate the performance of the technology utilized.

Although little difference in nut quality was found, sunburn symptoms did develop on both sun-exposed and shaded nuts; the time-course development of which is shown in Figures 1 and 2, respectively. Sunburn clearly developed earlier in sunlit conditions but again, little correlation with irrigation levels was observed. If anything, the more stressed nuts exhibited less sunburn, at least through August. This mild trend also existed in the shaded nuts, whose sunburn symptoms did not develop rapidly until early September.

Maximum daily kernel temperatures of sun-exposed and shaded nuts are shown in Figures 3 and 4, respectively. For the sunlit nuts, temperatures were consistently hotter in the deficit irrigated treatments. Interestingly, sunlit nut temperatures in the 33 and 66% ET plots were nearly identical through early September, while the 100% ET nuts had lower temperatures, especially for the...
month prior to harvest. Stressed nut temperatures commonly exceeded 40°C. Earlier work by Martin, Sibbett, and Ramos (1973) on Payne and Hartley cultivars showed that when kernel temperature at harvest exceeded 40°C, nut quality was markedly reduced, especially with Payne. Since this did not occur in our study, it appears that Chico trees are relatively insensitive to heat-related injury.

Much cooler kernel temperatures existed with the shaded nuts, and it's interesting to note that the 66 and 100% ET responses were nearly identical through harvest and differed appreciably from the 33% ET regime (Figure 4). This observation was confirmed by the manual measurements. (While the manual readings confirmed the trends and relative relationships observed using the continuously recording devices, the manual readings were 3 to 4°C less than the continuous readings. The reason for this discrepancy is currently unknown but under investigation.)

Relationships between daily peak kernel and ambient air temperatures (measured in the shaded tree canopies) throughout the season for sun-exposed and shaded nuts under 100% ET are shown in Figures 5 and 6, respectively. Similar relationships were found in the deficit irrigation regimes. Under full sun exposure, kernel and air temperatures consistently tracked each other with the kernel being hotter throughout the season. The relatively wide divergence after harvest (September 10) was presumably due to complete breakdown on the hulls, which included blackening and thus, greater solar radiation absorption. On the other hand, shaded nuts had kernel temperatures similar to the ambient air at all ET levels (Figure 6).

Relative differences between hull and kernel temperatures are easily observed by considering diurnal behavior on July 1 and August 3 which were cool (87°F peak temperature) and hot (101°F peak temperature) days, respectively. Figure 7 shows that for sun-exposed nuts under full ET, the hulls were slightly cooler than the kernels only between 11:00 a.m. and 4:00 p.m. On the other hand, the 33% ET sun-exposed nuts had warmer hulls relative to the kernels during this time period (Figure 8). This may be due to reduced water loss and associated cooling from the hulls due to the plant water stress. Regardless of the irrigation level, diurnal kernel and hull temperatures on July 1 were identical for shaded nuts (Figures 9 and 10).

Under higher evaporative demand (August 3), hull temperatures slightly exceeded kernel temperatures in the sun-exposed nuts in the 100% ET treatment (Figure 11). The differences and duration of divergence were greater in the water stressed nuts, as shown in Figure 12. This was presumably the result of less evaporative cooling by the hull. Although air temperatures were relatively hot on this day, again shaded nut hull and kernel temperatures were identical throughout the day over all ET regimes (data not shown).

CONCLUSIONS

Large differences throughout the season in kernel temperature (commonly 6 to 7°C) existed between nuts on fully and deficit irrigated trees. This occurred under both sun-exposed and shaded conditions. Temperature differences were presumably due to reduced evaporative cooling from the hulls resulting from the plant water stress. Peak kernel temperatures of sun-exposed nuts in the water-stressed trees regularly exceeded 40°C. However, little effect on nut
quality was observed, as indicated by nearly equal RLI values (averaging ≈ 51) and weekly observations of pelicle color. This indicates that cv. Chico is relatively insensitive to heat-related injury.

Early in the season, sun-exposed hull temperatures on fully irrigated nuts were slightly less than kernel temperatures. During this time, deficit irrigated nuts had hotter hulls relative to the kernels. As evaporative demand increased over the season and as the hulls began to break down, nuts at all irrigation levels had hotter hulls relative to the kernels. On shaded nuts, hull and kernel temperatures were identical over the season, regardless of the irrigation treatment.

We believe that the methodology developed in this study is sound and that the question of how irrigation-related nut temperature influences kernel quality is important. Accordingly, we anticipate repeating this work on more heat sensitive cultivars (Vina and Ashley) next season.
Figure 1. Sunburn Index rating with time for sun-exposed nuts.

Figure 2. Sunburn Index rating with time for shaded nuts.
Figure 3. Peak daily kernel temperature for sun-exposed nuts.

Figure 4. Peak daily kernel temperature for shaded nuts.
Figure 5. Peak kernel and air temperatures for sun-exposed nuts under 100% ET.

Figure 6. Peak kernel and air temperatures for shaded nuts under 100% ET.
Figure 7. Diurnal temperatures of sun-exposed nuts under 100% ET on July 1; a relatively cool day.

Figure 8. Diurnal temperatures of sun-exposed nuts under 33% ET on July 1.
Figure 9. Diurnal temperatures of shaded nuts under 100% ET on July 1.

Figure 10. Diurnal temperatures of shaded nuts under 33% ET on July 1.
Figure 11. Diurnal temperatures of sun-exposed nuts under 100% ET on August 3; a relatively hot day.

Figure 12. Diurnal temperatures of sun-exposed nuts under 33% ET on August 3.