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The Effect of Drastic Reduction of Water Input on Mature Walnut Trees[1]

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Abstract. **Withholding irrigation of walnut trees (*Juglans regia* L. cv. Ashley) for one growing season significantly reduced trunk growth and kernel weight. Tree survival and return cropping were unaffected. When irrigation was resumed kernel weight was significantly heavier than that from trees irrigated the previous year.**

Although the arid climes of the central valleys of California are often deficient in rainfall, readily available irrigation water provides adequate moisture throughout the growing season. Normally, the Sierra Nevada range positioned on the eastern border of the valleys supplies all the water necessary for irrigation. For 3 consecutive winters snowfall in the Sierra Nevada range and rainfall in the valleys of California was deficient, with 1975-76 and 1976-77 being the second and third driest years in the history of our precipitation records. During that period growers drilled new and deeper wells in searches for water and the outlook for perennial crops appeared grim for 1977.

Growers were concerned about tree survival under minimal irrigation but we had no previous experience or written reports of similar experiences to answer their questions. The purpose of this study was to compare minimal and adequate irrigation on a previously-irrigated walnut orchard and to measure tree and crop conditions during these treatments in 1977 and through 1978 when irrigation was resumed.

A block of 8-year-old 'Ashley' walnuts, on Yolo clay loam in the Davis experimental orchard was selected for use. The block was divided into 4 plots, alternating irrigated with non-irrigated plots. No data was taken from the non-irrigated trees closer than 15.8 m (3-½ tree rows) from the irrigated plots. All the trees had been irrigated by the flood method in their previous history and received 7 irrigations in 1976 with an average of 125 mm water per hectare per irrigation. The experimental treatments started in 1977 and the irrigated trees received 8 irrigations with an average of 125 mm water per hectare per irrigation and no water was applied to the non-irrigated trees. The 192 mm rainfall for 1976-77 which was received by both irrigated and non-irrigated plots occurred in the non-growing part of the season. The 100-year average rainfall is 675 mm.

Soil moisture at 30 cm increments to a depth of 240 cm was determined with a neutron probe at a single site in each plot (1). Four random leaves which could be sampled from the ground were taken on July 6, 20; August 3, 17, 30; September 14, 27, and October 11, 1977, at sunrise and leaf water potential (Ψw) estimated with the Scholander pressure chamber (3). These readings were compared to those taken from seedlings in pots that were allowed to exhaust the soil moisture for 6 days in warm conditions at which time the leaves were just beginning to wilt. Two leaves each were taken from 3 plants for pressure chamber readings. The potted plants were rewatered, regained turgor and allowed to wilt a second time for additional pressure chamber determinations.

The change in soil moisture percent was plotted starting in February, 1977 as the reference level (Fig. 1) just prior to the first irrigation.

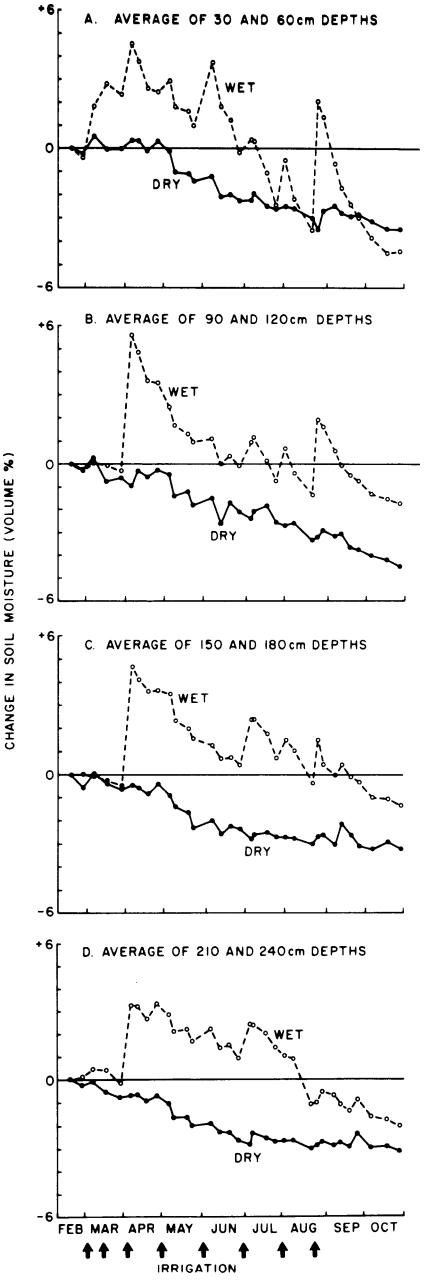

Fig. 1. Change in soil moisture as determined with the neutron probe for non-irrigated and irrigated 'Ashley' walnut, 1977. A) average of 30 and 60 cm readings; B) average of 90 and 120 cm readings; C) average of 150 and 180 cm readings; D) average of 210 and 240 cm readings. Irrigation dates noted with vertical arrows.

The first 2 irrigations in the irrigated plot resulted in water penetration down

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Table 1. Trunk growth, kernel weight, value, and quality from irrigated and non-irrigated Ashley walnuts, 1977 and 1978[z].

Treatment	Trunk growth (cm)	Kernel Wt (g)	Kernel Value (¢/kg)	Nut distribution by quality factors (%)[y] Light (A)	Lt. Amber (B)	Amber (C)	Total[x] Edible (A+B+C)	Off grade	Mold	Shrivel
				1977						
Non-irrigated	0.74 a	8.93 a	84.0 a	33.0 a	8.9 a	4.9 a	46.8 a	4.0 a	0.8 a	2.9 a
Irrigated	1.38 b	11.28 b	83.4 a	35.0 a	7.9 a	2.4 a	45.3 a	4.0 a	0.9 a	3.1 a
				1978						
Non-irrigated 1977, irrigated 1978	1.93 a	10.10 b	80.8 a	30.2 a	2.8 a	1.1 a	34.1 a	7.0 a	0	15.4 a
Irrigated 1977 & 1978	1.59 a	9.48 a	76.4 a	27.4 a	3.2 a	2.1 a	32.7 a	5.5 a	0	12.6 a

[z]Average of both plots for each irrigation regime. Mean separation within columns by Duncan's multiple range test, 5% level.

[y]USDA Standards for kernel color (light, light amber and amber), total edible kernel excluding shell, total off grade due to insect damage, mold and shrivel.

[x]Total edible – the sum of light, light amber and amber kernel grades. Example for 1977: the remaining percentage includes 4% off grade and 49.2% shell for non-irrigated and 4% off grade and 50.7% shell for irrigated.

to 60 cm. A heavy irrigation on April 1, resulted in infiltration down to 240 cm. Subsequent irrigations showed some detectable increases at all depths (Fig. 1A, B, C, D). The percent change in the non-irrigated plots crept steadily downward throughout the season as shown clearly in the 90 and 120 cm depths (Fig. 1B). This indicated that some soil moisture was available throughout the season even though the plot was not irrigated.

Early morning leaf Ψw in the irrigated trees was about −5 to −7 bars for most of the summer (Fig. 2). On August 30 it rose to −4 bars after a very effective irrigation on August 23 and finally decreased to −9 bars 6 weeks later. The leaf Ψw in the non-irrigated plots were always 1 to 3 bars lower indicating a greater stress in the non-irrigated trees than in the irrigated. However, the non-irrigated trees did not at any time show stress greater than −9 bars. Leaf Ψw of seedling trees just beginning to wilt was about −19 bars.

We counted pistillate flowers on 4 tagged limbs at bloom and the number of nuts remaining at harvest on the same 10 trees for each plot. Nuts were shaken to the ground and random 80 nut samples were evaluated for quality at harvest. Return bloom was determined in 1978 on each of the previously tagged limbs. Measurements of trunk circumference were made at a marked point on the north side of the trunk.

Trunk growth of trees in the non-irrigated plots was significantly less than irrigated plots in 1977 but there were no differences in trunk growth in 1978 when irrigation was resumed (Table 1). There were no significant differences in most kernel quality factors attributable to irrigation treatment in 1977 except for a reduction of kernel weight in non-irrigated plots (Table 1).

Normal irrigation was resumed in all plots in 1978. No differences in nut quality were found between treatments at the end of the 1978 growing season. A slight but significant increase in kernel weight was detected in the samples taken from the plot which had not been irrigated the previous year (Table 1).

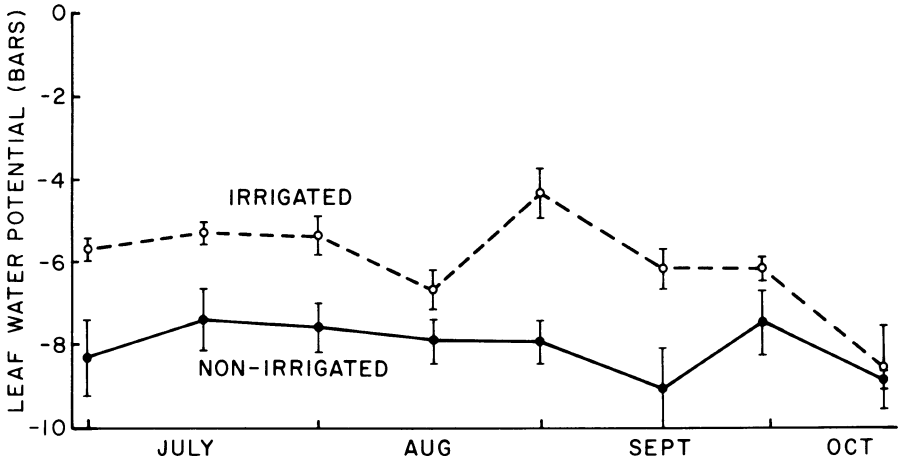

Fig. 2. Leaf water potential readings in bars from non-irrigated and irrigated 'Ashley' walnut leaflets, 1977.

The adaptability of the non-irrigated walnut trees was evident throughout the 1977 growing season. Tree survival was 100% with no obvious visual symptoms of stress. There were decreases in kernel weight, trunk growth, soil moisture and leaf Ψw in the non-irrigated block. Although economic value was reduced (21% smaller kernel weights in 1977) the orchard survived.

Reduced kernel quality and earlier defoliation in 1977 and fewer return blooms in 1978 were expected but not found in the non-irrigated trees. The reason for significantly heavier kernels in 1978 from trees not irrigated the previous year is not clear. Perhaps the non-irrigated 1977 trees conserved a marginal advantage in carbohydrate for early fruit growth in 1978.

Ramos et al. (2) in a similar study started in 1977 in the southern San Joaquin Valley on 'Serr' walnuts reported a 27% reduction in kernel weight from the non-irrigated plot and a decrease in percent light kernel and kernel value in non-irrigated nut samples. The poor quality nuts were found to be located in sun-exposed position of the trees. They reported no differences in quality between nuts taken from the shaded portion of trees of either irrigation treatment. The 'Serr' cultivar may be more sensitive to water stress than the 'Ashley' or the degree of water stress was different between the 2 experiments.

In our study the non-irrigated trees, although under more water stress than the irrigated trees, continually extracted soil moisture throughout the season (Fig. 1). Also, the relatively high leaf Ψw (−9 bars) of these trees (Fig. 2), which did not wilt, was much less than the Ψw (−19 bars) of seedling trees near the wilting point.

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