

Water stress affects size and quality of walnuts

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Irrigation is generally accepted as one of the most important single factors in producing high quality walnut kernels. Numerous reports describe the adverse effects of dry soil on kernel quality; but there is little experimental data to explain the effects of lack of soil moisture on the normal seasonal development of walnut fruit. To obtain such data, a study was conducted at the U.C. West Side Field Station, Five Points, in 1977.

Walnuts from frequently irrigated trees (cv. Serr) planted in 1966 at a spacing of 25 feet were compared with those from similar non-irrigated trees. All of the trees had received winter irrigation which wetted the soil profile (Panoche clay loam) to its field capacity over 6 feet deep. The wet plots then received supplemental irrigations throughout the growing season.

Two wet plots, each consisting of eight experimental trees surrounded by guard trees, were irrigated ten times between bloom and harvest. Two similar adjacent plots received no irrigation during this period. Periodic gravimetric soil moisture samples were taken to a depth of 6 feet. Fruit diameter growth was measured frequently on 40 tagged nuts in each plot.

Fruit samples consisting of four nuts from the lower canopy of each experimental tree were collected at about two-week intervals from each plot to determine fresh and dry weights and sugar and oil contents. Starting in mid-June, the kernels (embryos) were removed and analyzed separately from the remainder of the fruit. Nuts fully exposed to the sun (in the tops of trees) were sampled periodically from the end of June to harvest for a visual assessment of kernel skin (pellicle) darkening. At harvest, nut samples were taken from each experi-

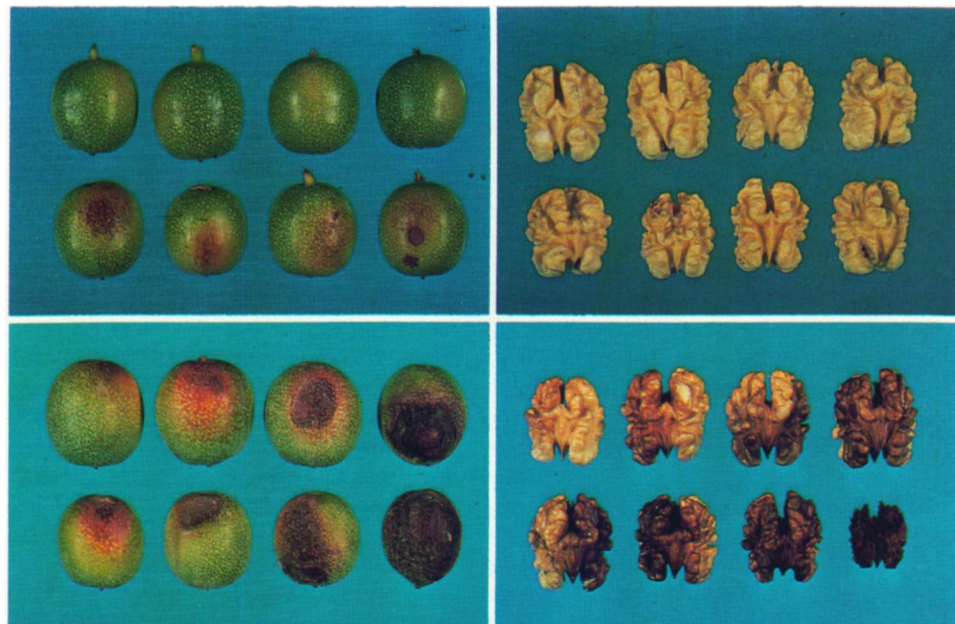


Fig. 1. Representative samples showing range of hull and kernel discoloration of nuts from exposed branches of wet vs. dry walnut trees in late June and early September.

mental tree and submitted to Diamond Walnut Growers, Inc., for a quality analysis of the cracked-out kernels.

Gravimetric soil moisture samples indicated that only the top 2 feet of soil were wetted at each irrigation (fig. 3). In spite of the water penetration problem, there was much more water available to irrigated trees throughout the season as a result of the frequent water applications (41.3 inches applied in ten irrigations). Soil moisture differences would be more obvious, particularly early in the season, if the soil sampling had followed irrigations more consistently. The wet plots never reached the permanent wilting percentage (PWP) in the upper 2 feet of soil, whereas the trees in the dry plots had exhausted the available moisture supply throughout the upper 6 feet by the end of June. Even before that time the dry trees were under some water stress compared with the wet trees; after that time, they were

under the severe stress of drought.

The difference in soil moisture regimes before the end of June was sufficient to affect fruit growth (fig. 4). By late May the nuts from the wet trees were larger, growing more rapidly than those from the dry trees until they reached final size in June. Maximum nut diameter in the wet trees was 42 mm, compared with 40 mm in the dry.

Early embryo development did not differ between treatments. The endosperm within the kernel skin began to change from a watery to a gelatinous consistency about mid-May, and was completely jellylike by mid-June when shell hardening began and kernel growth was visible. Even though the nuts virtually reached their maximum diameter and fresh weight by the end of June, the dry weight continued to increase through harvest because of the development of the kernel (fig. 5). However, dry matter accumulation was progressively less in nuts

Fig. 2. Kernel crack-out samples at harvest from wet and dry walnut trees.



from the dry trees.

The kernel became completely filled by mid-July, but continued to gain in dry weight through August and September primarily because of oil accumulation (fig. 6). The concentration of oil was the same in nuts from the wet and dry plots, reaching about 70 percent at harvest; however, the amount of oil accumulated per kernel was greater in the wet trees because of the larger nut size. The average size of dried harvested nuts from the wet trees was 9.63 grams compared with 7.58 grams from the dry, an increase of 27 percent.

Other determinants of walnut value include kernel skin color and kernel shrivel. Harvest samples from the dry trees clearly had a greater proportion of darkened, shriveled kernels (fig. 2). Color of kernels as judged by USDA standards averaged 32 percent light on an in-shell weight basis in the wet trees, compared with only 20 percent in the dry; dry trees produced about twice as many shriveled kernels (5 percent off-grade); and the percent of total edible kernel of nuts from the wet trees was 56, compared with 52 from the dry trees. Calculation of the net worth of the walnuts based on estimated 1977 walnut prices shows nuts from the wet trees were 12 percent higher in value at 47.9¢/pound. The combination of this increase in value and the larger nut size resulted in 43 percent higher returns from the wet trees.

At the end of June, the hulls of many exposed nuts showed increasing yellowish-brown discoloration, characteristic of sunburn injury; but exposed nuts on the dry trees exhibited the problem to a much greater degree. Nut samples taken from ex-

posed limbs on the southwest side of trees in the wet and dry plots showed that significant kernel discoloration was associated with the hull injury (fig. 1). In June and July small dark spots developed on the skin (speckling); by August and September there was a more general darkening of the kernel pellicle (see table). The damage was consistently much more severe on the exposed nuts from the dry trees. Beginning with the mid-July sample, there was a significant increase in the number of exposed nuts with black shriveled kernels on the dry trees. This was not evident in the exposed nuts collected from the wet trees. In contrast to the exposed nuts, there was practically no indication of kernel darkening or shrivel in the shaded nuts of either the wet or dry trees. In both treatments, 72 percent of the shaded nuts were light colored.

Nut development in walnuts occurs in two distinct stages: a period of rapid fruit enlargement between bloom and early June when the shell begins to harden; and a subsequent period during late summer in which there is no enlargement in nut size but dry matter continues to increase as a result of growth and oil accumulation by the kernel. Nut size, which is determined in the initial period of growth, is highly sensitive to soil moisture changes. This experiment indicates that nut size and, indirectly, yield are reduced when trees are under mild water stress early in the season, even though there may be some available soil moisture in the root zone. This places great importance on beginning the growing season with a fully wetted soil profile. Also, it is desirable to begin irrigations early and apply them frequently enough to maintain a high level of

soil moisture availability throughout the early, nut-growing period (April through June).

As water stress became more severe, dry matter accumulation in the fruit was progressively slowed down in the dry treatment resulting in large differences in yields and net returns at the end of the season.

Kernel quality is determined in the late summer with the development of the embryo. Sunburning which causes kernel darkening and shriveling on the tops or exposed parts of trees is greatly aggravated by severe water stress. Presumably this is the result of closure of the stomates, reduced transpiration of water, and a subsequent increase in the kernel temperature of exposed nuts. Failure to irrigate near harvest after the trees have depleted most of the soil moisture can result in a substantial reduction in kernel quality.

Because kernel quality is reduced primarily by exposure of nuts to the sun, anything that can provide some shade to nuts is of value. Invigoration of shoot growth can provide some natural shade to nuts in the upper portions of the tree: pruning and tree vigor probably have a tremendous influence on the degree of kernel damage induced by severe stress. If low soil moisture is anticipated for the summer, growers should prune more severely in the upper portions of the trees during the dormant season to stimulate more shoot growth and develop more leaf canopy for protection. Previous work has shown that whitewash sprays are ineffective in severe water stress situations.

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Kernel Discoloration and Shriveling in Nuts from Exposed Branches of Wet vs. Dry Walnut Trees

Sample	Wet % damaged kernels				Dry % damaged kernels					
	Speckled	Dark	Dark and shriveled	Total	% of pellicle surface darkened	Speckled	Dark	Dark and shriveled	Total	% of pellicle surface darkened
6/29	30	—	—	30	0.1	100	—	—	100	1.0
7/13	35	—	—	35	0.2	55	35	10	100	28.5
8/16	20	50	—	70	15.0	—	85	15	100	65.0
9/8	—	90	—	90	45.0	—	85	15	100	95.0

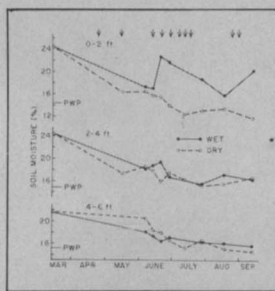


Fig. 3. Seasonal changes in soil moisture at three depths in irrigated vs. non-irrigated walnuts. Wet trees received ten irrigations during growing season as indicated by arrows.

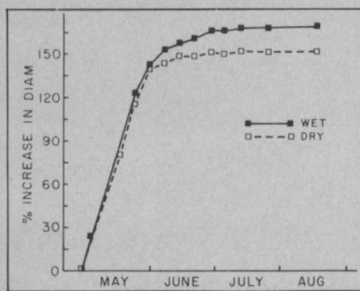


Fig. 4. Seasonal growth of walnuts on wet vs. dry trees.

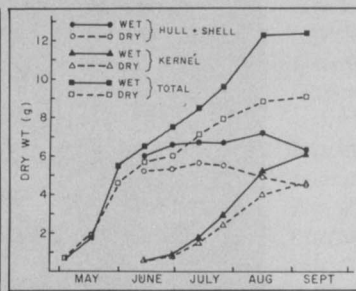


Fig. 5. Dry matter accumulation in walnuts from wet vs. dry trees. Hull and shell includes the packing tissue around and between kernel halves.

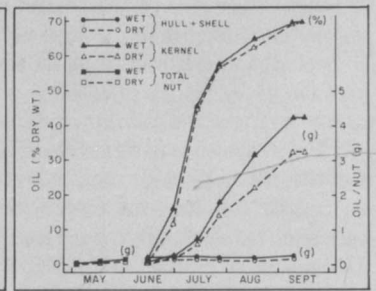


Fig. 6. Oil accumulation in walnuts from wet vs. dry trees. Hull and shell includes the packing tissue around and between kernel halves.