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A newsletter from the University of California Cooperative Extension seeking to support viable irrigated agriculture and wise and judicious use of limited water and land resources in the Northern Sacramento Valley.

In This Issue

Pages 1 through 4 provide a summary of an on-farm irrigation experiment in Chandler Walnut that was conducted on the Westside of Tehama County from 2002 through 2004. The article highlights how irrigation management can affect walnut yield, quality, and payment. The information is relevant as the 2005 irrigation season begins. The insert provides a reminder that weekly "Soil Moisture Loss Reports" are available to assist with making irrigation decisions. Thank you!

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Importance of Irrigation in Walnut

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About the Experiment…

Irrigation is one of several crucial cultural practices in walnut production. A field scale (nine acre) irrigation experiment was conducted on 8th, 9th, and 10th leaf Chandler walnut from 2002 through 2004 to evaluate and demonstrate the importance of irrigation management as a cultural practice. A second objective was to develop new tools for use at the farm level to aid in irrigation management decisions.

Test trees included Chandler on Paradox and Northern California Black Walnut rootstock. The orchard was hedged annually on alternating sides of the trees during the experiment. The experiment was conducted on the Maywood and Arbuckle series, soils common to the westside Sacramento Valley. The soils were predominantly course in texture with low water holding capacity (only 3 to 4 inches of soil moisture retention in root zone) and rapid drainage. Soil stratification tended to limit rooting depth to about three to four feet.

The orchard was irrigated with micro sprinklers. The experiment included three irrigation strategies replicated four times for evaluation. Irrigation regimes were described as low water stress, mild water stress, and moderate water stress. A range of 3.5 to 3.7 acre-feet water per acre was applied per season in the low water stress regime. A range of 2.2 to 2.6 acre-feet water per acre per season was applied in the mild stress regime. A range of 1.8 to 2.1 acre-feet water per acre per season was applied in the moderate stress regime. The seasonal orchard water status averaged –3.5, -6.0, and –7.2 bars, in the respective irrigation regimes. A pressure chamber was used to measure midday stem water potential (MSWP). Irrigation

was reduced in the mild and moderate stress irrigation regimes primarily in July, August, and September. The concept was to gradually withhold water to induce crop stress mid to late season after shoot growth and nut sizing were completed. This deficit irrigation strategy might minimize the effect of an irrigation deficit on crop productivity.

Shoot Growth Response to Irrigation

Walnut shoots grown in the current year provide the reproductive buds that may develop fruiting spurs the following year. Measurement of shoot growth for 96 pruned shoots in each irrigation regime revealed that shoot growth declined only in the moderate stressed irrigation regime (-7.2 bars). Cumulative shoot growth averaged 2.4 feet per season. The decline in shoot growth in the moderate stress regime occurred in both Paradox and Northern California Black walnut rootstocks. Cumulative shoot growth averaged 3.5 and 3.3 feet per season, respectively, in the low stress (-3.5 bars) and mild stress irrigation regimes (-6.0 bars). The absence of a significant decline in shoot growth in the mild stress irrigation regime (-6.0 bars) suggested walnut might withstand mild deficit irrigation without affecting productivity.

Dry In-shell Yield Response to Irrigation

Table 1 shows the average applied water and the corresponding dry in-shell walnut yield for each irrigation regime by year for Chandler grown on Paradox rootstock. Both mild (-6.0 bars) and moderate (-7.2 bars) levels of deficit irrigation decreased dry in-shell yield. Yields declined progressively over the three growing seasons and culminated in 2004 with 27 and 40 percent reductions in dry in-shell yield in the mild stress and moderate stress irrigation regimes, respectively.

Further evaluation revealed the primary reason for the yield reduction was that deficit irrigation progressively reduced the number of nuts set per tree. By 2004, the nut set was reduced 28 percent in the mild (-6.0 bars) water stress regime and 41 percent in the moderate (-7.2 bars) water stress regime. The reduction in number of nuts per tree was expected in the moderate water stress regime because a significant reduction in shoot growth was evident. However, the reduction in the number of nuts per tree in the mild water stress regime was more surprising since significant reduction in shoot growth was not measured. A subsequent evaluation of bud formation and development on tagged walnut shoots revealed an increasing proportion of buds on shoots in the mild water stressed regime were idle and did not produce foliage or walnut fruit spurs.

Table 1. The effect of irrigation on dry in-shell yield of Chandler walnut grown on Paradox rootstock. Tehama County, 2002 – 2004.

Year	Applied Water (ac-ft/ac)	Percent less water	Yield (lbs/tree)	Percent less Yield
02	3.65	-----	60.0 a	-----
02	2.60	29	55.2 a	8
02	2.15	41	50.9 a	15
03	3.70	-----	78.9 a	-----
03	2.18	41	69.4 a	12
03	1.80	51	61.8 b	22
04	3.58	------	63.4 a	-----
04	2.22	38	47.2 b	26
04	1.94	46	38.3 c	40

* Mean values followed by different letters a, b, or c in the yield column indicate averages that are statistically different at a 95 percent confidence level. Mean values with the same letter are not statistically different.

The effects of deficit irrigation on dry in-shell yield of Chandler on Northern California Black walnut rootstock were slightly more pronounced than for Chandler walnut on Paradox rootstock. After three consecutive years of deficit irrigation, yield reductions progressed to 29 and 45 percent less than in the low stress irrigation regime.

Walnut Quality Response to Irrigation

Table 2 provides the average applied water and corresponding walnut quality for each irrigation regime by year for Chandler on Paradox rootstock. Irrigation significantly affected walnut quality and walnut value two of the three years. The effect was largest in 2003 when deficit irrigation resulted in significantly darker kernel color, higher off-grade, and lower edible kernel. In combination, the negative effects of deficit irrigation on these three walnut quality parameters resulted in significantly lower crop value in 2003 (a reduction of more than $150 per 1000 lbs). The effect of deficit irrigation

was also significant in 2002. Nut size decreased while darker kernel color and off-grade increased in 2002. The net effect was a significant reduction in crop value (about $45 per 1000 lbs). Nut quality and crop value was not affected by irrigation in 2004 suggesting irrigation can significantly affect quality and value but not always.

Table 2. The effect of irrigation on walnut quality and value of Chandler walnut grown on Paradox rootstock. Tehama County, 2002 – 2004.

Year	Applied Water (ac-ft/ac)	% Large	% Light Amber + Amber	% Off-Grade	% Edible Kernel	Value $/1000 lbs
02	3.65	92.1 a	14.2 a	1.2 a	49.3	883.40 a
02	2.60	92.1 a	20.2 b	3.6 b	49.0	839.20 b
02	2.15	83.5 b	22.4 b	2.9 b	49.4	862.61 ab
03	3.70	81.9	11.7 a	2.4 a	53.7 a	1116.75 a
03	2.18	75.3	21.0 b	3.1 ab	51.3 b	1012.33 b
03	1.80	78.3	24.5 b	4.3 b	49.4 c	959.35 c
04	3.58	75.2	13.8	3.3	48.9	973.29
04	2.22	80.4	14.7	4.4	48.5	948.37
04	1.94	78.6	15.8	3.6	48.9	971.88

[1]Mean values followed by different letters a, b, or c in the columns indicate averages that are statistically different at a 95 percent confidence level. Mean values with the same letter are not statistically different.

The effects of deficit irrigation on quality and value of Chandler on Northern California Black walnut rootstock showed similar trends to those reported for Chandler on Paradox rootstock.

Effect of Irrigation on Total Payment

Total payment ($/tree) for walnuts is based upon the dry in-shell yield and crop value. Table 3 shows the average applied water and the corresponding total payment for each irrigation regime by year for Chandler on Paradox. The effect of irrigation on total payment for Chandler on Northern California Black showed similar trends.

Total payment for dry in-shell payment declined as irrigation was withheld. After the first year of deficit irrigation, total payment declined 12 and 17 percent in the mild (-6 bars) and moderate stress (-7.2 bars) irrigation regimes, respectively. The decline was partly due to a slight yield reduction related to reduced nut size and partly due to a decline in walnut quality and crop value.

After a second year of deficit irrigation, total payment continued to decline to 21 and 33 percent in the mild and moderate stress irrigation regimes, respectively. The reduced payment was due to both declining yield and walnut quality.

Table 3. The effect of irrigation on total payment of Chandler walnut grown on Paradox rootstock. Tehama County, 2002 – 2004.

Year	Applied Water (ac-ft/ac)	Total Payment ($/tree)	Percent Less Payment
02	3.65	52.95	------
02	2.60	46.48	12
02	2.15	44.10	17
03	3.70	88.81 a	------
03	2.18	70.24 b	21
03	1.80	59.66 b	33
04	3.58	61.76 a	------
04	2.22	45.17 b	27
04	1.94	37.33 b	40

[1]Mean values followed by different letters a, b, or c in the columns indicate averages that are statistically different at a 95 percent confidence level. Mean values with the same letter are not statistically different.

At the end of three consecutive years of imposing the mild and moderate stress irrigation regimes, total payment culminated in 27 and 40 percent reductions in total payment, respectively. A significant reduction in walnut yield was the primary reason for lower total payment after the third year of deficit irrigation.

Mismanagement of Irrigation Offsets Other Investments in Walnut Culture

At the beginning stages of orchard design and development, a consciences choice is made concerning rootstock and variety. Paradox and Northern California Black rootstock are the primary choices. Often, Paradox is preferred for its vigor and earlier and higher yield potential. However, it's more expensive than Northern California Black and is sensitive to crown gall.

Table 4 shows the effect of mild and moderate water stress on Chandler on both Paradox and Northern California Black rootstock. The average three-year cumulative yield is significantly and consistently higher for Chandler on Paradox rootstock when compared at the same level of irrigation. However, the results also illustrate that the advantage of

more expensive hybrid rootstock can be negated if irrigation is mismanaged. Dry in-shell yield and total payment for Chandler on Paradox rootstock under moderate water stress (-7.2 bars) was essentially the same as dry in-shell yield and total payment for Chandler Northern California Black rootstock under a low stress irrigation regime (-3.5 bars).

Table 4. The effect of irrigation on Paradox and Northern California Black rootstock. Tehama County, 2002 – 2004.

Rootstock	Three-year Avg Applied Water (ac-ft per acre)	Three-year Avg Dry Inshell Yield (lbs/tree)	Three-year Total Payment ($/tree)
Paradox	3.64	202	203.52
Paradox	2.33	172	161.89
Paradox	***1.97***	***151***	***141.09***
Black	***3.64***	***144***	***140.65***
Black	2.33	112	105.47
Black	1.97	101	92.97

Points to Remember

- This experiment was conducted on shallow soils typical of the westside of Tehama County
- These soils are quite different from alluvial soils closer to the Sacramento River. Because of this, the results are not suggesting that every orchard should receive 3.5 to 3. 7 ac-ft water per acre per season from irrigation. Walnuts grown on deeper alluvial soils may have substantially deeper rooting zones and a greater capacity to retain winter rainfall for use later in the growing season. In turn, this can greatly reduce the need for irrigation.
- These results demonstrate that irrigation management can have a strong influence on shoot growth, dry in-shell yield, walnut quality, and crop payment.
- If mismanaged, irrigation can negate other investments in walnut culture such as rootstock selection.
- Water management is a fundamental cultural practice requiring attention each season. These results demonstrate it can re-pay the effort invested substantially.