Walnut Marketing Board
Project Report
Project Year 2001-2002

Project Title: Irrigation Management and the Incidence of Phytophthora Root Rot in Young Walnut Trees

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Problem and its Significance:
The loss of walnut trees following spring planting has noticeably increased over the past few years. Symptoms include poor or minimal vegetative growth to outright tree death within the first or second season. Surviving trees with minimal first season growth often continue to perform poorly in the succeeding year and eventually are replaced. Possible explanations range from wet springs that saturate the root zone to the use/misuse of new technology irrigation systems such as micro-irrigation irrigation systems (drip and micro sprinklers). Both can encourage Phytophthora root and crown rot.

Continued observation of these problems has resulted in an emergence of two factors as important to the problem: first a desire to maximize tree growth can lead to over-irrigation and second, many growers (as well as ourselves) are uncertain about proper irrigation frequency, duration, and quantity of applied water. The presence/absence of Phytophthora inoculum can further complicate the situation. Over-irrigation can be prevented by reducing irrigation volumes to the estimated water use or by the correct use of soil-based water status devices to prevent soil saturation. However, no comprehensive guidelines for irrigating young walnuts currently exist.

This study seeks to determine the responses of English walnut (Chandler cultivar) grafted on Northern California Black and Paradox rootstocks to irrigation frequency, duration and quantity of applied irrigation water with and without soil infestation by Phytophthora. The responses evaluated will include magnitude of tree growth and incidence of Phytophthora-included disease.

Objectives:
(1) Determine growth response of English walnut grafted to both Northern California Black and Paradox rootstocks walnut rootstocks to irrigation frequency, duration and quantity of applied water.
(2) Evaluate the response (Objective 1) with and without inoculation of Phytophthora and the possible interaction.
(3) Determine the extent of wetted soil volume and the quality (matric potential) of the wetted area) which produces optimal vegetative growth.
(4) Develop a method of estimating the required applied water volume in newly planted trees to maximize growth and minimize disease hazard.

Plans and Procedures:

Treatments: Irrigation treatments: 4-irrigation duration and 4 irrigation frequencies are combined to provide 6 treatments, which vary the irrigation quantity (0.5x, 1x, and 2x). The irrigation quantity is held constant in the 1x treatments (T2, T3 T4 and T5) while varying the duration and frequency. The 1x treatments would be determined by the weekly estimate of applied water required for T2 through T5. The other treatments (T1 and T6) are scaled based on the 1x irrigation volumes. The range of moisture (4x) should provide for under- and over watered trees.

Table 1. Typical Application Water Volumes at Peak (Mid July)

	Treatment					
	1	2	3	4	5	6
Duration (hrs)	12	6	8	12	24	24
ETo & Canopy Adj.	1	1	1	1	1	1
Frequency (times/wk)	1	4	3	2	1	2
Emitter Flow Rate (g/hr)	5.7	5.7	5.7	5.7	5.7	5.7
Total Hours/wk	12	25	24	25	25	49
Volume (gal/wk)	69	139	138	139	139	277

Field Site: The planting is located at Campbell Tract on the University of California Davis campus (LAWR field site). The soil is a clay loam. The irrigation system is a single micro sprinkler per tree discharging 5.7 gallons per hour. The heads are Bowsmith full circle pattern achieving a 10-foot diameter surface wetted area. The heads are atop a 9-inch stand placed 36 inches to the west from each tree. Water is supplied from the campus-pressurized source.

Experimental Design: The design used is a factorial with four replications. The irrigation treatments will be randomized within each replication. The rootstocks (with and without inoculum) will be randomized within the irrigation treatments.

4 trees per plot
Trees required: 384
Area planted at 15 x 24 = 3.2 acres

2000 Activities

Field Activities: The field site was chiseled to 3 feet and land planed in fall 1999. All buried portions of the irrigation system were installed at that time also. The grafted trees were held in cold storage due to wet soil conditions at the site. The trees were planted into moist soil May 4, 2000. The above ground portions of the irrigation system were installed shortly after planting.

Irrigation: Water was applied to maintain adequate soil moisture in the root zone throughout the season based on soil monitoring. All treatments were irrigated equally to promote uniform growth. Water applied from planting through November 5th totaled 603 gallons per tree or 2.7 acre inches per acre.

Inoculation: Innoculation of the soil with cultures of Phytophthora species: *P. citrocola* and *P. cinnamomi* was performed September 5, 2000. The prepared cultures were placed to the on each side to the tree and rototilled into the soil to a depth of 4 to 5 inches. Care was taken not to contaminate adjacent non-inoculated treatments. Irrigation followed inoculation. Prior to winter rainfall, the centers were disked and harrowed. A soil berm was formed in the center of each

middle and at the end of each plot between trees of adjacent plots. The purpose was to control water movement from inoculated and non-inoculated plots.

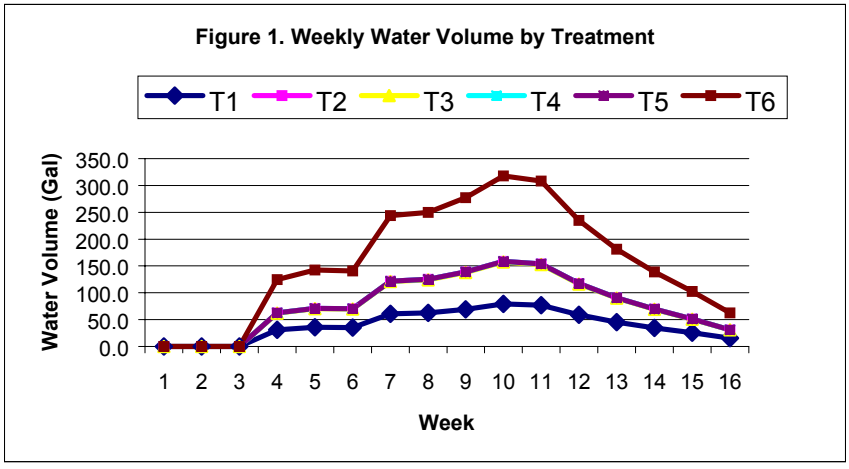
Weed Control: Goal and Prowl herbicides were applied in the fall. Spot treating with Roundup was used during the summer months.

2001 Activities

Field Activities: The dormant trees' trunks were painted and a pre-emergent herbicide (Prowl) was applied on March 13 followed by about 0.25 inch of irrigation water. All of the trees were pruned back to 3-4 buds above the graft union on April 9. Additional neutron probe wells were placed to fill out the grid in each of the treatments to assess soil moisture wetted area and volume. The trees received a directed application of granular fertilizer (15-15-15) on May 31. Mites were controlled with a directed application of Kelthane on July 10. The trees were fertilized again with CAN-17 injected into the irrigation system on July 18. Hoeing and spot spraying with Roundup controlled weeds.

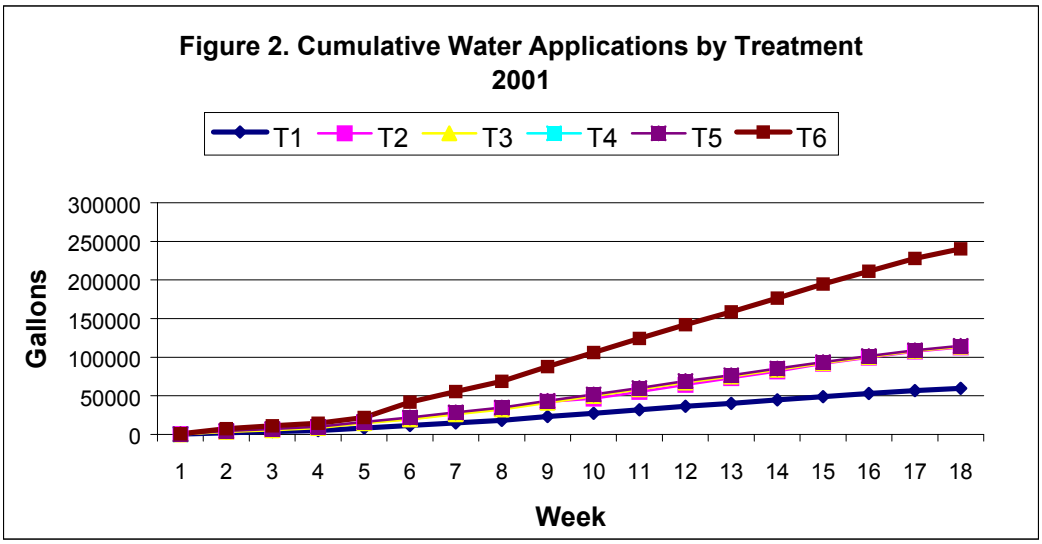
Irrigation:

Irrigation continued on a weekly basis from May through September. Irrigation volume delivered to each treatment was based on the irrigation duration, frequency, adjustment for climatic demand and the canopy volume. Climatic demand (Evapotranspiration, ET) reference values (ETo) available from the Davis CIMIS station were used. The expanding canopy size was estimated using a volume measurement technique. These factors along with emitter flow rate determined the volume applied to each treatment. Figure 1 shows the original target irrigation volumes. Note that the Treatments 2 through 5 are the same volume (although different duration and frequency) making them indistinguishable on the figure. The use of climatic ETo values and canopy factor are responsible for the low applied volumes early in the season. After the peak use period, the ETo is responsible for the decline in volumes even though the canopy was still increasing in size. This methodology will provide the basis for scheduling irrigations for developing orchards.



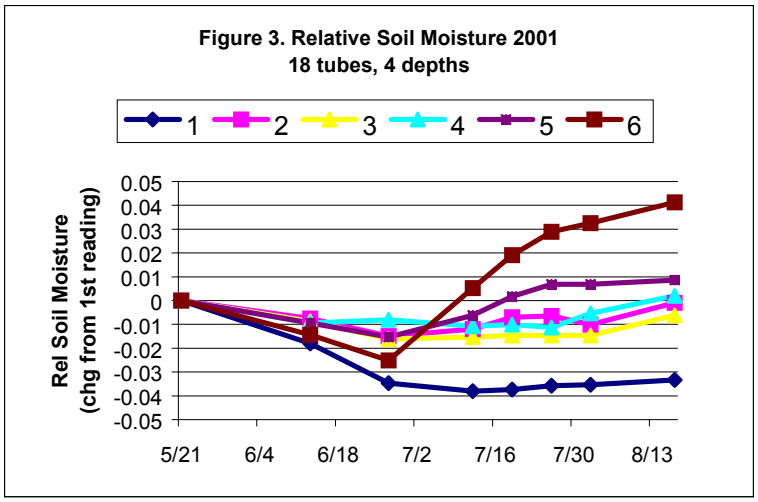
After the initiation of the irrigation season, soil moisture monitoring indicated the highest irrigation level (T6) was not as wet as anticipated. This was primarily due to the evaporation loss during irrigation and evaporation from the soil surface after irrigation from the 10-foot diameter wetted area. It was decided to increase the volume across all treatments. Figure 2

indicates the cumulative irrigation water applied over the season. This action amounted to about a 40 percent increase.



Soil Water Measurement: Neutron probe wells were installed in a grid fashion in each of the treatments to assess soil moisture wetted area and volume. Eighteen access wells were installed per monitored tree. The grid allows one to view water recharge and use in the entire area of the micro sprinkler area of influence. The soil water as an average of all 18 wells over the 4 depths measured indicates an overall average moisture status. It is plotted on a relative to the May 21st reading to assess moisture change in Figure 3.

From May through most of June, the relative decline represents the soil drying down combined with tree use and water applications. Beginning June 27th when irrigation water volumes increased, treatment differential becomes apparent. Treatment 1, which receives the least water, remained essentially flat in terms of water content. The irrigation water volume balanced the tree water use. When looking at the individual depth moisture content, only the 0-9 inch depth was recharging as a result of irrigation. Treatment 6, which received the most water, shows the greatest increase in soil water content. The remainder of the treatments received the same volume of water just at different duration and frequency of irrigation. Treatment 5 with the least frequency and greatest duration resulted in the most effective recharge as a result of less evaporatorative loss from the soil surface. The remaining treatments were less differential; however Treatment 3 had significantly less recharge the others receiving the same irrigation volume. Again, this is attributed to a higher frequency (4 irrigations/week) that resulted in more evaporation from the wetted soil.



Tree Growth Measurements: Tree height was measured July 13, August 20, and September 20, 2001. The growth from July 13 to August 20 was significantly different between treatments (Table 2). The treatments that at this time had higher moisture content were generally higher in growth (T5 and T4) (Figure 4.). In the later growth period from August 20 to September 20, there were not any significantly treatments; however there was a trend (p= 0.0641) (Table 2). Both the lowest moisture (T1) and the highest (T6) attained the least growth, indicating the treatment water volumes were appropriate to cause a reduction from too little and too much water (Figure 5).

Figure 4.

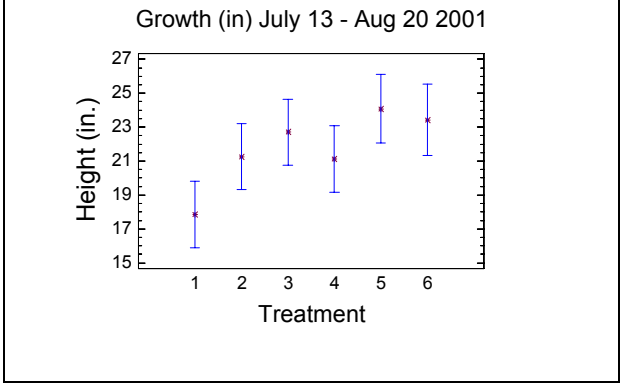


Figure 5.

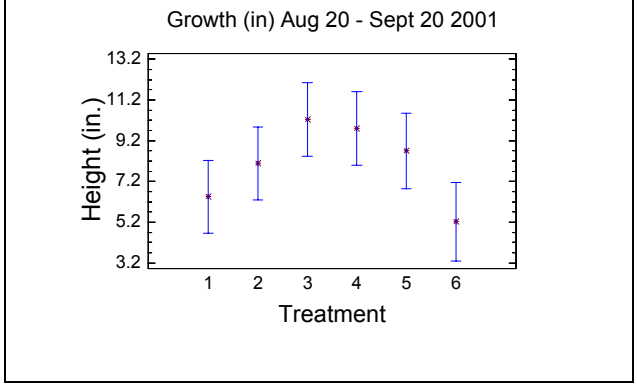


Table 2. Tree Growth at Two Periods

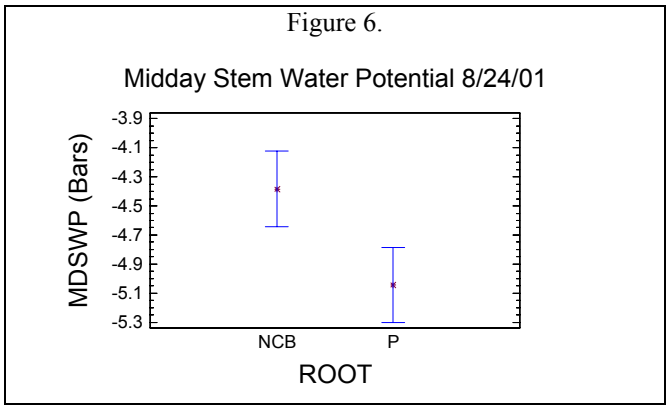
Treatment	July 13 – Aug. 20	Aug. 20 – Sept. 20
1	17.8 ab	6.4 ab
2	21.2 ab	8.0 ab
3	22.7 a	10.2 a
4	21.1 b	9.8 a
5	24.0 a	8.7 ab
6	23.4 a	5.2 b
P =	0.0354	0.0641

	July 13 – Aug. 20	Aug. 20 – Sept. 20
Rootstock		
Black	20.6	8.5
Paradox	22.8	7.7
P =	0.0616	0.4181
Inoculation		
C	22.2	8.6
I	21.2	7.5
P =	0.4139	0.3161

Tree mass will be measured at pruning. It is expected to yield better results than tree height since the lateral branches will be included. Trunk diameter was measured at leaf fall but will not be included in this report.

Water Potential: Numerous measurements were made of midday stem water potential; however the only significant differences were between the rootstocks. Figure 6 shows a relationship between Paradox and Northern California Black that was consistent throughout the season. Paradox was about 0.7 bars more negative than NC Black.

Figure 6.



Phytophthora Evaluation: It was decided to wait until next fall to evaluate the sampling is destructive and the trial since only at the last growth period did high water treatment begin to show a slowing of growth.

Conclusion:

The irrigation methodology seems sound in determining the appropriate amount of irrigation water to apply to achieve both too dry and too wet conditions. It remains to be seen if frequency and duration of irrigations make a significant difference in growth and the incidence of Phytophthora.