Final Project Report
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Project Title: Irrigation Management and the Incidence of Kernel Mold in Walnut

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## Problem and its Significance:

Kernel mold is a serious and increasing problem facing walnut growers and handlers. Mold reduces yield, kernel quality and grower returns.

Numerous theories have been advanced as to the cause of kernel mold. They include the time nuts are on the ground, wet soil conditions during and just prior to harvest and irrigation management. Observation of kernel mold problems has resulted in an emergence of a causal theory that mid/late season water stress is a major factor in kernel mold. This is supported by the fact that: (1) later harvest cultivars such as Chandler and Howard continue to use water that can effect the nut past the time of earlier harvest cultivars, and (2) many young, later harvest cultivar orchards are achieving full canopy coverage. This maximizes tree water use and increases the potential for orchard under-irrigation and tree water deficits.

This study seeks to determine the responses of walnut to the presence /absence of mid-late season water deficits and the affect of these deficits on the incidence of kernel mold.

## Objective:

Determine incidence of kernel mold in walnut under different irrigation regimes causing presence/absence of water deficits.

## Plans and Procedures:

Two orchards were chosen for this experiment. The first is located in Butte County, slightly south of Chico, California. The site has a deep, high water holding capacity soil and is planted to the Chandler cultivar. The orchard has a history of increasing mold over time as evidenced by crop grade sheets. Irrigation is provided by a micro sprinkler irrigation system with one sprinkler per tree. Fifteen plots were designated, each containing 12 trees. Each plot consisted of 3 rows and 4 trees in each row. The experimental design is a randomized complete block with three treatments and five replications. One late season deficit irrigation treatment (T2) was compared to a fully irrigated control (T1).

Changing the sprinklers to emit half the amount of the standard treatment on 6/14/01 started to create the water deficit treatment. They were reduced to 16.4 gallons/hour compared to the control, emitting 32.8 gal/hr. On 8/13/01, the sprinklers within each stressed plot (T2) were plugged. At this time of year, the orchard is irrigated twice a week (Tuesday and Friday) for 18 hours each time. Sprinklers were again allowed to emit 16.4 gallons/hour on 9/21/01 on the same schedule until pre-harvest cutoff on 9/27/01. Stem water potential measurements were collected on Thursday (the day before the next irrigation) of each week in order to measure when the highest level of water stress that irrigation cycle. The water status of the two center trees of each plot was monitored by weekly measurements of midday stem water potential (MDSWP) using a pressure chamber. Nut samples were collected from the same trees that were monitored for MDSWP.

The second site is located in San Joaquin County, near Clements, California. The site has a moderate depth, medium water holding capacity soil and is planted to the Chandler cultivar. Irrigation is provided by a solid set sprinkler irrigation system with one sprinkler every other tree in the tree row. Fifteen plots were designated, each containing 12 trees. Each plot consisted of 3 rows and 4 trees in each row. The experimental design is a randomized complete block with three treatments and five replications. One mid-late season deficit irrigation treatment (T2) and one late season deficit treatment (T3) were compared to a control grower more nearly full irrigated control (T1). Sprinkler nozzles in Treatments 2 and 3 were changed to emit half the amount of the standard treatment on 6/23/01, creating the water deficit treatments. On 8/2/01, the sprinkler nozzles within Treatment 2 were plugged, and then returned to the reduced size nozzle on 8/28/01. Sprinkler nozzles in Treatment 3 were then (8/28/01) plugged until harvest. After treatment imposition and during irrigation, it was found that water infiltration difficulties caused water from another area of the field to runoff into some of the replications. Two of the replications were as a result not included in the data analysis.

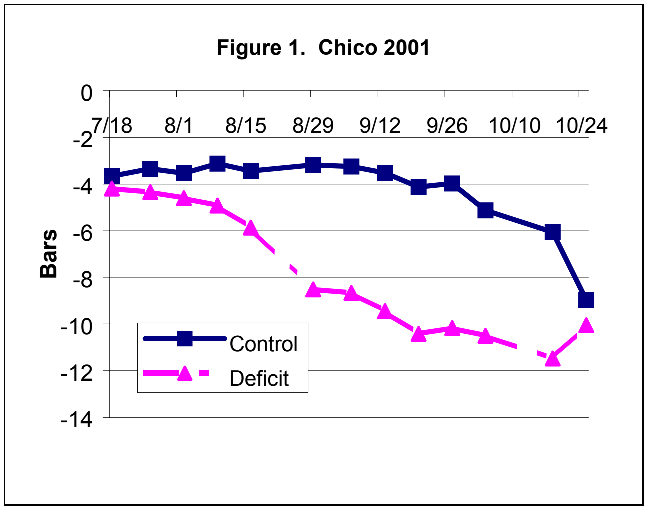
Another site in the Lockeford and Farmington area of San Joaquin County were initiated in cooperation with Bruce Lampinen and Nick Mills. Both orchards were the Vina cultivar. The Farmington site is a heavy clay soil while the Lockeford is a deep sandy loam. Sprinkler nozzles were reduce in size and plugged to create treatments just 5/15/01. The Farmington trial consisted of three treatments based on nozzle size all irrigated using the grower's irrigation schedule. Treatment 1 was the grower's 7/64-inch nozzle while T2 was a 5/64-inch and T3 plugged. The only nozzle changed was between the two measurement trees therefore the actual application rate is not solely based on the nozzle size mentioned for each treatment since adjacent row nozzle was not changed. Four replications of treatments were used. The Lockeford trial consisted of three treatments with eight replications using the same layout as in the Farmington trial with the exception that there was a sprinkler between each tree.

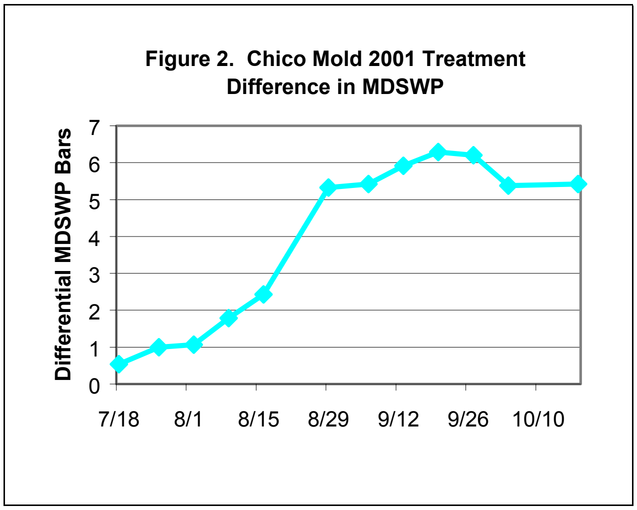
All nuts containing mold were individually stored for identification by microscopic examination. Molds are currently being isolated into pure culture and identified from culture. Identification will be based on standard taxonomic works and comparison with reference cultures as needed. Mold identification is currently under way results will not be reported in this document.

## Results

### Chico

Midday stem water potential (MDSWP) was measured from 7/18/01 through harvest on 10/18/01, then post harvest ending on 10/24/01. Slight differences in MDSWP were noted between treatments as a result of the reduction in nozzle size (Figure1). After plugging the nozzles, significant differences began to show (Figure2). T1 always exhibited a better water status than T2. The control (T1) was irrigated at a near baseline (well irrigated) condition until the pre-harvest cutoff on 10/27/01. Significant differences occur after July 17th, maximizing at over 6 bars by 9/20/01. This was when the sprinklers were plugged to stop all irrigation. The maximum water deficits were measured on 10/18/01 at –11.5 bars. After the pre harvest water cutoff on T1, MDWSP increased in stress from 14 to 19 bars indicating most of the soil moisture was depleted.




The incidence of kernel mold and other grading parameters was measured in each plot by first collecting 200 nuts of the windfall nuts followed by sweeping then collecting 200 nuts of the shake nuts. Diamond Walnut, using their standard grading system, evaluated each sample separately. Table 1 shows the harvest nut grading for the number of baby nuts, insects, mold, shrivel, stain and edible kernel weight. With the exception of significantly more baby nuts found in the windfall nut sample, no significant differences were found in any parameter in windfall or shake nuts between treatments.

Table 1. Chico 2001 Walnut Harvest

| Treatment | Baby Nuts (no.) | Insect (%) | Mold (%) | Shrivel (%) | Stain (%) | Edible Kernel Wt. (gms) |
|---|---|---|---|---|---|---|
| | Windfall | | | | | |
| 1 | 2.6 | 1.0 | 1.0 | 3.8 | 15.8 | 477.4 |
| 2 | 4.0 | 2.2 | 2.2 | 4.4 | 13.4 | 453.4 |
| P = | 0.0046 | 0.1087 | 0.1087 | 0.6483 | 0.7548 | 0.1022 |
| | Shake | | | | | |
| 1 | 4.4 | 0.0 | 3.0 | 0.6 | 9.8 | 478.4 |
| 2 | 4.0 | 0.2 | 1.4 | 1.6 | 4.2 | 484.6 |
| P = | 0.8541 | 0.3739 | 0.3058 | 0.3739 | 0.0516 | 0.5560 |

Clements

Midday stem water potential (MDSWP) was measured from 7/31/01 through 9/28/01. Slight differences in MDSWP were noted between treatments as a result of the reduction in nozzle size (Figure 3.). After plugging the nozzles in Treatment 2, significant differences began to show achieving a –10 bar MDSWP on 8/28/01. After the Treatment 2 nozzles were returned to the reduced size on 8/28/01, deficits were relieved to near –5 bars, which was not significantly different than the control treatment (T1) from 9/8/01 to 913/01. Treatment 2 did suffer more stress during longer irrigation intervals after 9/18/01 due to less soil-stored moisture as a result of the earlier deficits. After 9/11/01, the MDSWP increased in stress with Treatment 1 to near –10 bars since both had the same size nozzles and were operated the same time. Treatment 2, the late stress treatment, began to increase in stress slightly through 8/28/01 as a result of the reduced size nozzles when the nozzles were plugged. After plugging, stress increased to near –12 bars for the remainder of the season. The incidence of kernel mold and other grading parameters was similar to the Chico trial with the exception that the samples were collected after the shake which included windfall and shaken nuts. Table 2 shows the harvest nut grading for the number of percent insects, mold, shrivel, stain, RLI1 and edible kernel weight. No significant differences were found in any parameter between treatments.

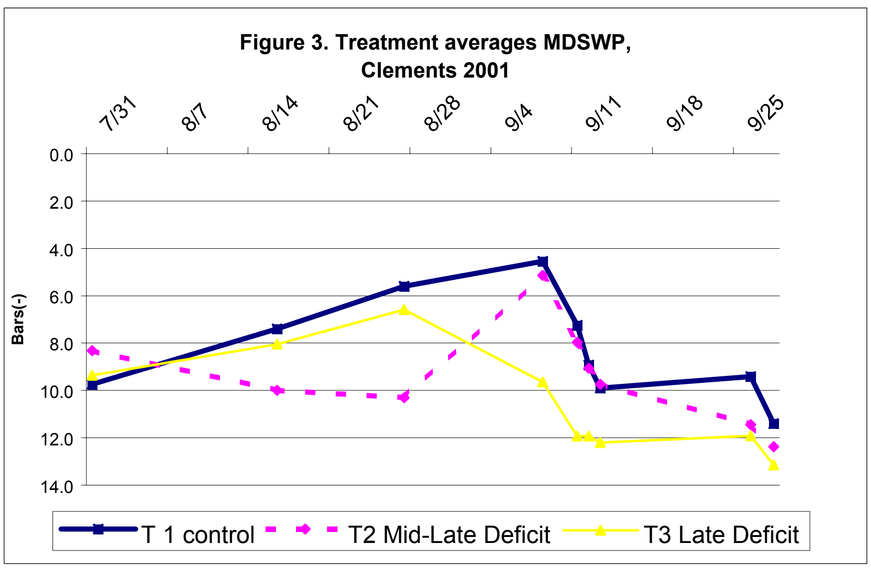



Table 2. Clements 2001 Walnut Harvest

| Treatment | Insect (%) | Mold (%) | Shrivel (%) | RLI 1 | Edible Kernel Wt. (gms) | Stain (%) |
|---|---|---|---|---|---|---|
| 1 | 0.67 | 4.7 | 1.0 | 46.7 | 563.3 | 14.3 |
| 2 | 0.33 | 6.3 | 1.3 | 44.2 | 492.0 | 8.0 |
| 3 | 0 | 6.0 | 2.7 | 43.8 | 490.7 | 12.7 |
| P = | 0.4444 | 0.8799 | 0.2844 | 0.0760 | 0.8036 | 0.1580 |

Farmington

Midday stem water potential (MDSWP) was measured from 5/27/01 through 9/10/01. Only slight differences in MDSWP were noted between treatments as a result of the reduction in nozzle size (Figure 4). After July 29, Treatment 3 was found to have significantly more water stress than the other treatments. Treatments 1 and 2 were not significantly different in MDSWP for the entire season. All treatments suffered relatively high stress beginning in late May being only substantially relieved in early June. Treatments 1 and 2 averaged –13.0 bars after July2 while treatment 3 averaged –14.3 bars. All of the treatments suffered substantial water stress.

The incidence of kernel mold and other grading parameters was similar to the Chico trial with the exception that the samples were collected after the shake which included windfall and shaken nuts. Table 3 shows the harvest nut grading for the number of percent insects, mold, shrivel, RLI1, edible kernel weight and large sound nuts no significant differences were found in any parameter in between treatments.

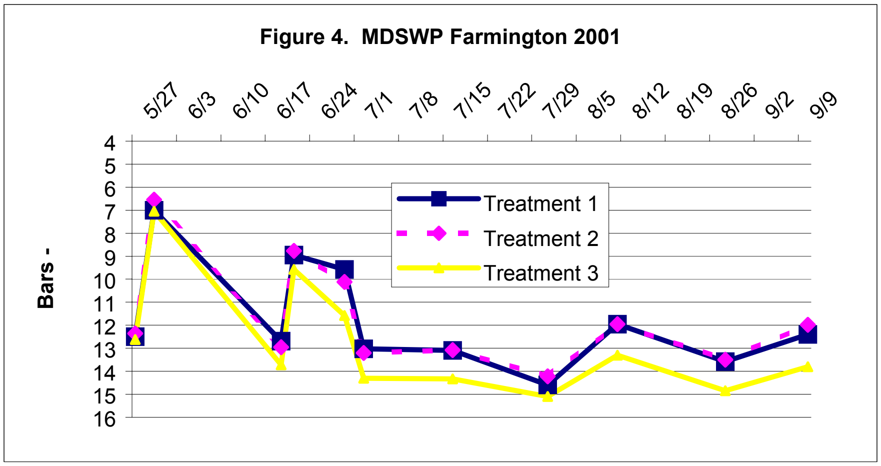



Table 3. Farmington 2001 Walnut Harvest

| Treatment | Insect (%) | Mold (%) | Shrivel (%) | RLI 1 | Edible Kernel Wt. (%) | Large Sound (%) |
|---|---|---|---|---|---|---|
| 1 | 1.8 | 0.3 | 2.3 | 37.0 | 45.1 | 25.4 |
| 2 | 1.3 | 0.5 | 1.4 | 38.3 | 46.1 | 25.4 |
| 3 | 1.2 | 0.5 | 2.0 | 37.5 | 43.7 | 20.8 |
| P = | 0.6330 | 0.8799 | 0.2844 | 0.5997 | 0.0654 | 0.7674 |

<u>Lockeford</u>

Midday stem water potential (MDSWP) was measured from 5/17/01 through 8/24/01. Only slight insignificant differences in MDSWP were noted between treatments as a result of the reduction in nozzle size (Figure 5.). All treatments began the measurement period the same at near –7 bars ending the season at near –10 bars. During the month of July the stress increased to –10.5 to –12 bars (depending on treatment). Since treatments did not significantly effect MDSWP it was no surprise there was no significant differences in yield/quality parameters.

The incidence of kernel mold and other grading parameters was similar to the Chico trial with the exception that the samples were collected after the shake which included windfall and shaken nuts. Table 4 shows the harvest nut grading for the number of percent insects, mold, shrivel, RLI1, edible kernel weight and large sound nuts.

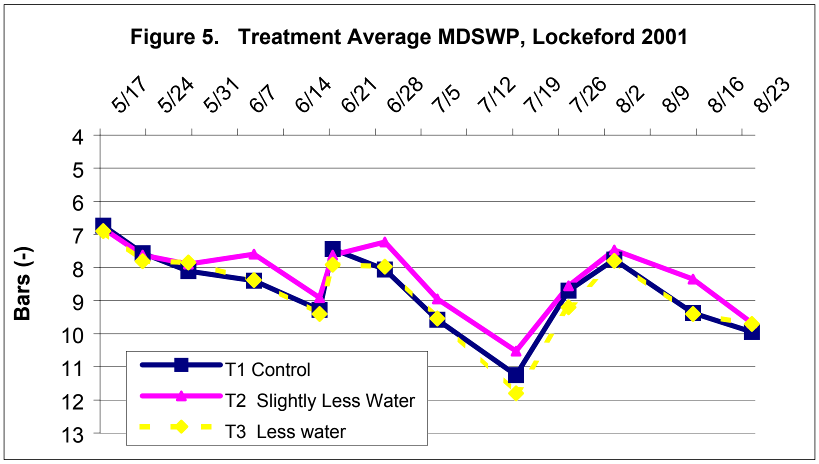



Table 4. Lockeford 2001 Walnut Harvest

| Treatment | Insect (%) | Mold (%) | Shrivel (%) | RLI 1 | Edible Kernel Wt. (%) | Large Sound (%) |
|---|---|---|---|---|---|---|
| 1 | 1.2 | 2.3 | 4.2 | 33.4 | 41.9 | 40.3 |
| 2 | 1.5 | 2.8 | 3.6 | 33.8 | 42.0 | 50.2 |
| 3 | 0.7 | 1.9 | 4.6 | 33.6 | 42.3 | 44.6 |
| P = | 0.3060 | 0.6792 | 0.6040 | 0.4022 | 0.8589 | 0.2013 |

Summary:

There is no doubt that kernel mold reduces edible yield and therefore price received for the crop. Figure 6 shows that relationship from data generated at the Chico trial data. The approach we took was sound. We withheld irrigation water while monitoring the tree water status with a pressure chamber until significant differences in water stress were achieved. Two closely controlled trials were conducted to access the effects of water deficits on the incidence of walnut kernel mold in mature Chandler orchards. In the Chico trial, a comparison was made between well-watered and significant water stress conditions occurring at a time when it was hypothesized to have the most effect on the incidence of mold. Figure 7 illustrates the relationship found between mold and MDSWP. There is no relationship. The Clements trial achieved stress to a lesser differential but at two timings. Both of the treatments had no significant effect on the presence of mold. Additionally two other less controlled trials were also conducted in mature Vina orchards. The differential water stress between treatments was not as great. However, high levels of water stress were achieved resulting in a small amount of kernel mold. It is often hypnotized the nuts that fall early onto the wet soil surface will have a higher incidence of mold. To address this issue, nuts were collected from trees prior to shaking that were on the soil surface still moist from micro sprinkler irrigation. No significant difference was found between windfall and shake nuts with or without water stress. There is an indication that the percent adhering hull and percent stain are related to the incidence of kernel mold (Figures 8 and 9). Even though both of these external defects and can be selected out at the huller, this relationship should be food for thought in attempting to devise a strategy to reduce the incidence of kernel mold.

Figure 6. Chico 2001

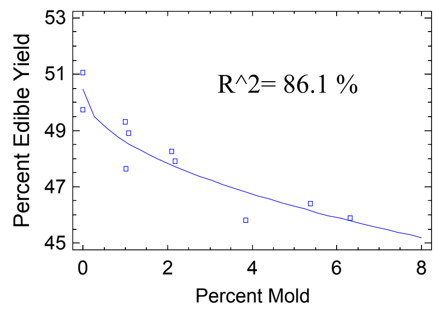



Figure 7. Chico Windfall and Shake Nuts, 2001

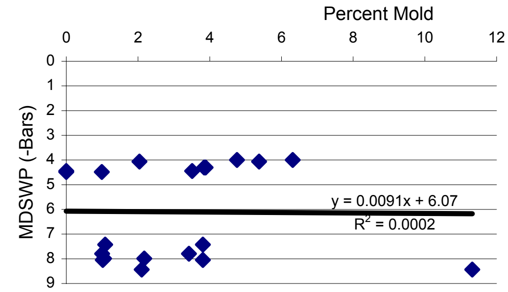



Figure 8.

Chico Shake Nuts

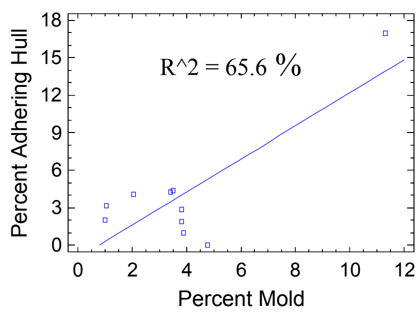



Figure 9.

Chico Windfall, Shake and Clements