**CONTINUING PROJECT REPORT** **YEAR**: 3 of 3
**WTFRC Project Number:**

**Project Title**: Irrigation and fertilization for optimal cherry fruit quality

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**Total project funding request:** $109,061 **Year 1**: $35,874 **Year 2**: $36,127 **Year 3**:$37,060

**Other funding sources**

**Agency Name**: NRCS
**Amount requested/awarded**: $5,000
**Notes**: Funds were used to offset irrigation supplies and labor costs for reconfiguration of the irrigation system to accommodate the experimental design.

**Budget 1 Todd Einhorn**
**Organization Name:** OSU-MCAREC **Contract Administrator:** Dorothy Beaton
**Telephone:** 541 737-3228 **Email address:** dorothy.beaton@oregonstate.edu

| Item | 2009 | 2010 | 2011 |
|---|---|---|---|
| **Salaries[1]** | **15,000** | **13,800** | **14,352** |
| **Benefits[3]** | **9,330** | **9,522** | **9,903** |
| **Wages[2]** | **4,000** | **5,000** | **5,000** |
| **Benefits[3]** | **1,044** | **1,305** | **1,305** |
| **Equipment** | **0** | **0** | **0** |
| **Supplies** | **4,500** | **4,500** | **4,500** |
| **Travel** | **2,000** | **2,000** | **2,000** |
| **Miscellaneous** | **0** | **0** | **0** |
| **Total** | **35,874** | **36,127** | **37,060** |

**Footnotes:**

[1] .50 FTE Technician (D. Laraway), yr 3 includes 4% pay raise

[2] Hourly labor, .20 FTE (temporary technician)

[3] Technician OPE rate is 69% based on actual, hourly OPE rate is 26%

## Objectives

1) Optimize irrigation scheduling and fertilization of sweet cherry through measuring and monitoring soil moisture and plant growth and development, and develop a predictive model for cherry fruit and shoot growth based on soil moisture and plant measurements.
2) Determine the effect of drip irrigation on fruit and shoot processes.
3) Determine the appropriate allowable depletion of soil moisture for optimizing cherry fruit quality and yields, and managing vigor.

## Significant Findings

- For two cherry orchards planted on Mazzard rootstock, on fairly deep soils (3-4 feet of soil), significant water savings were achievable by application of deficit irrigation.
- Deficit treatments replaced between 45% to 65% of Lapins/Mazzard cumulative reference evapotranspiration (ET0).
- Early spring monitoring of soil moisture resulted in water savings by delaying the start of irrigations.
- Yields of Lapins were not significantly affected by deficit irrigation of 55% of ET0 in each of the three years of the study, though when water was withheld to 45% to 50% of ET0, yield reductions approaching 10% were observed in year 3.
- Fruit quality of Tieton and Lapins was neither improved, nor limited, by deficit irrigation at harvest, or after three weeks of postharvest storage.
- In 2011 the T1 treatment level of irrigation was increased to replace 96 % ET0.
- Fruit growth rates were not affected at any point throughout the season for deficit irrigation treatments.
- Shoot growth was not significantly affected by deficit irrigation.
- For ‘Tieton’ and ‘Lapins’ trials, stem water potential (measure of water stress) declined as the season progressed, irrespective of treatment. In 2011, the Lapins T1 treatment (receiving 96 % ET0) had significantly higher stem water potential than the deficit treatments. No differences were observed among the other levels of deficit irrigation (reaching values as low as -1.3 MPa). Trunk growth was limited in 2011 in all deficit treatments relative to T1.
- In all years of the study, deficit treatments utilized significantly more water to meet their evaporative demand from greater soil depths than the T1 treatment. Subsequently, the heightened activity of deep roots mitigated the onset of water stress. These findings support the general lack of differences observed for yield and fruit quality of deficit irrigated treatments. ‘Tieton’ had the additional benefit of an early harvest date before significant soil moisture depletion occurred.
- Tieton trees receiving irrigation at higher frequencies (4x per week), but with less water per event experienced greater water stress than those receiving low frequency applications (once per week). Yields of these treatments were slightly reduced. Quality was not affected.
- Overall three-year yields were not significantly influenced by nitrogen rate (100 lbs or 60 lbs actual N per acre) or by delivery technique (Split broadcast application vs. fertigation).
- Shoot growth of 60 lb N per acre was slightly reduced relative to the 100 lb rates.

## Results and Discussion

***Site 1. Lapins/Mazzard-Irrigation***. In 2011, irrigation volume of the T1 treatment was increased to provide non-limiting irrigation supply, and when summed with precipitation events after bloom, received 96% of total seasonal reference evapotranspiration (ET0) (Fig 1). In each of the previous two seasons, ET0 replacement for T1 was ~65%. 2011 seasonal irrigation supply and postbloom precipitation (summed) provided 55%, 45%, and 50% of ET0 to T1, T2 and RDI treatments, respectively (Fig 1); the latter three treatments received similar volumes of irrigation in each year of the three-year study.  The decision to increase the volume of T1 in 2011 was based on the nonsignificant differences observed among treatments for yield and fruit quality in 2009 and 2010. During the previous years we had also observed a lack of difference in stem water potential (measure of plant water status and stress) among treatments, and attributed this to the large reserve of soil water built up from winter and spring rain events. In other words, our measurements of soil moisture extraction showed that Mazzard roots were actively utilizing water at depths of 3 feet (plausibly at depths exceeding 3 feet), thus supplementing our deficit treatments with adequate water to produce good yields of high-quality fruit.  However, our hypothesis that provision of irrigation between 40% and 65% ET0 would not adversely impact yield or fruit quality could not be proven without comparing these treatments against a non-limiting irrigation 'control', since it is possible that all of the treatments were limited by the relatively low percentages of ET replacement.

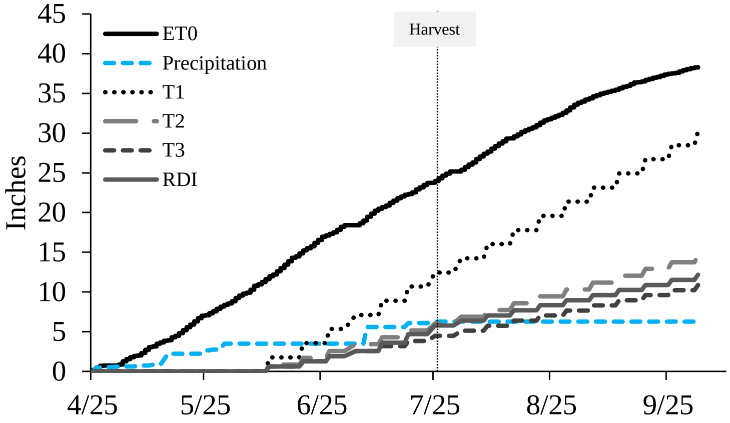

Fig 1.  2011 cumulative water lost through evaporation/transpiration [reference ET (ET0)], or gained via precipitation, and irrigation events received by four different irrigation treatments (T1, T2, T3, RDI) for Lapins/Mazzard.  An acre inch of water=27,154 gallons.

At full bloom (April 25) ~ 3 inches of water per foot of soil (25% by volume) was present throughout the soil profile (Fig 2).  For this soil, field capacity is ~3.4 inches, or 28% by volume.  Irrigations were delayed (47 DAFB) to allow for some utilization of water in the top 2 ft. of soil (Fig 2).  The relatively cool temperatures and precipitation between bloom and 47 DAFB, in combination with soil moisture monitoring, facilitated early-season water savings.  In situations where nitrogen is broadcasted in one to two applications in spring, early irrigations to 'full' profiles can exacerbate leaching (particularly when N is applied in the form of nitrate).  An increase in soil moisture for the RDI treatment can be observed after 68 DAFB, when it was increased from 45 % ET replacement to 65% (Fig 2).  This corresponded with the end of pit-hardening, and the period of rapid fruit growth (Fig 3).  In general, control (T1) soil moisture was maintained above 85% FC, and was significantly higher than other treatments from 50 DAFB through the remainder of the season.  Increased soil water depletion, at all depths monitored, was observed for the deficit treatments as the season progressed (Fig 2).  Between 68 DAFB and harvest (92 DAFB), soil moisture differences could be seen relative to the degree of deficit.  The post-harvest period was associated with greater evaporative demand, and all deficit treatments were observed to equally deplete soil water reserves.  These data were in agreement with results from 2009 and 2010; the only differences were those of the T1 treatment, which received ~65% ET in 2009 and 2010.   In those two seasons T1 had statistically higher soil moisture levels than deficit treatments, but intermediate between deficit treatments and the 2011 T1.  These data, together, show the value of soil moisture measurement as an effective irrigation scheduling tool.  Monitoring soil water levels to depths of three feet are advisable for vigorous rootstocks such as Mazzard.  With more dwarfing rootstocks greater root activity will likely take place at shallower depths. However, knowledge of ‘storage’ water between 2 and 3 feet is still important since it can move through capillary forces to the shallower profile.

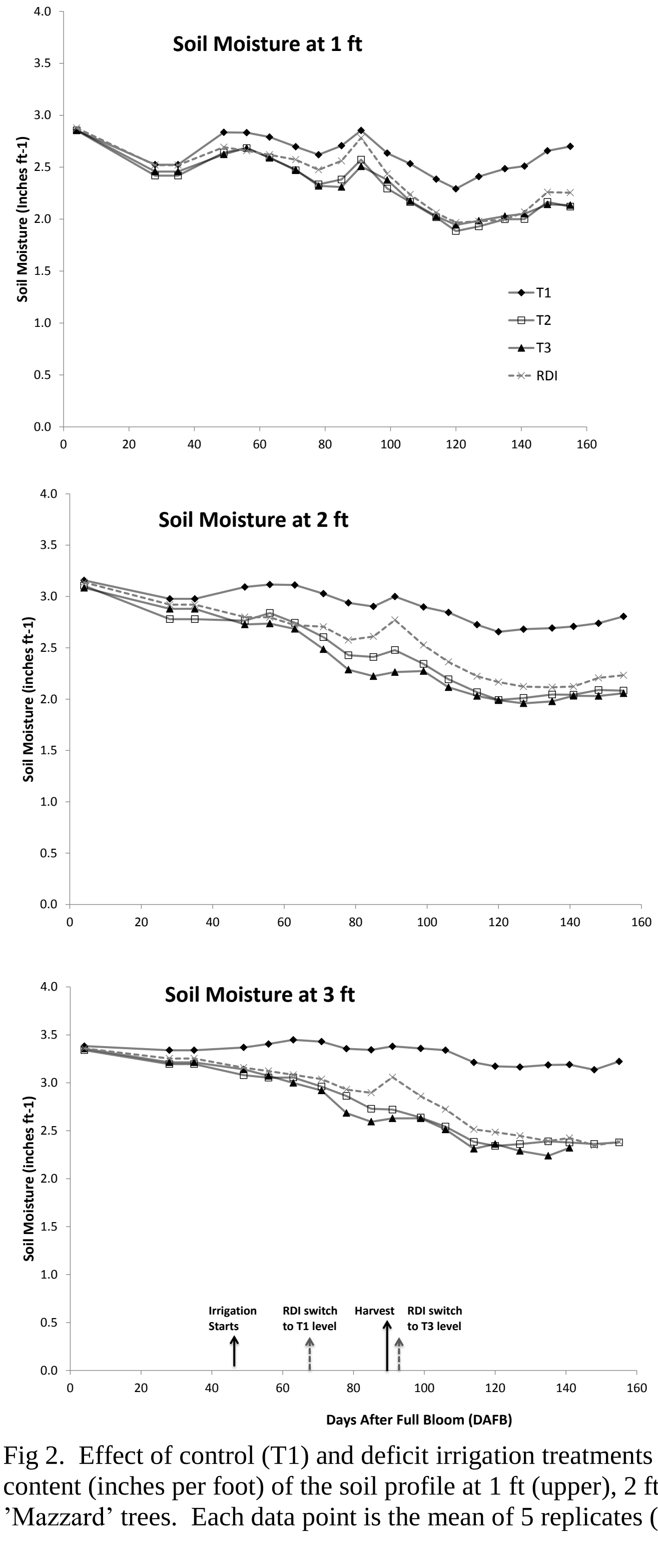

Fig 2. Effect of control (T1) and deficit irrigation treatments (T2, T3, and RDI) on volumetric soil moisture content (inches per foot) of the soil profile at 1 ft (upper), 2 ft (center), and 3 ft (lower) depths for ‘Lapins’/ ’Mazzard’ trees. Each data point is the mean of 5 replicates (n=3).

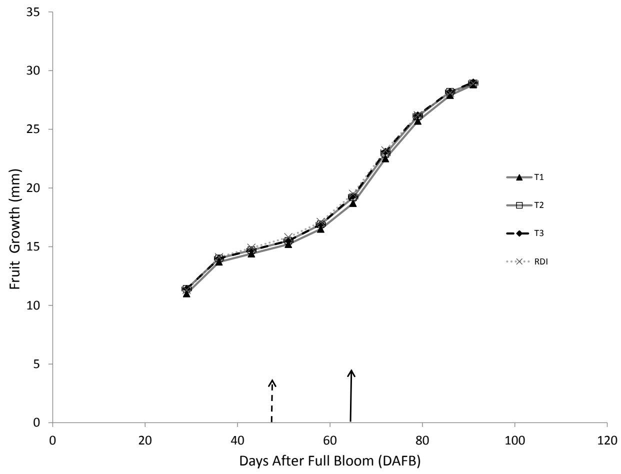

Fig 3. 2011 fruit growth of Lapins/Mazzard as affected by irrigation treatment. T1, 96% ET; T2, 55% ET; T3, 45 % ET; RDI, 45% ET between 47 DAFB and 68 DAFB, 65% ET between 68 DAFB-Harvest, and 45% ET after harvest. Data are the means of 5 replications (n=15). Dashed arrow at bottom signifies start of irrigation treatments; solid arrow signifies RDI switch from 30% to 60 % ET. Harvest was one day following last data point.

Monitoring fruit growth rates provided a plant-based indicator of water stress. As in 2010, we observed no treatment differences in cumulative fruit growth rate (Fig 3). Shoot length was also not significantly affected by irrigation level (data not shown). Trunk cross-sectional area increase, however, was highest for T1 trees in the postharvest interval in 2011 only (5.5% increase compared to 3.7% for T2 and T3, and 3% for RDI). Trunks have previously been shown to compete poorly with shoots and fruit for carbohydrates (Whiting et al.). Subsequently, a significant proportion of their annual growth occurs after harvest; a time which coincides with greater water stress in the deficit treatments.

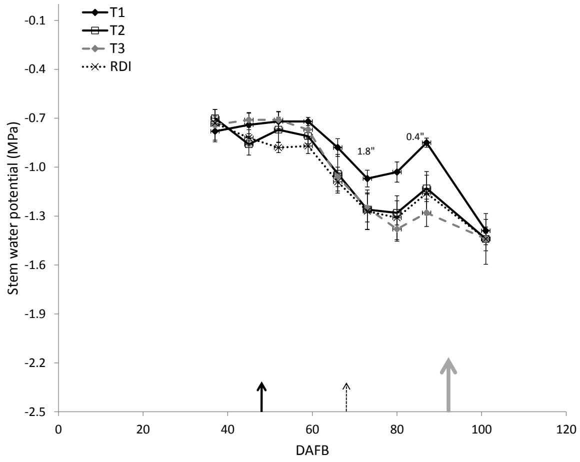

Fig 4. 2011 stem water potential (-MPa) of Lapins/Mazzard in response to irrigation treatment. T1, 100% ET; T2, 50% ET; T3, 30 % ET; RDI, 45% 47 DAFB-68 DAFB, 65 % 68 DAFB-Harvest, 45% Postharvest. Data are the means of 5 replications (n=4). Black solid arrow at bottom (47 DAFB) signifies start of irrigation treatments; dashed arrow (68 DAFB) signifies RDI switch from 45% to 65% ET; tall grey arrow (92 DAFB) signifies harvest.

In early spring (until 59 DAFB) all treatments had high (less negative) stem water potential values, signifying non-limiting hydraulic conditions for growth (Fig 4). No differences among treatments were detected until 73 DAFB, when the control (T1) had significantly higher values than the deficit treatments [i.e., less stress] (Fig 4). Stem water potential can be seen to become progressively more negative as the season advanced, irrespective of irrigation treatment (Fig 4). The declining stem water potential of Control trees was a response to an increasing atmospheric demand (i.e., hotter and dryer). In woody plants, the flow of water from the soil to the leaf encounters a higher resistance than that between the leaf surface and the atmosphere. Therefore, under higher evaporative conditions, water is being lost from the leaf faster than it can be taken up from the roots and translocated back to the leaf. The consequence is a lower water potential, despite the presence of adequate available soil moisture, as can be seen in control (T1) trees (Figs 2 and 4). The lower water potential of the deficit treatments improved the ability of these trees to extract soil water in the upper profile which was becoming increasingly dryer (Fig 2). Previous work with sweet cherries suggests that photosynthesis is not limited until stem water potential drops below -1.5 MPa. During the pre-harvest interval, trees in 2011 never reached values this low (Fig 4), as was similarly observed in previous years of the study (data not shown). In 2009 and 2010 photosynthesis measurements were taken on a few pre-harvest dates. No differences in photosynthesis were observed (data not shown). Following harvest, stem water potential reached minimum values of -1.9 MPa in 2009, and -1.6 MPa in 2010 and 2011 (data not shown) for the Lapins site. It is plausible that low stem water potential coinciding with the postharvest period could have reduced floral bud development for the following year, as previously documented for other deciduous fruit trees. Return bloom dynamics were not investigated in the present project. The increase in water potential for all treatments just prior to harvest was the result of untimely rain events.

Table 1. Effect of irrigation treatments on average tree yield of 'Lapins'/'Mazzard' for each year of a 3-year study. Data are means of 5 replications (n=5).

| Treatment | Yield (lbs per tree) | | | |
|---|---|---|---|---|
| Irrigation | 2009 | 2010 | 2011 | 2009-2011 |
| T1 | 181 | 141 a | 100 a | 422 |
| T2 | 179 | 115 b | 105 a | 399 |
| T3 | 185 | 123 ab | 91 b | 399 |
| RDI | 175 | 118 ab | 89 b | 382 |
| Stat.signif. | ns | * | * | ns |

ns=not significant; * significant at *P* <0.05

Treatment yields for the entirety of the project are provided in Table 1. Overall, tree yields appear to be declining throughout the experimental period. It should be noted, however, that uncharacteristically high croploads occurred in 2009. Average 2009 yields were not affected by irrigation treatment, and equated to 14.5 tons per acre at the planting density of the orchard. The fact that 2010 yields were reduced is likely a direct response to the high croploads of 2009. However, 2010 yields were reduced for all treatments relative to T1. In 2011, yields were ~10% reduced for T3 and RDI (Table 1). The yield deficits observed may be attributed to differences in fruit set, since there were no negative effects of irrigation treatment on fruit size in 2011 (Table 2), or in either of the two previous years (data from 2009 and 2010 were provided in earlier reports, and omitted here for space). Lapins fruit quality in 2011 was excellent (Table 2). Soluble solids content was reduced in T1, likely due to active accumulation of soluble solids in deficit fruit (Table 2). All other quality attributes were unaffected by irrigation treatment (Table 2). The occurrence of several separate rain events totaling 2.5 inches (Fig 1) during rapid fruit growth in early to mid-July, and a 0.25 inch event the day preceding harvest, provided an opportunity to observe the influence of irrigation treatment on cracking. The total percentage of cracking (sum of side cracks and stem-bowl cracks) was ~ 22 %, and was not related to irrigation volume (Table 2), even though statistically significant differences in soil water moisture (Fig 2) and stem water potential (Fig 4) were found during these events.

Table 2. Effect of 2011 irrigation treatment on fruit quality attributes (fruit wt. and diameter; FF= firmness; SS=soluble solids; TA= total acids; cracks [ttl side and stem bowl cracks]) at harvest for 'Lapins'/'Mazzard'. Data are means of 5 replications (n=4 for wt; n=200 for FF and mm fruit size; n=2 for SS and TA; n=100 for cracking analysis).

| Treatment Irrigation | Avg. fruit (g) | vg.fruit siz (mm) | FF g/mm | SS % | TA % | Cracks % |
|---|---|---|---|---|---|---|
| T1 | 12.8 | 30.4 | 332 | 17.2 b | 0.47 | 24 |
| T2 | 12.5 | 30.1 | 325 | 18.1 ab | 0.52 | 19 |
| T3 | 12.9 | 30.4 | 332 | 18.5 ab | 0.48 | 24 |
| RDI | 12.8 | 30.4 | 335 | 19 a | 0.46 | 23 |
| Statist. signif. | ns | ns | ns | * | ns | ns |

ns=not significant; * significant at *P* <0.05

Post-harvest fruit quality was not affected by irrigation treatment in 2009 or 2010 (data not shown). Postharvest quality was not analyzed in 2011; however, differences in postharvest quality would not have been expected given the lack of differences in quality attributes at harvest, notwithstanding SS content.

***<u>Site 1. Lapins/Mazzard-Nitrogen</u>***. The influence of nitrogen rate and delivery method on shoot growth, yield and fruit quality was also investigated at the Lapins site. Trees were either provided 100 lbs of actual nitrogen per acre through microsprinklers (fertigation), or broadcast in a split application. An additional treatment of 60 lb nitrogen per acre (fertigation) was also evaluated. All nitrogen treatments were superimposed on the irrigation treatments outlined above. Shoot growth was slightly reduced for the 60 lb N treatment (Fig 5), albeit nonsignificantly.

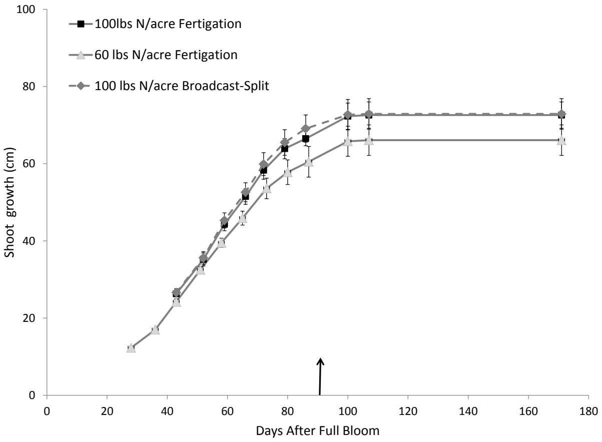

Fig 5. 2011 shoot length of Lapins/Mazzard as affected by nitrogen treatment. Nitrogen was delivered through irrigation lines [i.e., fertigation] at100 lbs or 60 lbs actual N per acre or broadcast at 100 lbs actual N per acre in a split application; first application 10 days after bloom, second application 24 days after full bloom. Data are the means of 5 replications (n=12 [3 shoots per cardinal direction]). Arrow at bottom signifies harvest (92 days after bloom).

In 2010, yields were greatest for the high N treatments, irrespective of delivery mode; however, these results were not repeated in 2011 (Table 3). That the three-year yield was not further reduced by the low nitrogen treatment is surprising. These data would suggest that either improved nitrogen use efficiency was achieved by fertigating the lower rates of N, or that sufficient N pools existed to support growth of shoots and fruit under the current croploads. As a standard practice, foliar urea (20 lbs actual N) was applied postharvest in late summer, and might have raised the total seasonal N pool of the low N treatment to adequate levels. The significant yield effects observed in 2011 could have been attributed to nitrogen losses from harvested fruit alone, given that yields were >14 tons per acre. The results also suggest that fertigation of 100 lbs N per acre had no distinct advantages over broadcast applications for yield, or fruit quality (data not shown). It is unlikely that significant leaching would have occurred for any of our irrigation treatments, though this parameter was not evaluated. Practices which improve nitrogen use efficiency, and result in reduced application rates deserve further attention.

Table 3. Effect of fertilization treatments on total tree yields (lbs) of ‘Lapins’/’Mazzard’. Data are means of 5 replications (n=3).

| Treatment | Yield (lbs per tree) | | | |
|---|---|---|---|---|
| Fertilization | 2009 | 2010 | 2011 | 2009-2011 |
| Broadcast (100 lb N) | 179 | 123 ab | 93 | 396 |
| Fertigation (100lb N) | 183 | 132 a | 101 | 416 |
| Fertigation (60 lb N) | 177 | 117 b | 96 | 389 |
| Stat.signif. | ns | * | ns | ns |

ns=not significant; * significant at *P*<0.05.

*Site 2.Tieton/Mazzard*. A three-year experiment comparing different rates of drip irrigation, at two different frequencies, was initiated in a Tieton/Mazzard block in 2009. Marked variability in yield limited our ability to resolve significant differences among treatments throughout the experiment, despite treatment means being comprised of 25 trees. Three-year yields were only significantly reduced for the HF T3 treatment (Table 4). In all years of the study, significant water depletion of the soil profile occurred as the season progressed (data not shown). Concomitantly, increased water stress was observed relative to the degree of deficit irrigation [stem water potential values of ~2.0 MPa for T3 treatments occurred by mid-summer] (data not shown). The soil for this site is lighter (higher percentage of sand) in comparison with Site 1, and has less water holding capacity. Water depletion below 50% field capacity was observed for deficit treatments in the 3 ft profile in each year (data shown previously, but omitted for space considerations). The lack of considerable adverse effects on yield is likely attributed to a combination of early harvest timing, and low productivity associated with Tieton.

Table 4. Effect of 2011 irrigation treatments on average tree yield of ‘Tieton’/’Mazzard’. LF = low frequency (one irrigation event per week); HF= high frequency (equivalent amount of total weekly irrigation supplied to LF, but provided in small doses every other day). Data are means of 5 replications (n=5).

| Treatment | Tree yield (lbs per tree) | | | |
|---|---|---|---|---|
| Irrigation | 2009 | 2010 | 2011 | 2009-2011 |
| T1 LF | 93 | 69 | 94 | 256 a |
| T1 HF | 92 | 61 | 82 | 235 a |
| T2 LF | 92 | 76 | 83 | 251 a |
| T2 HF | 93 | 74 | 84 | 251 a |
| RDI LF | 86 | 79 | 97 | 262 a |
| RDI HF | 94 | 76 | 89 | 259 a |
| Statist. signif. | ns | ns | ns | * |

ns=not significant; * = significance at *P* <0.05.

Fruit quality was also not affected in 2011 by irrigation treatment (Table 5), as was the case in the two preceding years of the study (data not shown). Fruit were softer in 2011, regardless of treatment, which is interesting given the relatively cool year. No effects on postharvest fruit quality were observed in 2011 (data not shown).

In all years, results have been similar to those observed with Lapins, and can be attributed to a vigorous Mazzard root system, active at the 3 foot depth. By the time water stress develops, shoot growth is complete, and fruit has been harvested. Irrigation frequency did not consistently affect yield or fruit quality (Tables 4 and 5).

In 2010 we reported slightly lower water potential (greater stress) values for HF treatments compared to LF, and attributed increased evaporative losses from the wetted surface of the HF soil (wetted 4 times per week more frequently than LF). However, in 2011 these results were not observed.

We previously documented that water stress coinciding with high temperatures during early August did not exacerbate doubling/twinning of fruit the following year, as has been linked to peach and nectarine varieties.

Table 5. Effect of 2011 irrigation treatment on fruit quality attributes (fruit wt. and diameter; FF= firmness; SS=soluble solids; TA= total acids) at harvest for 'Tieton'/'Mazzard'. Data are means of 5 replications (n=4 for wt; n=250 for FF and mm fruit size; n=2 for SS and TA).

| Treatment Irrigation | Avg. fruit (g) | vg.fruit siz (mm) | FF g/mm | SS % | TA % |
|---|---|---|---|---|---|
| T1 LF | 11.7 | 29.3 | 244 | 16.4 | 0.65 |
| T1 HF | 11.7 | 29.3 | 250 | 16.3 | 0.65 |
| T2 LF | 11.7 | 29.2 | 241 | 16.8 | 0.65 |
| T2 HF | 11.4 | 29.2 | 242 | 17.0 | 0.65 |
| T3 LF | 11.5 | 29.2 | 251 | 16.5 | 0.64 |
| T3HF | 11.6 | 29.1 | 233 | 16.8 | 0.65 |
| RDI LF | 11.5 | 29.2 | 246 | 16.4 | 0.65 |
| RDI HF | 11.7 | 29.4 | 246 | 16.7 | 0.65 |
| Statist. signif. | ns | ns | ns | ns | ns |

ns=not significant; * = significance at *P* <0.05.

**Methods**

*Objectives 1 and 3*: A ten-year-old 'Lapins'/'Mazzard' orchard, located in The Dalles, OR, and trained to a multi-leader system, was used for a fertilization x irrigation experiment. The experimental design was a 2 x 2 factorial, split plot with four levels of irrigation volume and three levels of fertilization. Main plot treatments (irrigation volume) were arranged in an RCBD, with five replicates. Subplot treatments were fertilization. Each replicate comprised of four trees, with the two center trees used for data collection. Four levels of irrigation amount, based on replacement of a percentage of tree water use, were delivered once weekly via microsprinklers, and were: 1) T1 (65% ET applied in 2009 and 2010, and 96% ET applied in 2011), 2) T2, 55% of ET, 3) T3, 45% of ET and, 4) regulated deficit irrigation (RDI), in which trees received 45% ET between the first irrigation and pit-hardening, 65% ET from pit-hardening through harvest, and 45% ET postharvest. Irrigation sets were controlled by automated valves.

Nitrogen was either broadcast to experimental plots in a split application roughly two weeks apart, beginning within one to two weeks from full bloom, or provided through the irrigation system (fertigation). Fertigation events occurred once per week for an eight-week period. For each event, nitrogen was injected over a four hour period during the middle of the irrigation set. The fertigation pump was controlled by an automated programmer. Rates were 100, 100, and 60 lbs/a, for the broadcast, fertigation-high, and fertigation-moderate treatments, respectively.

*Objectives 2 and 3*: A nine-year-old drip irrigated 'Tieton'/'Mazzard' orchard, located in Mosier, OR, and trained to a multi-leader system, was used for an irrigation volume x frequency experiment. The experimental design was a 2 x 2 factorial, split plot with four levels of irrigation volume and two levels of frequency. Main plot treatments (irrigation volume) were arranged in an RCBD, in five replicates. Subplot treatment was frequency. Each treatment/replicate was applied to an individual row (13 trees), and 5 trees per row were chosen for measurements based on similar trunk size and canopies. Four levels of irrigation volume were applied to replace tree water use via drip irrigation either once weekly (Low frequency- 12 hour set), or every other day (High frequency- 3 hour set; totaling an equivalent amount of weekly irrigation as Low frequency).

Soil moisture was measured at three sites per replicate (Lapins), or one site per replicate for Tietons, to a depth of 3 feet, in 6 inch intervals using a neutron probe. Stem water potential was measured using a pressure chamber every 7-10 days, to study plant water status.  Briefly, shoot leaves were selected in the mid portion of one-year-old shoot sections, bagged, and allowed to equilibrate for a minimum of 30 minutes prior to measurement.  Four leaves per replicate tree were measured.  Leaves were bagged roughly 1 hour prior to solar noon so measurements could bracket solar noon (+/- 1 hr).

Fruit and shoot growth was measured weekly during 2010 and 2011 at the Lapins site.  Trunk circumference was recorded in spring, at harvest and in the fall, each year, and converted to cross-sectional area.  At harvest, individual tree yields were recorded (5 per replicate for Tieton, and 6 per replicate for Lapins) and 100 fruit subsamples per replicate were collected for evaluation of fruit quality attributes (size, soluble solids, total acids, and firmness).  Fruit quality attributes were evaluated similarly following four weeks of storage at 1° C.

## Executive Summary

A three-year study was initiated in 2009 to investigate the effect of deficit irrigation treatments on sweet cherry yield, fruit quality and vegetative growth. Experiments were conducted at two sites. The first site consisted of microsprinkler irrigated, 9-year-old Lapins/Mazzard, planted at a density of 161 trees per acre. Treatment applications replaced different percentages of season-long reference evapotranspiration (ET0) and were, T1) 65% ET0 in 2009 and 2010, and 96% ET0 in 2011, T2) 55% ET0 (2009-2011), T3) 45% ET0 (2009-2011), and regulated deficit irrigation (RDI), which replaced 45% ET0 from the first irrigation in spring through pit-hardening, 65% ET0 from the end of pit-hardening until harvest, and 45% ET0 throughout the entire postharvest period (2009-2011). In addition, a nitrogen rate by delivery experiment was superimposed on the irrigation treatments. Nitrogen was applied at 100 lbs actual N per acre via microsprinklers (fertigation), or by ground application. A low rate of 60 lbs N per acre was also fertigated.

In 2011, yields of T3 and RDI were reduced ~10%, relative to T1 and T2. Over the three-year experiment, cumulative yields were reduced by 5% for all treatments relative to T1, albeit non-significantly. Yield reductions were attributed to differences in fruit number. No consistent differences were observed in fruit quality throughout the experiment. Fruit growth rate during 2010 and 2011, and final fruit size at harvest, were not affected by irrigation treatments, in any year. Shoot growth was not negatively affected by deficit irrigation. Trunk growth was limited in 2011 during the postharvest period by all deficit treatments, relative to T1. Stem water potential (indication of plant water status) declined (more stressed) as the season advanced, irrespective of treatment. In 2009-2010 treatment differences were slight and nonsignificant. However, when T1 was increased to 96% ET0 replacement in 2011, significant differences were observed by 3 weeks prior to harvest, where T1 trees had the highest water potential (less stressed). Water potential differences among the three deficit treatments were not significant. Measurement of soil moisture showed that roots of deficit treatments extracted significantly more water at the 2 and 3 foot depths. The additional water from deep soil reserves compensated for the reduced irrigation supply to deficit treatments.

Nitrogen (N) treatments (rate and delivery) did not consistently alter yield or fruit quality. In 2010, 60 lbs N via fertigation reduced yields. Differences between the two 100 lb per acre treatments were not significant. The reduction in 2010 yield followed high croploads in 2009 (14.5 tons per acre). There were no significant interactions between N and irrigation on yield or fruit quality.

The second site consisted of drip irrigated, 9-year-old Tieton/Mazzard. Trees were provided similar levels of replacement irrigation as described above, but delivered either once per week, or in four applications per week (same total volume per week). Frequency of irrigation did not consistently affect yield or fruit quality. Similar results were observed as described for Lapins above.

Overall, significant water savings were achieved at both sites. Fruit growth and quality was unaffected by deficit irrigation. Slight reductions in cumulative yield were observed in the most severe treatments. Drip irrigation resulted in greater water savings than micro-sprinkler irrigation, though this was enabled by the very short fruit development period, and low productivity, of Tieton. At both sites, deep soil moisture reserves served to limit the development of tree water stress during the pre-harvest interval. Caution is required when interpreting our results. Application of low percentages of ET0, such as those reported herein, to plantings in either shallow or light soils, or to dwarfing rootstocks and/or productive, late-season varieties (i.e., Sweetheart) would not be expected to produce similar results, and could in fact result in severe stress. Moreover, much our results can be attributed to good soil recharge occurring from adequate precipitation during dormancy and early spring. Future research should focus on deficit irrigation in high-density orchards planted on dwarfing rootstocks.