FINAL REPORT
WTFRC Project # AE-01-46 **WSU Project # 5802**

Project title: Effect of herbivory and water stress on pome fruit photosynthesis and productivity

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Funding history: Funded 2000-01 ($28,746), 2001-02 ($20,000)

Objectives:
1. Determine if water stress significantly increases the negative effect of mite feeding damage on four cultivars of apple. (2000-2002).
2. Determine diurnal pattern of CO_2 assimilation on mite-damaged and/or water stressed trees. (2000).

Significant findings:
Findings from the 2000 season indicate that water stress caused a 37% decrease in net photosynthesis (Pn) after six weeks of reduced irrigation levels, although this effect was temporary (Pn rates recovered after moisture stress was alleviated). Mite levels were low in 2000 and did not have a significant effect on Pn. Data from the 2001 season have not been completely analyzed, although preliminary analysis indicates no reduction in Pn due to either mites or water stress.

Methods:
1. Create mite-infested and mite-free trees in a uniform block of 5th leaf trees containing plots with the cultivars 'Oregon Spur,' 'Golden Delicious' and 'Fuji BC 2' and 'Royal Gala.' For each level of mite damage, create two levels of water stress (optimum water, stressed). Count mites *in situ* at biweekly intervals to calculate the cumulative feeding damage (mite days/leaf or cm^2). Equalize crop load early in the season. Measure gas exchange with a portable IRGA on the entire tree canopy at intervals throughout the season. Count leaves and obtain average leaf area and use to obtain a measure of m^2 canopy surface area in order to calculate photosynthetic rate. Measure fruit size shortly after June drop and again at harvest. Measure fruit quality parameters and storability of fruit.
2. Measure whole-canopy photosynthesis at 2-hour intervals during the photophase three times during the period of maximum water stress and mite infestation (July/August).

Results and discussion (2001):
Trees were hand infested with mites from a laboratory colony of twospotted spider mite, *Tetranychus urticae* Koch. Repeated inoculations were performed on the high mite treatment plots. The entire block was sprayed several times throughout the growing season with esfenvalerate to eliminate predatory mite populations. Mites were counted ca. weekly by removing 10 leaves/tree, brushing the leaves with a Leedom mite-brushing machine and counting the mites that fell onto the revolving glass plate. Five to 10 leaves/tree were collected and kept cool during transportation and storage. The mites were brushed from the leaves with a Leedom mite-brushing machine and collected on a revolving sticky glass plate. The composite sample on the plate was counted using a stereoscopic microscope. All stages and species of phytophagous and predatory mites were recorded, including the eggs and motile stages of European red mite (ERM), *Panonychus ulmi* (Koch); twospotted spider mite (TSM), *Tetranychus* urticae Koch; McDaniel spider mite (MCD), *Tetranychus mcdanieli* McGregor (the eggs of TSM and MCD could not be distinguished and were recorded as a group); western predatory mite, *Typhlodromus* (=*Galendromus*) *occidentalis* (Nesbitt); a stigmaeid predatory mite, *Zetzellia mali* Ewing; and motile stages of apple rust mite (ARM), *Aculus schlechtendali* (Nalepa). Mite days were accumulated to provided a summation of mite feeding stress according the following formula:

$$\Sigma CMD = ((p_1 + p_2)*.5)*(d_2-d_1)$$

where p_1 is the mite population (in average mites/leaf) at d_1 (date 1) and p_2 is the population on d_2 (date 2).

The population was composed primarily of *T. urticae* with a lesser proportion of *P. ulmi.* Despite inoculations, tetranychid mite populations remained low throughout the season (Fig. 1); functionally, no mite stress occurred on the trees. Predatory mites, however, were relatively numerous (Fig. 2) and were doubtless in part responsible for the ongoing suppression of phytophagous mites. This level of *T. occidentalis* in the presence of nearly continual residues of esfenvalerate is unprecedented, and further investigation is necessary to determine the tolerance status of this predator.

Water stress: An above-ground microsprinkler irrigation system was superimposed on the existing solid-set impact system in the test orchard. Each 6-tree plot in each of the 9 rows of the orchard could be irrigated individually; however, the entire 3-row x 6-tree plot was treated as a unit. In addition, Sentek® Enviroscan soil moisture probes were installed in two of the four replicates, with sensors located at four soil depths in each probe (20, 30, 40, and 60 mm). Capacitance data were downloaded weekly from the solar-powered datalogger. The Enviroscan monitors allowed real-time visualization of both the amount of soil moisture and movement of irrigation pulses through the soil profile.

The high-water plots were watered weekly (usually 8-hour sets) (Table 1), and the low-water plots were watered ca. every third week, or three times during the stress period (July-August). There was good separation between the high- and low-water plots over the course of the water stress period (July-Aug) (Fig. 3).

Table 1. Irrigation schedule, 2001.

			Water treatment level	
Date	Time	Hours	High (1, 3)	Low (2,4)
7/12/01	9:00am-5:00pm	8	x	x
7/16/01	9:00am-5:00pm	8	x	
7/23/01	9:00am-5:00pm	8	x	
7/30/01	9:00am-5:00pm	8	x	x
8/7/01	9:00am-5:00pm	8	x	
8/15/01	9:00am-9:00am	24	x	
8/21/01	8:30am-4:30pm	8	x	
9/4/01	9:00am-5:00pm	8	x	x

Whole-canopy photosynthesis: (WCP) was measured on 'Oregon Spur' trees the week of Aug 27. On each sampling date, one replicate (one tree/treatment) was measured approximately between 10 am and 3 pm. Total leaf area was estimated for each tree at the same time. Leaf area estimates were made by systematically counting all the leaves on the tree and removing every 100th leaf. A composite measurement of these leaves was made with a Li-Cor leaf area meter.

No differences were found either among treatments or either of the two factor levels (mites, water) (Tables 2, 3). The lack of differences in the mite factor levels is expected, given that mite stress in 2001 was almost nonexistent. The differences in soil moisture, however, did not translate to a reduction in photosynthesis.

Table 2. Net assimilation measurements, 28 Aug - 2 Sep, 2001 - treatment means.

			Net assimilation	
Mites	Water	n	umoles/m2/sec	
High	High	4	22.92	a
High	Low	4	22.37	a
Low	High	4	22.95	a
Low	Low	4	20.77	a

Table 3. Net assimilation measurements, 28 Aug - 2 Sep, 2001 - factorial means.

		Net assimilation	
Mite	n	umoles/m2/sec	
High	8	22.64	a
Low	8	21.86	a

		Net assimilation	
Water	n	umoles/m2/sec	
High	8	22.93	a
Low	8	21.57	a

Fruit measurements: Forty fruits/tree were sampled for quality assessments, 20 for each of two storage periods. These measurements will be completed in February 2002.

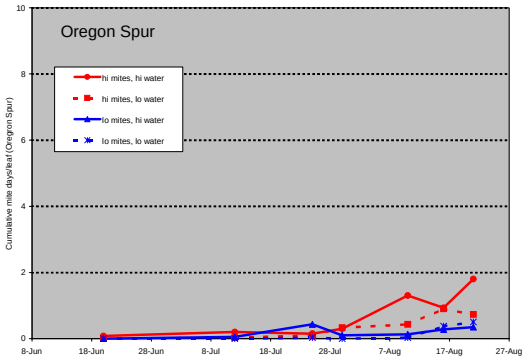

Fig. 1. Tetranychid mite populations, 2001

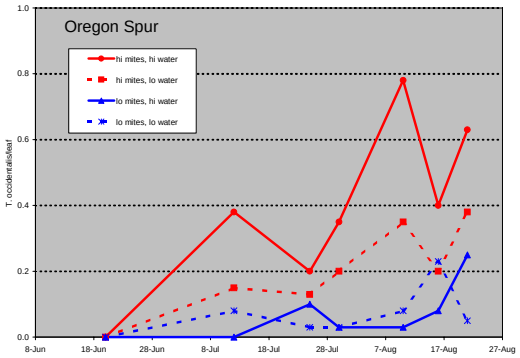

Fig. 2. Predatory mite populations, 2001

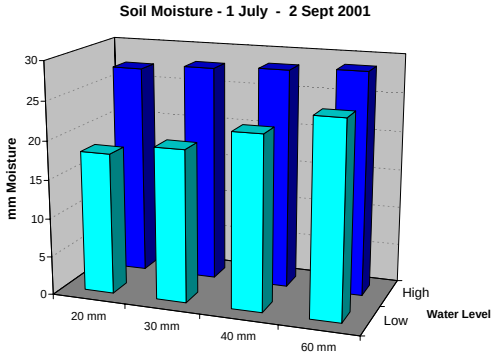

Fig. 3. Soil moisture levels, 2001