# Effect of Fruit Crop Load on Peach Root Growth

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**Abstract**

**Field experiments were conducted on mature, late-maturing peach trees ('O' Henry') to study the influence of assimilate availability on root growth. Crop load was used to vary assimilate availability by imposing three different fruit thinning treatments: thinned to commercial fruit loads, unthinned and completely defruited. Seven trees were used for each treatment, and four ingrowth root bags were buried per tree during four different periods of the growing season (corresponding to the three fruit growth stages and after fruit harvest). The bags were collected one month after burial and the root growth into each bag was determined from dry weight of all newly developed roots in a bag. Root growth values varied depending on crop load and fruit growth stage. During the first stage of fruit growth there was no effect of crop load on root growth. Root growth in all thinning treatments increased compared to the first stage and was significantly higher for the defruited trees. The root growth was minimal during the third stage of fruit growth in all the treatments. After harvest, root growth increased again in all the treatments. These experiments clearly demonstrated that there are seasonal patterns to root growth activity in peach trees and that crop load clearly influences the extent of that activity primarily during the late spring when the fruits are in the second stage of fruit growth.**

## INTRODUCTION

Dry matter partitioning at any given time is determined by the availability of resources to be partitioned, the conditional growth capacity and maintenance requirements of each organ and the relative availability of each organ to compete for the resources (DeJong, 1999). Competition for assimilates is a function of the overall demand for assimilates at any given time, location of organs relative to the sources of assimilates, organ sink efficiency and the overall availability of assimilates. The partitioning of assimilates in a mature fruit tree is expected to have the following priority: leaves>fruit>frame>laterals>roots (Layne and Flore, 1995). Roots are generally assumed to be the weakest sink in competing for resources. Grossman and DeJong (1994) modeled the carbohydrate partitioning to root growth as a residual and obtained reasonable results. However if the conceptual demand driven model of dry matter partitioning proposed by DeJong (1999) is correct, the best way to understand dry matter partitioning to root growth is to gain some understanding of the potential growth demands of roots during different parts of the growing season and determine if relative differences in assimilate availability influence root growth.

It is fairly well known that root growth in temperate fruit trees exhibits strong seasonal periodicity and can be affected by crop load (Atkinson, 1980). Peach appears to be no exception, and several researchers have reported clear peaks of root growth in the spring and after harvest but there is some controversy over whether the peaks in root growth are coordinated with periods of shoot growth, crop demands for assimilates or soil growth conditions (Richards and Crockroft, 1975; Williamson and Coston, 1989; Glenn and Welker, 1993). Furthermore, the goal of all the previous peach studies was to describe the natural patterns of root growth under field conditions using root observation boxes or mini-rhizotrons but not necessarily to quantify root growth potential.

The aim of this work was to quantify and compare the growth of roots under conditions that were highly favorable for root growth to estimate comparative conditional root growth potential through the growing season on trees with different crop loads. This was accomplished by using the ingrowth root bag method (Finer and Laine, 2000) as employed in other root growth experiments with peach (Marsal et al., 2003).

## MATERIALS AND METHOD

Before bloom, 84 mature trees of late-maturing 'O' Henry' peach [*P. persica* (L.) Batsch] budded on Lovell peach rootstock were selected for uniformity, in a block at the UC Davis Wolfskill Experimental orchard in Winters, California. The trees received all horticultural care for a commercial orchard.

The trees were divided into 3 blocks of 28 trees each. Each block was randomly assigned one of the three thinning treatments: (T1) unthinned with no fruit removed from the tree; (T2) trees with a standard commercial crop load; and (T3) completely defruited trees. Trees were thinned at the end of March, two weeks after full bloom.

Within each thinning treatment, the block was divided in four sub-blocks, consisting of 7 trees each. During four different periods of the season, four ingrowth root bags (Finer and Laine, 2000) per tree were buried at a depth of 5 cm. The bags were constructed of "root proof" landscape cloth and filled with ~2.0 l of 100% calcined clay (Turface™ Profile Products IL). The nutrient content of each bag was enriched by submerging each bag in Hoagland's Solution #1 before placing the bags in the soil. At the time of burial a root of ~5 mm diameter was cut and the root end that was attached to the tree was inserted into an end of the bag. The bags prevented the roots growing from the cut end of the root from going out or other roots from growing in so all the fibrous roots found in the bags when they were recovered were newly formed from the initial 5 mm root. The bags were sampled after 30 to 50 days, and all of the newly developed roots were collected, washed, dried and their dry weight determined. The four periods of the experiments corresponded to the three fruit growth stages plus a postharvest period (Table 1). Fruit growth was also followed by measuring fruit diameter of tagged fruit on the two cropped treatments.

## RESULTS AND DISCUSSION

As expected fruit growth was significantly less in unthinned trees than commercially thinned trees (Fig. 1). This result is similar to previous reports indicating that peach fruit diameter increased with declining tree crop load (Johnson and Handley, 1989).

Root growth during the first fruit growth stage was not significantly different among the three cropping treatments (Fig. 2). Fruit growth during this stage can be source limited when there are high crop loads per tree (Pavel and DeJong, 1993) as could be expected for the unthinned treatment. There was a slight trend for the unthinned (T1) treatment to have lower root biomass than the other treatments but that trend was not significant. Therefore it appears unlikely that there was substantial competition between fruit and root growth during this period. Vegetative growth is also an important sink for assimilates during this period but that sink also did not appear to have a differential effect on root growth with respect to the three treatments.

More root growth was observed in all treatments during the second stage of fruit growth compared to the first stage and root dry weight accumulated in the bags was significantly higher for defruited trees than for the two fruited treatments (Fig. 3). It is interesting that the effects of cropping on root growth were more apparent during this period than the previous period even though fruit growth during this period is thought to be sink limited (Pavel and DeJong, 1993; DeJong and Grossman, 1995). The higher overall rate of root dry weight accumulation during this period compared to earlier in the season probably relates to differences in soil temperature although we did not specifically measure soil temperature in this experiment.

Root growth during the third fruit growth stage was significantly higher for defruited trees (T3) than for the two other treatments (Fig. 4). Competition during this period apparently increased with increased fruit demand for assimilates (Fig. 1). This corresponds to the evidence that, with moderate to high crop loads, peach fruit growth is limited by assimilate availability during this stage (Pavel and DeJong, 1993; DeJong and Grossman, 1995). However it is very interesting to note that root dry weight accumulated in the ingrowth bags was less than for all other periods across all thinning treatments. Thus the decreased root growth during this period was not solely due to competition from crop since the defruited treatment had no crop. The reduction for defruited trees could indicate an effect of high temperatures during that period on root growth. With maize, Brouwer (1981) observed an increase of root growth with increasing temperature before a decline with high temperature. Preliminary studies of temperature effects on peach roots indicate that root growth declines at root temperatures above 32°C (Ben Mimoun, unpublished data).

Root growth after harvest was the highest of any period (Fig. 5 and 6) and was not significantly different for any of the cropping treatments. Thus, the surge of root growth during this postharvest period was likely not related to a rebounding of growth subsequent to cropping due to an increase in availability of carbohydrates, because the defruited trees had essentially the same pattern as the cropped trees.

The root growth rate (g DW/day) pattern was similar in shape for all the treatments but differed in magnitude (Fig. 6). It was reduced during the first and third fruit growth stages and increased during the second fruit stage and after harvest. Defruiting (T3) had a significant effect on root growth rate during the second and third fruit growth stage but no significant differences in root growth rates between the commercially thinned (T2) and the unthinned (T1) treatments were observed at any period of the experiment. After harvest, root growth rate increased for all the treatments.

Thaler and Pages (1996) observed that root growth in (*Hevea brasiliensis*) is related to competition for assimilates and occurs opposite the periods of shoot growth. Head (1967) and Williamson and Coston (1989) reported similar trends for young apple and peach trees, respectively. The current findings are consistent with those reports, and thus it appears that root growth periodicity may be related more with periodicity of shoot growth than with direct competition with the fruit crop. However, that does not preclude that crop load does moderate root growth.

Root growth rate differences between defruited trees and the other treatments was likely related to assimilate availability that was reduced by high fruit demand during specific periods (DeJong and Grossman, 1995). This result is in complete accordance with previous works regarding crop load effects on root growth (Head, 1969; Williamson and Coston, 1989; Palmer, 1992).

In summary, the present research shows that roots develop throughout the growing season; however, the apparent root growth potential varies considerably during different periods. Crop load and the inherent differences in assimilate availability appear to affect actual root growth during periods of maximum growth potential, but other factors appear to modulate the periodic root growth potential. Periods of apparently high root growth potential are somewhat out of phase with vegetative growth indicating that maintenance of a “balance” between shoot and root growth (Brouwer, 1981) may be related to some of the periodicity of root growth.

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## Tables

Table 1. The four periods during which ingrowth root bags were buried to quantify root growth that corresponded to various fruit growth stages. The starting and ending dates indicate dates of bag burial and removal followed by total days of each burial period.

| Fruit growth stage | Starting | Ending | Number of days |
|---|---|---|---|
| Stage I | April 12th | May 21st | 39 |
| Stage II | May 26th | July 15th | 50 |
| Stage III | July 21st | August 24th | 30 |
| After harvest | August 27th | September 29th | 33 |

**Figures**

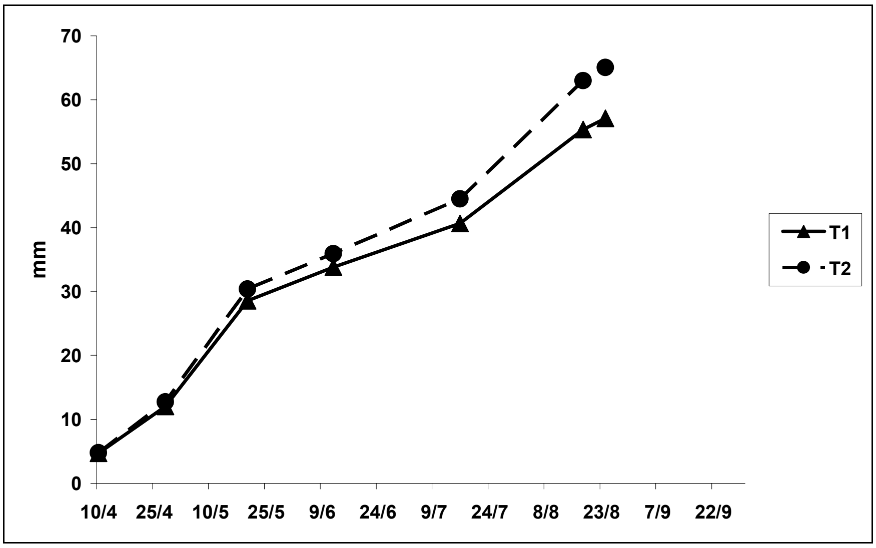


Fig. 1. The seasonal pattern of fruit diameter growth for the commercial thinned (T1) and unthinned (T2) ‘O’Henry’ peach trees used in this experiment.

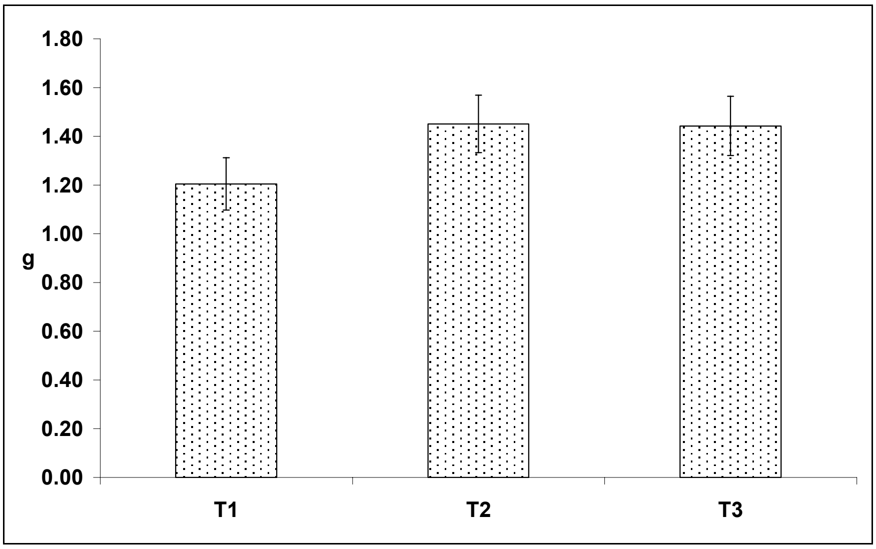


Fig. 2. Mean (± SE) root dry weight (g) accumulated in ingrowth root bags during the first stage of fruit growth in ‘O’Henry’ peach trees subjected to three different thinning treatments; defruited (T1), commercially thinned (T2), and unthinned (T3).

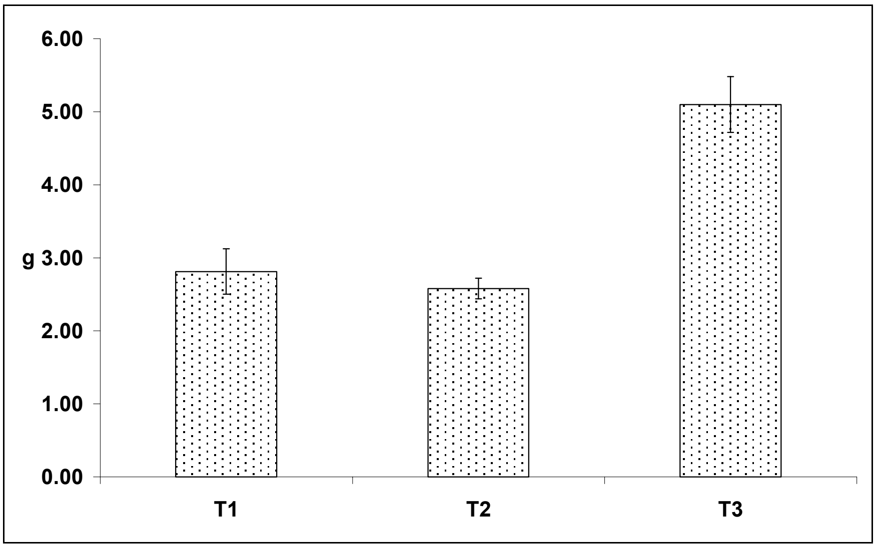


Fig. 3. Mean (± SE) root dry weight (g) accumulated in ingrowth root bags during the second stage of fruit growth in 'O'Henry' peach trees subjected to three different thinning treatments; defruited (T1), commercially thinned (T2), and unthinned (T3).

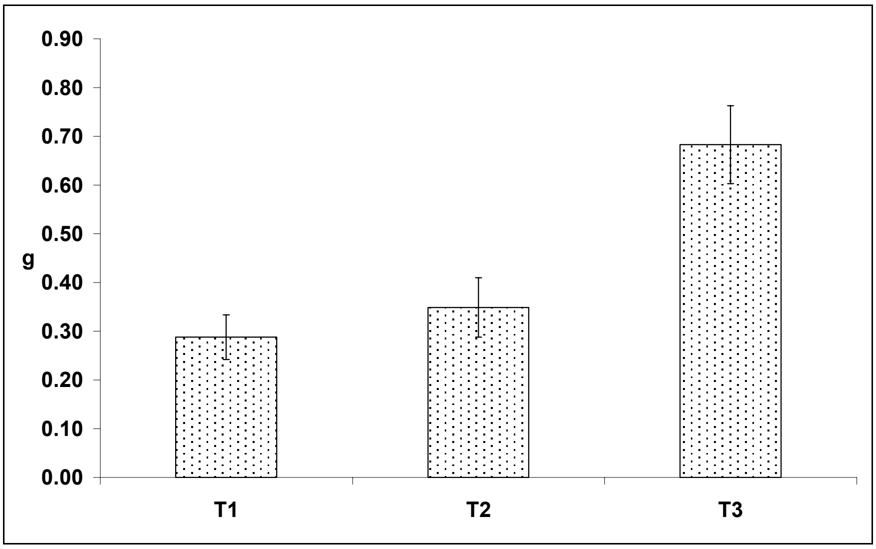


Fig. 4. Mean (± SE) root dry weight (g) accumulated in ingrowth root bags during the third stage of fruit growth in 'O'Henry' peach trees subjected to three different thinning treatments; defruited (T1), commercially thinned (T2), and unthinned (T3).

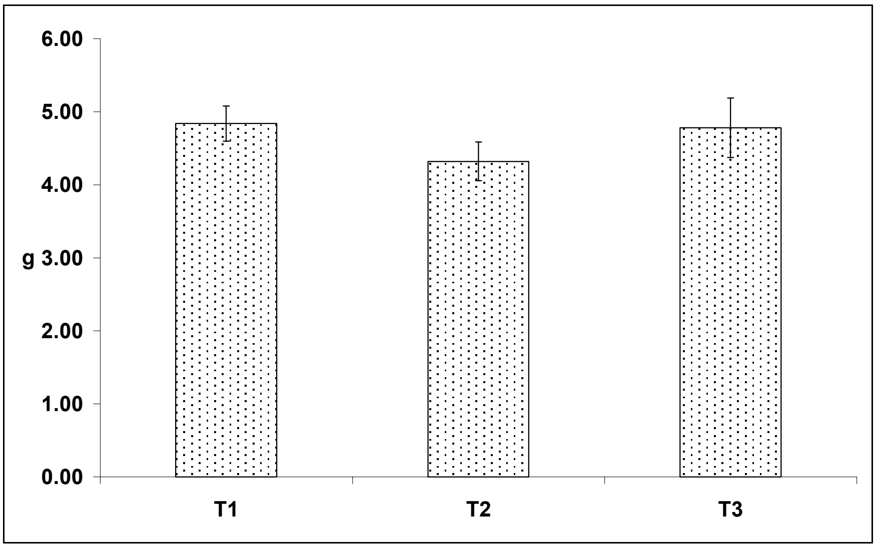


Fig. 5. Mean (± SE) root dry weight (g) accumulated in ingrowth root bags during the postharvest period in 'O'Henry' peach trees subjected to three different thinning treatments; defruited (T1), commercially thinned (T2), and unthinned (T3).

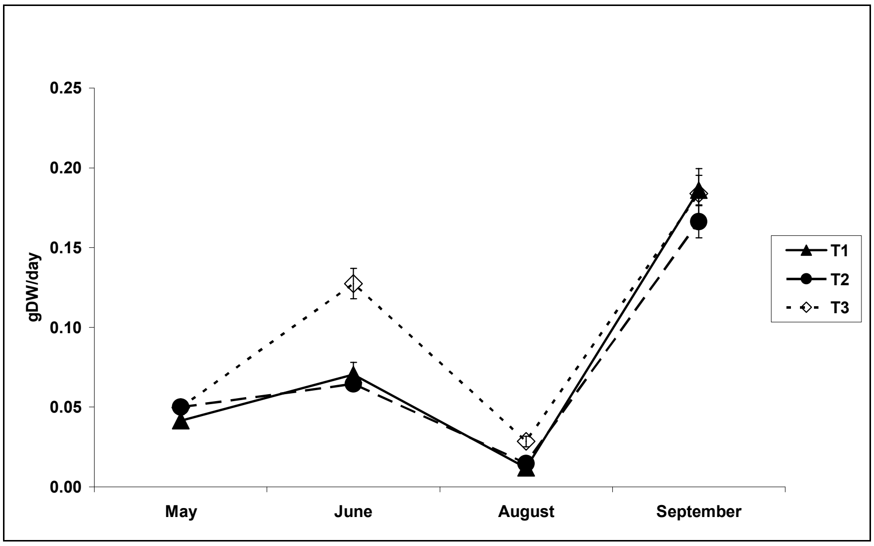


Fig. 6. The seasonal patterns of mean (± SE) root growth rates (g DW/day) measured in ingrowth root bags during four periods (Table 1) in 'O'Henry' peach trees subjected to three different thinning treatments; defruited (T1), commercially thinned (T2), and unthinned (T3).