WALNUT PRODUCTION AND QUALITY AS INFLUENCED BY ORCHARD AND WITHIN TREE CANOPY ENVIRONMENT

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ABSTRACT

There are differences in walnut quality through the tree canopy which may be related to water relations and/or light gradients. We have made significant progress on understanding the role of canopy position and light exposure on quality related problems in walnut. Shading related pellicle darkening and kernel shrivel is associated with low light levels. In addition, it appears that orchards running near the fully watered baseline (in the -4 to -5.5 bar midday stem water potential range) may have a decrease in nut quality compared to orchards in the -6 to -7 bar range although the mechanism is not yet known. Finally nuts with yellow pellicle occurred on branches that were in full sun early in the season but became shaded as the season progressed due to higher limbs coming down on top of them as the nuts filled and weighted them down.

INTRODUCTION

A study was set up in two Chandler walnut orchards in San Joaquin County. The first orchard was planted in 1998 and has 30’ x 30’ equilateral triangle layout. The second orchard was planted in 1994 and also has a 30’ x 30’ equilateral triangle layout. Both orchards have a history of producing kernels with a yellow pellicle. The grower has observed that the problem is worse at about 9 years of age and tends to be less severe as the orchard ages beyond 9 years.

PROBLEM AND SIGNIFICANCE

Walnut quality can vary within the tree canopy. The differences are likely related to both water relations and light distribution. Outer, exposed nuts can be susceptible to sunburn related damage. In addition to these more easily visible, outer canopy nuts, many walnut quality problems also occur in inner canopy, shaded positions. The authors have observed that these problems tend to be most severe in productive orchards with a high percentage of midday canopy light interception. Examples of the problems that have been observed in these inner canopy shaded positions include shriveled kernels, oilless nuts, the black Chandler problem and more recently kernels with yellow pellicles. All of these problems can have significant impacts on walnut yield and/or quality.

The relationship between orchard design, light interception and the potential impacts of these factors on nut quality is largely unknown.

The goal of this project is to investigate the role of orchard structure, tree physiology and microenvironmental conditions within the tree canopy on resulting nut quality. The intent is to use this information to aid in orchard layout, tree training and canopy management in order to maximize productivity and quality.

BACKGROUND

Walnut sizing occurs during the first 14 weeks after bloom. Kernel filling begins about 8 weeks after bloom and continues until about 20 weeks after bloom. Interruptions in carbon availability, which could be caused by lack of water, excess water, excessive heat, etc. during the first 14 weeks after bloom can result in smaller sized nuts while interruptions from 8 to 20 weeks after bloom can result in kernel filling and or quality problems. Any of these stresses likely would have more severe impacts on nuts in interior, shaded positions.

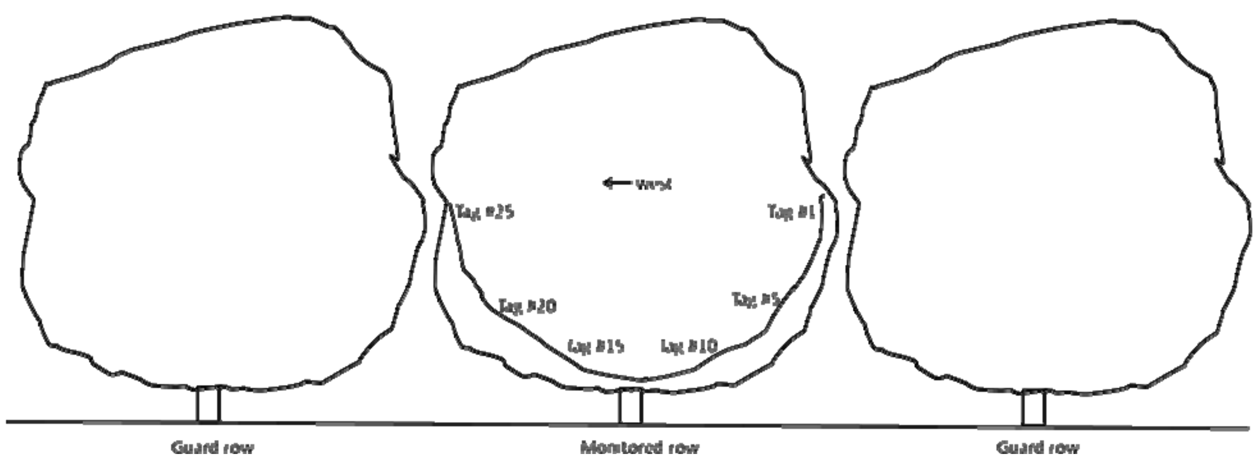
OBJECTIVES

The goal of this project is to monitor conditions throughout the tree canopy during the kernel filling period and attempt to relate these conditions to resulting kernel development and quality.

PROCEDURES

A study was set up in two Chandler walnut orchards in San Joaquin County. The first orchard was planted in 1998 and has 26’ x 26’ equilateral triangle layout. The second orchard was planted in 1994 and also has a 26’ x 26’ equilateral triangle layout. Both orchards have a history of producing kernels with a yellow pellicle. The grower has observed that the problem is worse at about 9 years of age and tends to be less severe as the orchard ages beyond 9 years.

Four irrigation treatments were set up in each orchard. Treatments included a fully irrigated control and treatments with water cutoffs on Aug. 1, Aug. 15, and Aug. 30. Each replication consisted of three rows and approximately seven trees per row. Midday stem water potential was measured approximately weekly on five trees in each of the four irrigation treatments in both orchards. In May 2007, all nuts on 25 spurs were tagged on each of the five monitored trees in each treatment (total of 1000 spurs). The spurs were tagged in the pattern shown below. Midday canopy light interception for the overall orchard and midday canopy light interception directly



underneath the tree canopy were measured approximately every 1-2 weeks during the growing season using a Decagon Sunfleck Ceptometer (Decagon Devices, Pullman, WA 99163). The

number of yellow leaves and the number of nuts that dropped beneath each monitored tree were also measured approximately every 1-2 weeks.
The diameters of the tagged nuts were measured at the time of tagging in late May and again in late July. In late July, one tree in each orchard was outfitted with individual photodiodes on one nut and one terminal leaflet on each tagged spur (total of 50 photodiodes per tree). The photodiodes measured the incident light falling on the nut and leaf. Data was recorded on a Campbell Scientific CR10 datalogger at one minute intervals for 3 days in each orchard. On the two trees that had the light sensors attached, an adjacent spur (selected to have similar characteristics to the monitored spur) was sampled and used for measurement of leaf area as well as leaf specific masst. Leaf disks were taken with a cork borer from each of the terminal leaflets on all tagged spurs in early September. The leaf disks were dried and weighed to determine leaf specific mass expressed as grams of dry weight per meter squared of leaf area. The longest leaf and the number of leaves on each tagged spur were counted on each tagged spur in early October 2007.

Temperature and relative humidity were monitored in one control tree in each orchard Data was collected at 0.5 to 1 hour intervals throughout the season.

PRELIMINARY RESULTS AND DISCUSSION

Water potentials generally ran about 1 to 2 bars less stressed in the 9 year old orchard than in the 13 year old orchard (Fig.1). When irrigation was stopped, water potentials tended to drop off more rapidly in the 13 year old orchard than in the 9 year old orchard on the Aug. 1 and Aug. 15 cutoff dates but not on the Aug. 30 cutoff date (Fig. 1). Because the irrigation system was only operated once per week, desired levels of stress were not always reached since if the level was near the target but not quite there, another week might have resulted in overshooting the target with potentially damaging effects on yield or quality.

Midday canopy light interception was very high in both orchards with overall orchard levels at about 86 to 94% interception and levels underneath the tree at about 97 to 99% interception (Fig. 2). There was significantly higher overall midday canopy light interception in the 13 year old orchard compared to the 9 year old orchard (Table 2). These are very high levels of light interception which would be expected to result in shading resulted dieback of lower leaves based on our earlier data from other walnut orchards. Although we did see dieback of lower leaves and branches, it was not as high as the authors would have expected based on previous data. There are two management related issues that may have acted to help minimize shading related dieback. First, the trees were kept very near the fully irrigated baseline throughout the season since the grower uses a pressure chamber to aid in irrigation scheduling. This means that leaves that might otherwise have become a net negative and dropped, might have stayed a net positive for a longer period. Most orchards would go through some stress cycles at some time during the season that would cause some of these lower leaves to abort. The second management practice that may have helped to minimize shading related dieback was a pruning program that was done the previous winter which had a goal of selectively removing higher canopy limbs to increase light penetration lower into the canopy with the goal of preserving lower fruiting wood.

Although there was an increase in yellowing and leaf drop in the lower canopy associated with the irrigation cutoff treatments (Fig. 3), it was not enough to cause a noticeable change in midday canopy light interception in any of the treatments in either orchard (Fig. 2). The increase in leaf drop was only significant for the August 1 cutoff date in the 13 year old orchard (Table 1). There was no increase in dropped nuts associated with any of the treatments (Table 1). However, there likely were effects on nut sizing and quality on individual spurs that lost their leaves.

There was a lot of variability in nut size at the time of tagging in late May 2007 due to a protracted bloom in the orchard that was common in many Chandler orchards in 2007. Nuts that were smaller at the time of tagging in late May 2007 grew at a faster rate than nuts that were larger at the time of tagging (Fig. 3). Nuts on spurs with one nut were able to grow faster than those with two nuts and the effect was more pronounced in the 9 year old orchard (Fig. 4).

The total kernel dry weight at the time of harvest was greater on spurs with two nuts as compared to those with one nut (Fig. 5). This suggests that spurs with one nut may be able to build up more reserves in store for the following year compared to spurs with two nuts which would likely be more depleted of reserves. Severely shriveled nuts tended to be on spurs with very low leaf dry weights (Fig. 5). Interestingly, nuts on spurs with very high dry weights tended to have slight kernel shrivel as well (Fig. 5). This could be due to competition for carbon from the actively growing shoots.

The percentage of yellow kernels in these two orchards was extremely small in 2007. The growers' records indicate that there were less than 1% of the nuts with yellow kernels in these two orchards in 2007. We did observe the position on the tree where the yellow nuts did occur. They generally were in lower positions over the drive row where a higher limb fell down on top of them as the crop weight on the trees increased. This resulted in spurs (and nuts) which had been in a good light position early in the season, becoming densely shaded in mid-summer. The result of this shading was often a fully formed and filled kernel and a black, mushy hull (not unlike the appearance of a husk fly infested nut although no larvae were found) with a yellow pellicle on the kernel. Since this event was rare in 2007, we are not sure how many of our tagged nuts will have this characteristic (we have only processed about 10% of the nuts at the time of reporting). In addition, we concentrated on nuts in the lower canopy, shaded positions and had relatively few tags over the drive row where this problem occurred. We did find yellow pellicles on nuts in similar positions in at least two other orchards.

We have good data on shrivel and darkening of pellicles associated with shaded positions in the inner canopy although most of the data has not yet been processed. In general, nuts in shaded positions which had a darkening of the hull (but not the mushy hull described above in association with yellow pellicles) tended to have darkened pellicles and/or shriveled kernels. Further analysis of this data set will help to clarify the level of light required to prevent these problems from occurring. The data in Figure 5 suggests that above about 5 umol per day of light, the curve flattens and there is no associated increase in leaf specific mass.

In summary, we have made significant progress on understanding the role of canopy position and light exposure on quality related problems in walnut. It appears that shading related pellicle darkening and shrivel is associated with low light levels. In addition, it appears that orchards running near the fully watered baseline (in the -4 to -5.5 bar midday stem water potential range) may have a decrease in nut quality although the mechanism is not yet known. Finally nuts with yellow pellicle occurred on branches that were in full sun early in the season but became shaded as the season progressed due to higher limbs coming down on top of them.

The goal of this project in the 2008 season will be to finish analyzing the large dataset on light and nut quality that we collected in the 2007 season and use this information to both guide further field studies for the 2008 season on the areas in the canopy which are likely problematic for nut quality and to begin to design an orchard layout and management regime that minimizes potential for these problems.

ACKNOWLEDGEMENTS

Thanks to the Walnut Marketing Board, the Barton Ranch and Diamond Foods, Inc. for supporting this work.

TABLES AND FIGURES

Table 1. Average number of yellow leaves and dropped nuts by orchard and treatment. Letters indicate significant difference between orchards.

	Ave. yellow leaves				Ave. dropped nuts			
Orchard	No-cutoff	Aug-1	Aug-15	Aug-30	No-cutoff	Aug-1	Aug-15	Aug-30
13 yr old	4.58 a	11.93* a	7.60 a	6.61 a	2.60 a	3.00 a	1.92 a	1.72 a
9 yr old	2.04 b	3.07 b	3.02 b	2.38 b	1.50 a	1.62 a	2.12 a	2.10 a

*significantly different from all other treatments- only significant difference between treatments

Table 2. Midday stem water potential, light interception and quality differences between the 13 and 9 year old orchards.

Orchard	**Seasonal average MSWP**	**Midday light interception (%)**	**Light interception under tree canopy (%)**	**Average nut weight (g)**	**Mold (%)**	**RLI**	**Relative value**
13 yr old	-6.34 b	90.3 a	99.0 a	11.48 a	0.70 a	56.52 a	1.028 a
9 yr old	-4.83 a	88.1 b	99.2 a	11.06 b	1.30 a	55.40 b	1.003 b

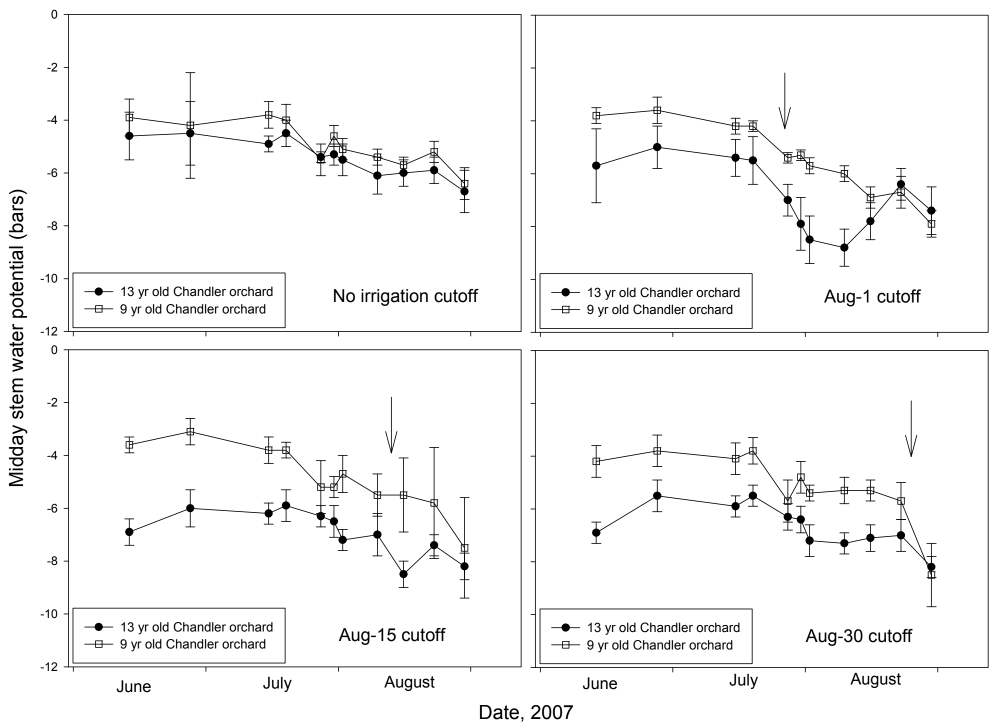


Fig. 1. Midday stem water potential by irrigation treatment and orchard. Arrows indicate approximate date of irrigation cutoff.

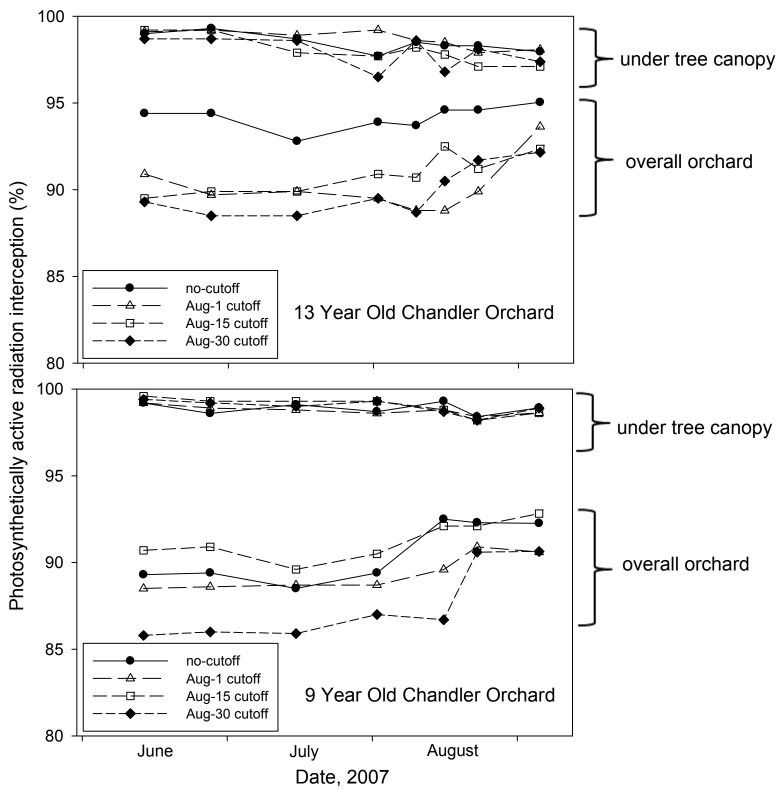


Fig. 2. Midday canopy light interception for the overall orchard and underneath the tree canopy for the 13 and 9 year old orchards over the 2007 season

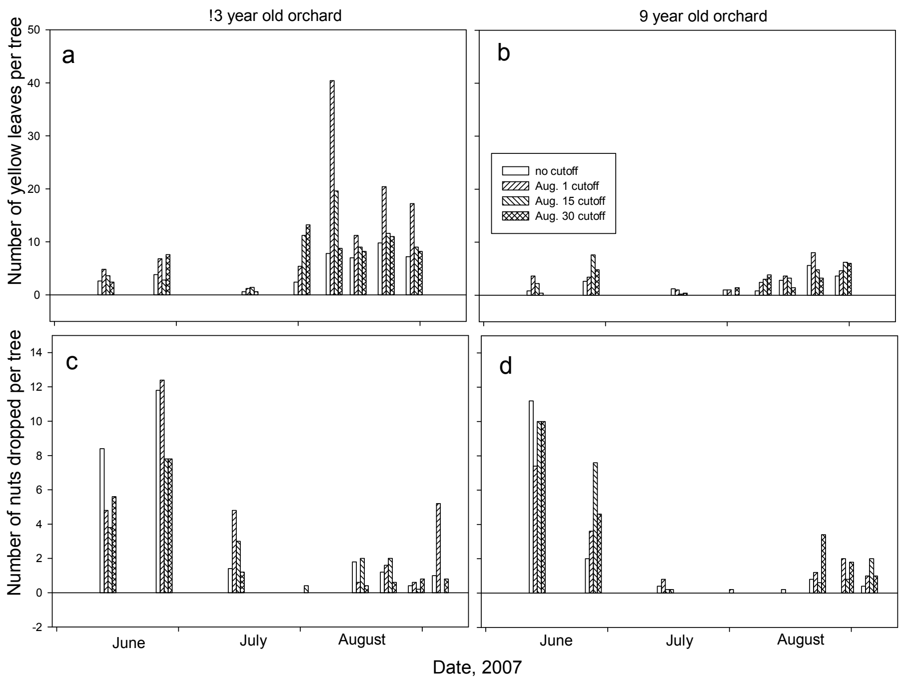


Fig. 3. Seasonal pattern of yellow leaves in the a) 13 year old orchard and b) 9 year old orchard and number of nuts dropped on each sampling data in the c) 13 year old orchard and d) 9 year old orchard.

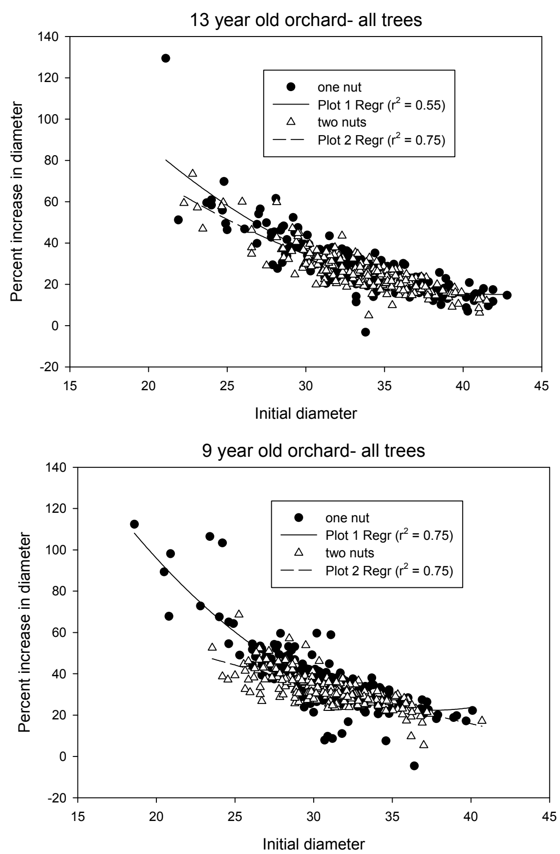


Fig. 4. Diameter at first measurement date in late May versus percent increase in diameter by late July.

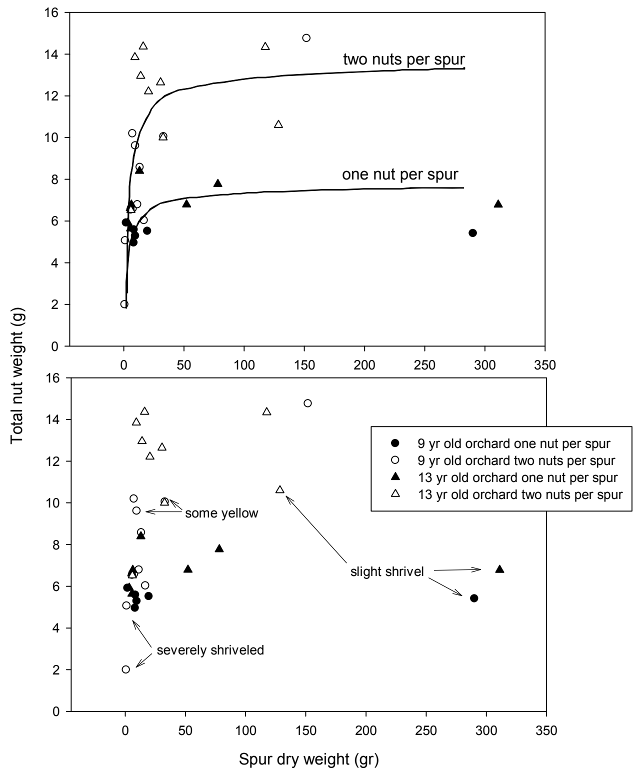


Fig. 5. Relationship between total dry weight of spur leaves and total kernel weight per spur. For spurs with two nuts, kernel weight given is the total for both nuts on the spur.

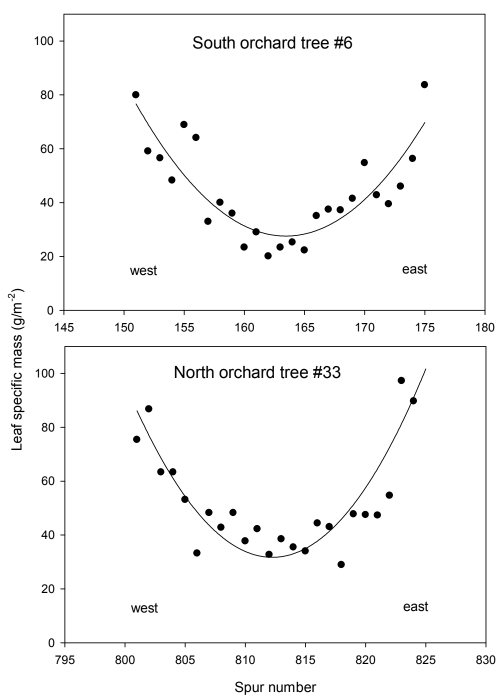


Fig. 6. Leaf specific mass as it varied across the tagged spurs on tree #7 in the south orchard and tree #33 in the north orchard. The lowest numbered tag is high on the west side of the tree and the highest numbered tag is high on the east side of the tree.

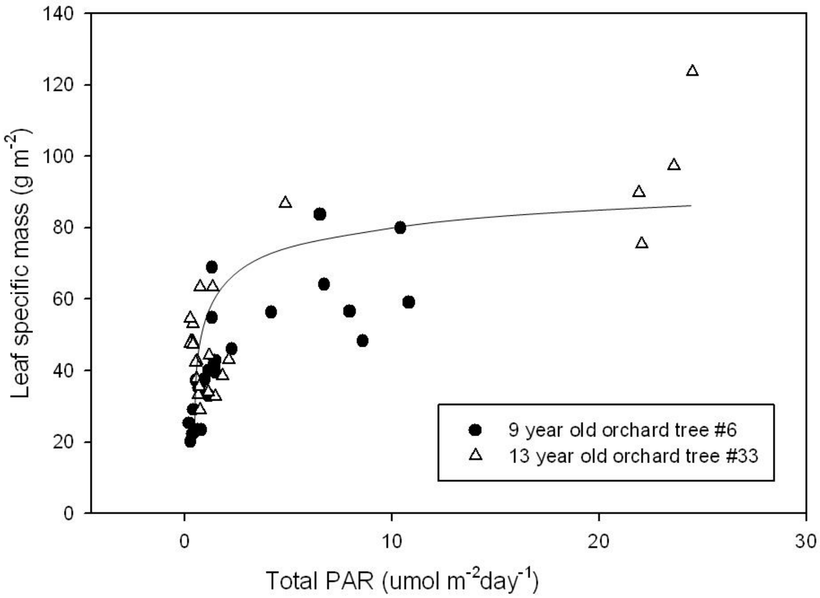


Fig. 7. Total photosynthetically active radiation falling on leaf (measured with photodiode and datalogger) and leaf specific mass.

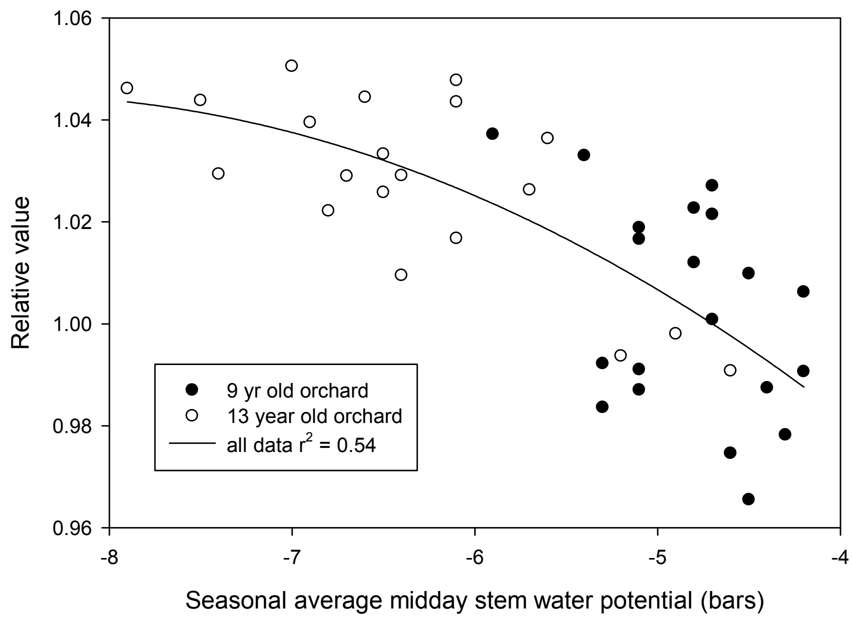


Fig. 8. Relationship between seasonal average midday stem water potential and relative nut value (as evaluated by Diamond Walnut) for the 9 year old and 13 year old orchards. Regression line is fit to data from both orchards combined.