

CHANDLER WALNUT HEDGEROW PRUNING AND TRAINING TRIAL 2014

Bruce Lampinen, Janine Hasey, Carolyn DeBuse, John Edstrom, Sam Metcalf, William Stewart,
and Loreto Contador

ABSTRACT

Hedgerow walnut orchards have been studied since the 1970s as a high density system to reduce pruning costs and to benefit early production. At present, the common pruning methods are similar to the methods used to establish conventionally spaced orchards with some differences in heading height of the trunk and height of the first scaffold selected and the amount of wood removed in the early years. This trial looks at ways to improve this pruning method to gain a better tree structure, improve the amount of fruit wood, decrease wind damage and potentially reduce the need for early hedging of the orchard. Four hedgerow training systems were implemented starting in 2009 after the first season of growth; heavily pruned, minimally pruned, minimally pruned with restricted irrigation and unpruned. Tree growth characteristics of diameter, height, canopy size (light interception), and yield were measured in 2009-2014. Plant water status was measured using midday stem water potential throughout the growing season. 2014 Chandler results show a difference in average circumference and height, with the heavily pruned treatment being significantly smaller and shorter than the minimally pruned treatment and the untrained/unpruned treatment but no significant difference in PAR interception, yield, cumulative yield, or yield per unit PAR intercepted among treatments in 2013. In 2012-2014, unlike in earlier years, the midday stem water potential of the Chandelers showed no significant difference between treatments throughout the season although the unpruned treatment tended to be the least stressed and the deficit irrigation treatment tended to be more stressed than the other treatments on most dates, particularly early in the season.

OBJECTIVE

The objective of this trial is to consider different training styles in the early years for hedgerow planted Chandler walnuts. This trial also does a cursory evaluation of two new varieties, Gillet and Forde, and compares them to the older varieties of Tulare and Chandler for their ability to be trained in a hedgerow planting. A secondary goal of this experiment is to see if reducing vigor with deficit irrigation in the 3-6th year would postpone the need for early hedging and help maintain a smaller sized tree without negative impacts on yield.

PROCEDURES

The trial is located within the Nickels Soil Lab hedgerow planting of Chandler that also contains three rows of other varieties; one row each of Tulare, Forde and Gillet. The trees were planted in March 2008 on a one foot berm, at a spacing of 15 ft. x 22 ft. (132 trees per acre). The trees were nursery budded on Paradox rootstock. The orchard is irrigated with double line drip with inline emitters spaced 22 inches apart. Pruning is done in March of every year.

Training systems for this trial began at the end of the first growing season. Four training systems were applied in a randomized block experimental design containing 6 replicated plots of each treatment. Each plot is three rows across with 5 trees in each row. Data was collected from the three interior trees. The training systems were renamed and refined before the second year pruning to create more distinction between treatments. The training systems include:

1. **Heavily pruned hedgerow training (T1).** After the first growing season, choose one central leader and remove other shoots. Head the one year old (2009) trees at a height of 6 feet. Second year (2010), select and head a central leader by 1/3 of length. Select 4-6 primary scaffolds and head each by 1/3 their length. If necessary, heights of scaffolds were maintained below the height of the central leader by heading. All unselected branches were removed if they were large and likely to compete with chosen scaffolds. Forked branches were reduced to a single branch and branches below 3-4 feet were removed. All remaining branches and fruit wood were tipped or removed. In the third year (2011), the central leader from previous year was examined and if choked out by a stronger branch, a new central leader was chosen. The chosen central leader had 40% of the growth from previous year removed. Branches that were competing with the leader were removed. In season branching points were removed in secondary scaffolds. Secondary scaffolds were chosen in all directions without being too close together and headed by 40% making sure no secondary scaffold was taller than central leader. All twisted, crossed or rubbing branches were removed. Fourth year (2012), 1/3 of the new extension growth from last season was cut off. All other scaffolds and branches were also headed making sure that no scaffold was higher than the heading cut on the central leader. All rubbing, crossing or twisted branches were also removed. There was no pruning in 2013 or 2014.
2. **Minimally pruned hedgerow/deficit irrigation training (T2).** Follow minimal hedgerow training (3) with restricted irrigation from year 3 on to create lower vigor. Irrigation was restricted to 75% of control levels since June of 2011.
3. **Minimally pruned hedgerow training (T3).** First year (2009), main scaffold headed at 6 feet. Second year (2010), central leader selected and 1/3 of previous season's growth was removed. 4-6 primary scaffolds were selected and headed below the height of the central leader. The heading cut removed 1/4 to 1/3 of the length of the previous season growth. Forked branches on chosen scaffolds were reduced to a single branch. Remaining unselected branches and small caliper fruit wood were left unpruned and unheaded to create early fruiting wood. Third year (2011), the strongest, tallest scaffold was chosen as the leader and 33% of the previous season's growth was removed. Other scaffolds were left alone if they were growing in a vertical position. One or two strong scaffolds were chosen on the sides of the canopy, one in each cardinal direction and 33% of the new growth was removed. Forked branches were left but twisted, rubbing or overlapping branches were removed. Fourth year (2012), the top of the tree was left alone. No pruning cuts were made on upright scaffolds or the central leader. One or two scaffolds in each cardinal direction were headed by removing approximately 12-24 inches. A total of 3-5 cuts were made per tree. There was no pruning in 2013 or 2014.

4. **No heading/pruning hedgerow training (T4).** First year, lower branches below 3-4 feet were removed and one main trunk was selected but it was not headed. In the following years, there was no pruning or heading done unless lower branches needed to be removed for reasons of safety or ease of maintenance and harvest.

The variety training trial was restricted due to the fact that only one row of trees were planted of each variety- Tulare, Forde and Gillet. Within each of these varieties, 7 plots of 5 trees were randomly chosen for one of three training treatments: 2 plots of heavily pruned (T1), 2 plots minimally pruned (T3) and 3 plots no pruning (T4). Minimal/low vigor training (T2) was not included in the variety trial. The limited number of replications makes statistical analysis not possible. Data collected from these three rows is not shown due to lack of true replication, but the trends generally follow those from the Chandler trial. Starting in 2012, no pruning was done on any treatments of the Forde, Gillet or Tulare.

Data collected in the growing season of 2009 for all varieties included, diameter (mm) at 2 and 6 feet of height in March and again at 2 feet at the end of the season in December, height of main trunk after pruning in March and in December, total number of emerging shoots in May, and number of emerging shoots above 3 feet from the ground in May. Midday stem water potential was measured in June, July, and September on the Chandler variety. Number of shoots per 10 centimeters of main trunk was calculated.

In 2010-2014, circumference at 2 feet above ground level (in November), height of tallest branch, midday canopy light interception (Mule mobile platform), and yield were measured. During the 2010-2014 growing seasons, midday stem water potential was measured using a pressure chamber approximately every 2 weeks. In 2014 midday stem water potential was measured approximately monthly.

RESULTS AND DISCUSSION

For Chandler in 2011, the heavily pruned treatment (T1) had significantly smaller trunk circumference compared to the other three treatments (Table 1). In 2012 and 2013, the heavily pruned treatment had significantly smaller trunk circumference compared to the minimal and unpruned treatments (Table 1). In 2014, there were no significant differences in trunk circumference (Table 1).

There were no significant treatment differences in tree height in 2011 or 2012 (Table 2). In 2013 and 2014, the unpruned and minimally pruned treatments were significantly taller than the heavily pruned treatment (Table 2). The alternate year elongation growth can be clearly seen in the unpruned treatment when it did not increase in height between 2009 and 2010 (Fig. 1).

In 2014, though there were no differences between the treatments for July midday canopy light interception (Table 3). There were also no significant treatment differences in yield, yield per unit PAR intercepted or in cumulative yield (Table 3).

Yield efficiency can be expressed as the yield per unit PAR intercepted. Figure 2 shows the trends in yield per unit PAR intercepted over the 6 years of the study. Yield per unit PAR intercepted was significantly higher in the unpruned treatment (T4) compared to all other treatments in both 2010 and 2011 but not in 2012, 2013 or 2014. Fig. 3 shows the data for all of the walnut light bar sites with the 2014 data for the Nickels Chandler pruning trial shown in pink circles.

The cumulative yield for the unpruned treatment (T4) was significantly higher than all other treatments in 2009 and 2010 and significantly higher than all except the minimally pruned deficit treatment (T2) in 2011. By 2013, there were no longer any significant differences in annual or cumulative yield among treatments and this same pattern continued in 2014 (Table 3). This is not unexpected since none of the treatments have been pruned for the past two dormant seasons.

The relatively high vigor and yield in the minimal/deficit irrigation treatment may be partially explained due to the plots being located in better soil on average compared to the other treatments. Over the years, we have gained a better understanding of the soil and slope differences that occur within the trial and have found that at the time we created our plots, we inadvertently placed all of the minimal/deficit irrigation plots in better soil on level ground. The deficit irrigation has now been in place for the last 4 growing seasons and it appears that tree height is being decreased by the deficit treatment (Table 2) but yields continue to be not significantly less than the other treatments. It is interesting that the minimum pruned deficit treatment had similar yields to the minimal pruned until 2010 but after the deficit was imposed the yields increased for the deficit treatment (see arrow in Fig. 4 showing where deficit was imposed). This suggests there may have been some benefit to the deficit treatment in increasing fruit set and/or yield meaning there may be some periods, likely during spring when the normally irrigated trees may have been too wet.

In 2010, the midday stem water potential of the Chandlers showed a different trend from the year before (Figure 4). The unpruned treatment showed the highest stress in the spring between the treatments though was not significantly different. Progressively from August until the end of the season the unpruned treatment showed the least amount of stress with the midday stem water potential being at or above the baseline. By the end of the season the midday stem water potential of the unpruned treatment was significantly higher (less stressed) than all other treatments.

In 2011, the midday stem water potential of the Chandlers showed no significant difference between treatments throughout the season except the minimally pruned plus deficit irrigation treatment (T2) was more stressed than the untrained, unpruned treatment (T4) on most dates (Fig. 5). The heavily pruned treatment (T1) in the Forde and Gillet was more stressed than the other treatments during late August and early September but all varieties returned to the fully watered base line on the date of the last reading in mid-September.

In 2012, 2013 and 2014, there were no significant differences in midday stem water potential among treatments on any date although the untrained/unpruned treatment tended to be less stressed early in the season (Figure 7, 8, 9). However, it should be noted that all treatments went through four substantial stress events during the 2012 season and two stress events in the 2013 season and each of these stress events was likely severe enough to slow down or stop vegetative growth.

In the winter of 2011, a time lapse camera was set up in the orchard with a view of trees from the minimal pruned (T3) and unpruned, untrained (T4) treatments. The resulting photos shown in Figure 8 were taken at the beginning and the end of the season in 2011 and at the end of the season in 2012. The tree to the left is a minimally pruned tree and the one the right is an unpruned tree. The dramatic growth on the east side (right) of the unpruned tree shows the tree's ability to fill in areas of the canopy that were empty even if the branches on that side are not tipped or headed in the pruning manner understood to 'promote' growth. In a healthy tree, bud

and resulting shoot growth are stimulated by light and in areas of greater light (i.e. empty areas of canopy) branches will continue to grow throughout the season. Note that the central leader from the 2010 season which was leaning to the left on the unpruned, untrained (T4) treatment tree became a side scaffold by the end of the 2011 season as the tree filled in the canopy gaps.

Observational data on the Forde, Gillet and Tulare show no differences between treatments for circumference, height and canopy light interception (PAR), or yield (data not shown). There are not enough reps and the statistical design is not sufficient to determine if there are statistical differences. The one observation that is worth noting is that the Forde heavily pruned trees had a high number of short side branches growing on the current season wood (2010). The effect was very similar to what would be called ‘witches broom’. This made the 2011 pruning difficult and tedious to remove most of these short branches so that normally spaced branches were left. At this time we would recommend that Forde be minimally pruned and have no large heading cuts, cuts over 30% of current season’s growth, made in the establishment years.

PRELIMINARY CONCLUSIONS

In 2014, there were no longer significant differences in average trunk circumference (Table 1) but the heavily pruned treatment continued to be significantly shorter than the minimal or unpruned treatments (Table 2). PAR interception, yield, cumulative yield, and yield per unit PAR intercepted were not significantly different among treatments in 2014 (Table 3). In 2012, 2013 and 2014, unlike in earlier years, the midday stem water potential of the Chandlers showed no significant difference between treatments throughout the season although the unpruned treatment tended to be the least stressed and the deficit irrigation treatment tended to be more stressed than the other treatments on most dates. The likely reason for the decreasing treatment differences with time is that the amount of pruning done (especially on the minimal pruned treatment) becomes much less significant as the trees age. By the fifth dormant pruning, the 4 or 5 cuts made on the minimal treatment means that only a small proportion of the canopy is cut and in fact the treatment is little different from the unpruned treatment. For the past two dormant seasons, no pruning has been done on any treatments. These results are similar to what we saw with the Howard pruning trial (Lampinen et.al, 2010) with unpruned treatments tending to produce higher yields in the early years and cumulative treatment differences becoming non-significant by the 5th year.

This study continues to suggest that walnut trees can be grown with minimal or no pruning in years 1-6 without detrimental effects on tree size, yield or quality. Grower trials, as part of the Orchard Management Project, with minimally pruned and unpruned walnuts are ongoing to determine results in a variety of geographical locations, tree densities, and management systems. Data on root growth in this trial is presented in a separate report titled “Root Growth Dynamics and Constraints on Above Ground Growth and Yield in Walnuts”.

REFERENCES

Lampinen, B., J. Edstrom, D. Ramos, S. Metcalf, B. Stewert, L. Contador and S. Cutter. 2011. Comparison of growth and productivity of pruned and unpruned ‘Howard’ walnut trees as impacted by crop load. Walnut Research Reports 2010. California Walnut Board, Folsom, CA. pp. 117-124.

Table 1. Average circumference of the Chandler in each treatment in March 2009, December 2009, November 2010, November 2011, November 2012, November 2013 and November 2014. Letters indicate significant difference between treatments (Duncan's Multiple Range Test, $P < 0.05$).

Treatment	Ave. circumference at 2' above ground (cm)						
	Mar. 2009	Dec. 2009	Nov. 2010	Nov 2011	Nov 2012	Nov. 2013	Nov. 2014
Heavily pruned (T1)	8.25 a	20.4 a	27.9 b	34.5 b	40.1 b	45.1 b	50.0 a
Minimally pruned/deficit irrigation (T2)	8.25 a	21.7 a	32.0 a	37.9 a	43.1 ab	47.7 ab	51.2 a
Minimally pruned (T3)	7.89 a	20.3 a	29.7 ab	37.2 a	43.9 a	50.4 a	53.9 a
No heading/pruning (T4)	8.17 a	20.9 a	30.4 a	37.5 a	43.8 a	49.4 a	54.0 a

Table 2. The average height of Chandler in March 2009, December 2009, November 2010, November 2011, December 2012, December 2013 and December 2014. Letters indicate significant difference between treatments (Duncan's Multiple Range Test, $P < 0.05$).

Treatment	Average Height (cm)						
	Mar 2009	Dec 2009	Nov 2010	Nov 2011	Dec 2012	Dec 2013	Dec 2014
Heavily pruned (T1)	192.2 b	389.4 c	468.2 c	557.8 a	594.1 a	685.4 c	756.2 b
Minimal pruned./deficit irrigation (T2)	197.2 b	421.1 b	525.2 a	561.4 a	630.8 a	715.6 bc	800.3 b
Minimal pruned (T3)	190.6 b	389.6 c	510.9 ab	584.7 a	647.1 a	789.6 ab	910.2 a
No heading/pruning (T4)	280.4 a	481.6 a	480.8 bc	591.5 a	648.9 a	819.2 a	912.6 a

Table 3. Average canopy PAR interception of Chandler measured with Mule mobile platform in July 2014, average yield and average cumulative yield. Letters indicate significant difference between treatments (Duncan's Multiple Range Test, $P < 0.05$).

Treatment	2014 PAR intercept. (%)	2014 yield (tons/acre)	2014 yield per unit PAR intercepted	Cumulative yield (tons/acre)
Heavily pruned (T1)	66.0 a	3.22 a	0.022 a	8.42 a
Minimal/deficit irrigation (T2)	72.1 a	3.65 a	0.024 a	10.42 a
Minimally pruned (T3)	73.5 a	3.49 a	0.022 a	9.42 a
No heading/pruning (T4)	69.8 a	3.51 a	0.027 a	10.01 a

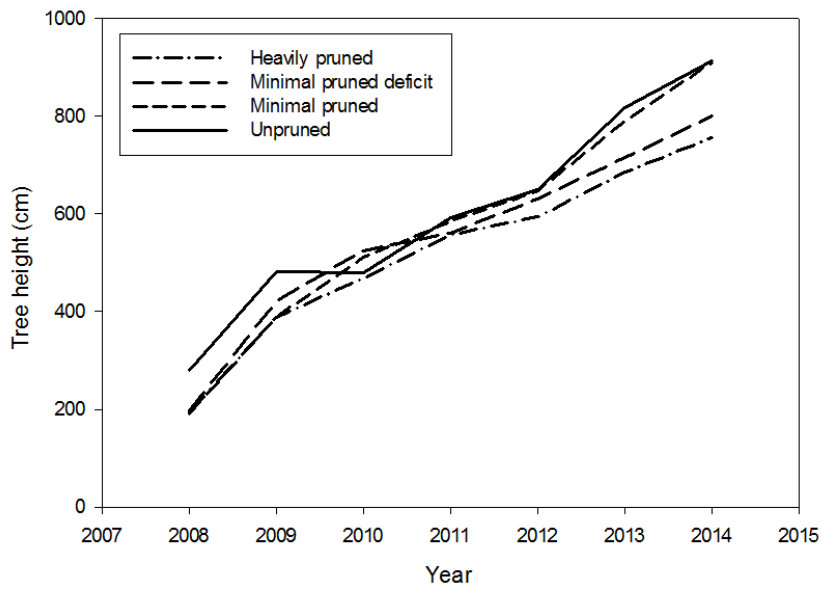


Fig. 1. Tree height by treatment and year. For significance of differences see Table 2.

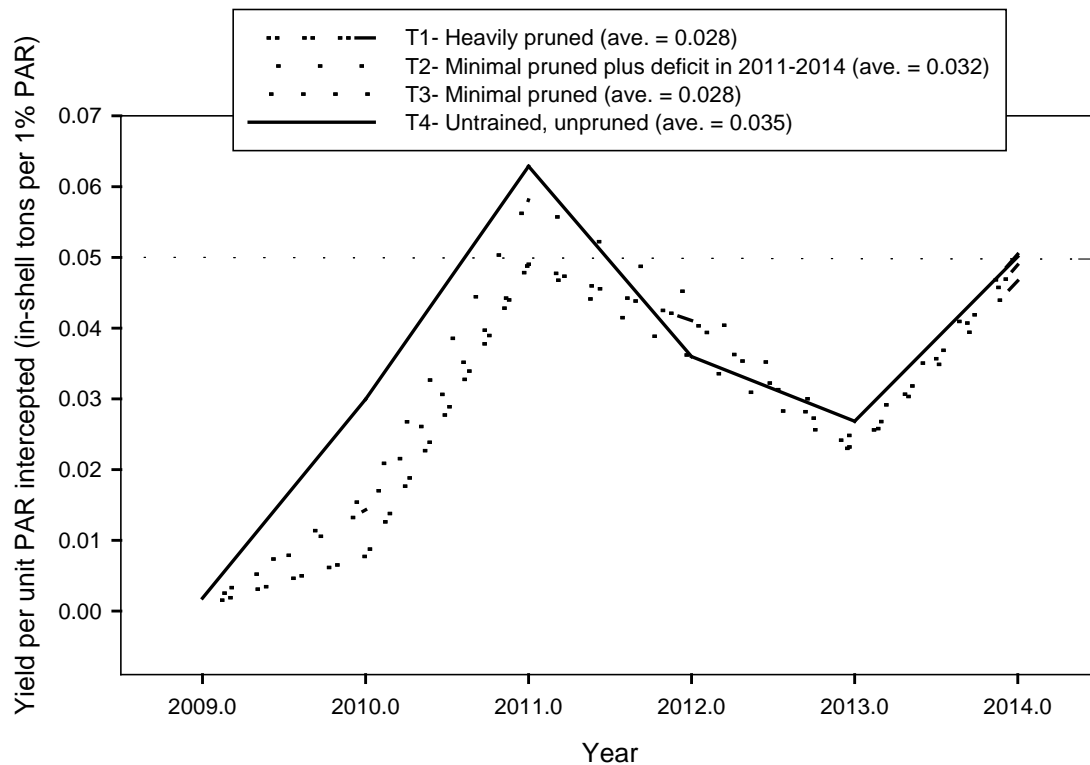


Fig. 2. Yield efficiency (expressed as tons per acre yield per 1% PAR intercepted) by treatment and year for Chandler. Horizontal dashed line indicates level around which the best orchards can fluctuate.

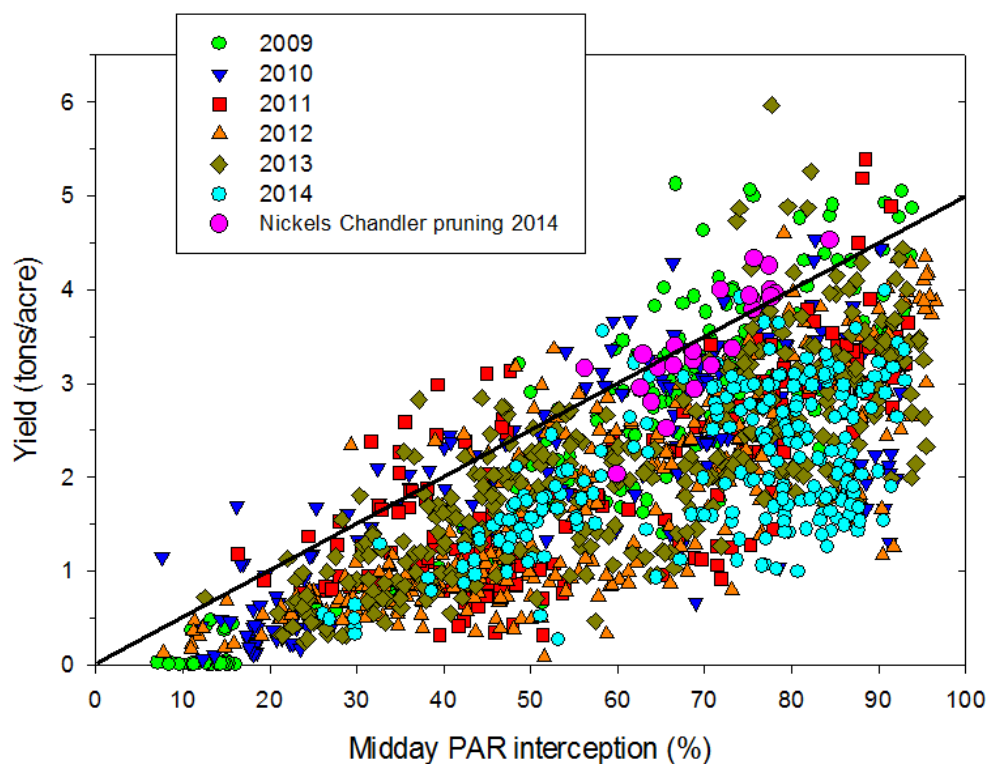


Fig. 3. Midday photosynthetically active radiation (PAR) interception versus yield for all walnut light bar sites with Nickels Chandler pruning trial data for 2014 highlighted in pink circles.

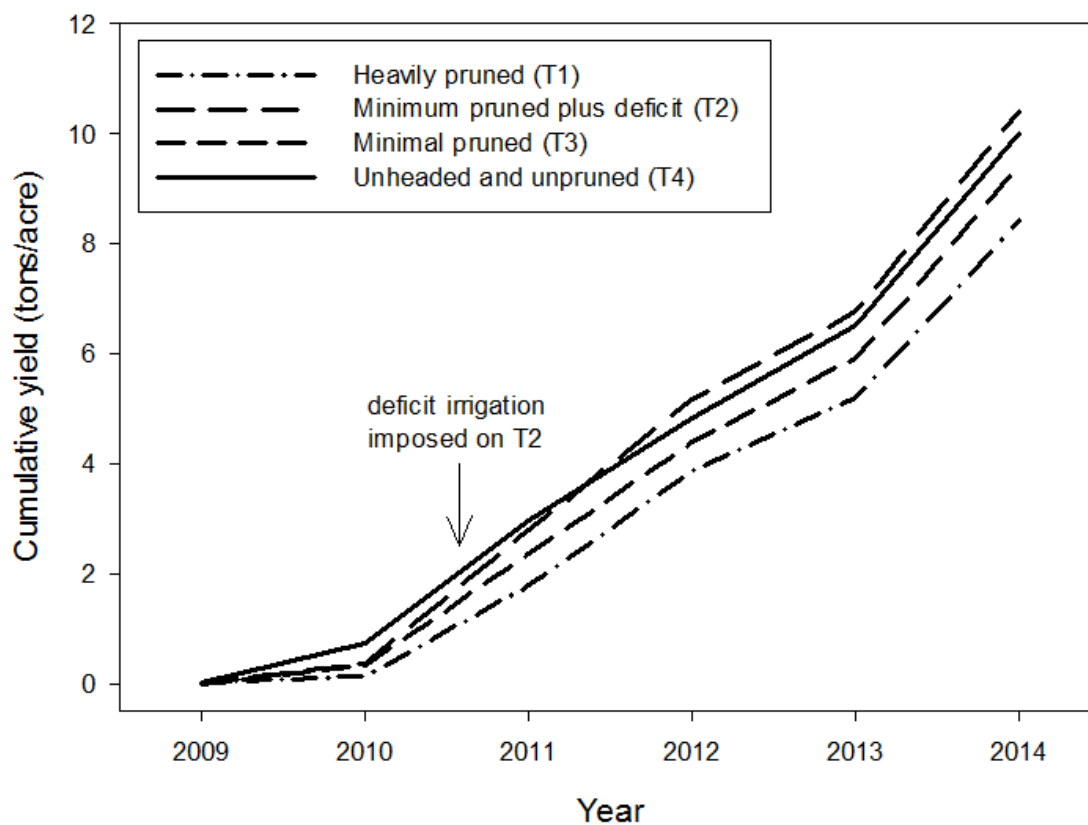


Fig. 4. Chandler cumulative yield (tons/acre) by pruning treatment and year.

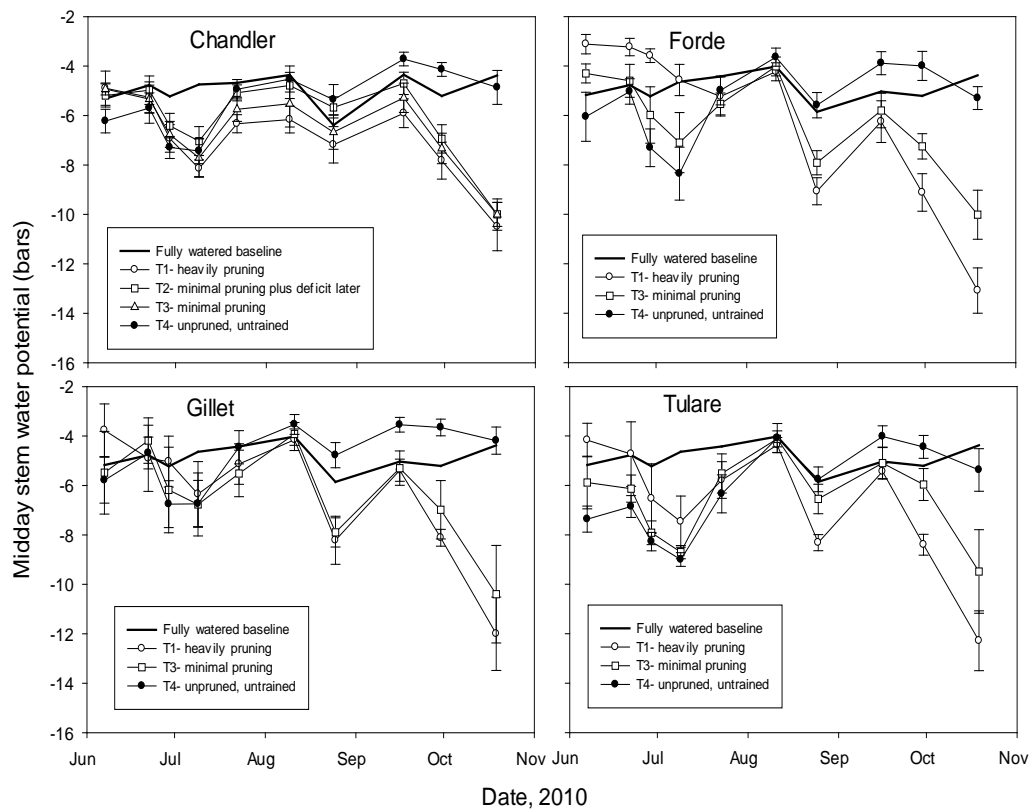


Fig. 5. Midday stem water potential (bars) for the different varieties and pruning treatments for the 2010 season.

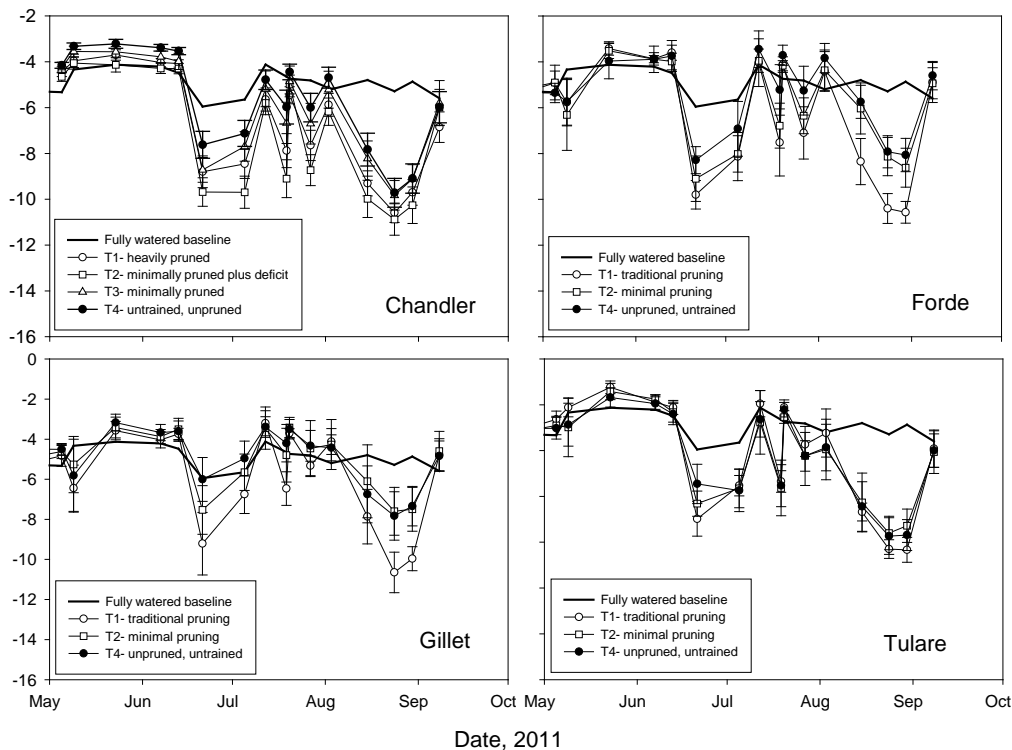


Fig.6. Midday stem water potential (bars) for the different varieties and pruning treatments for the 2011 season.

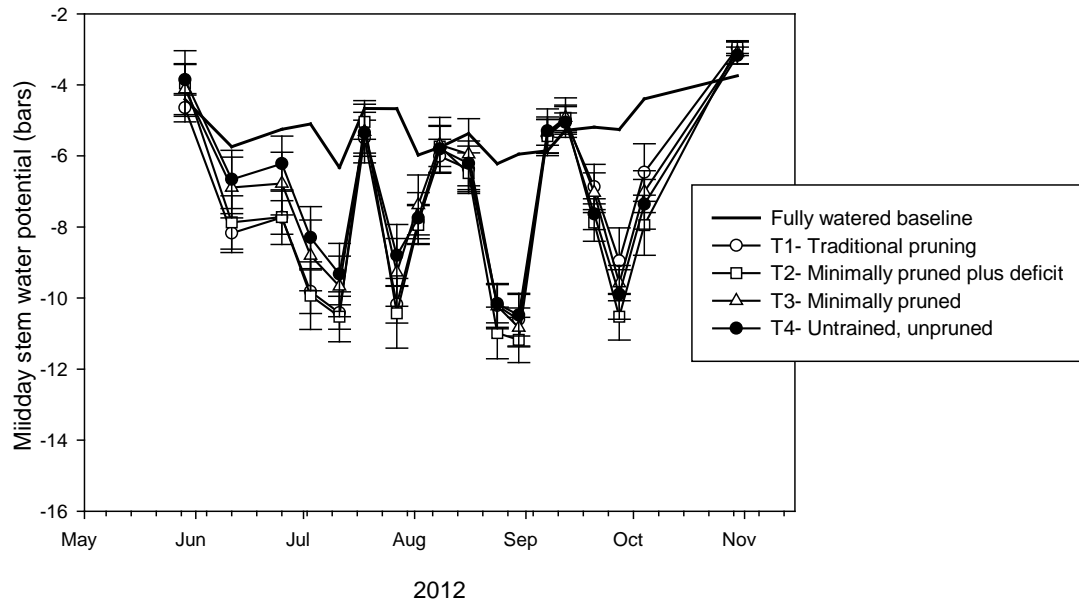


Figure 7. Midday stem water potential (bars) for the Chandler pruning trial by pruning treatment for the 2012 season.

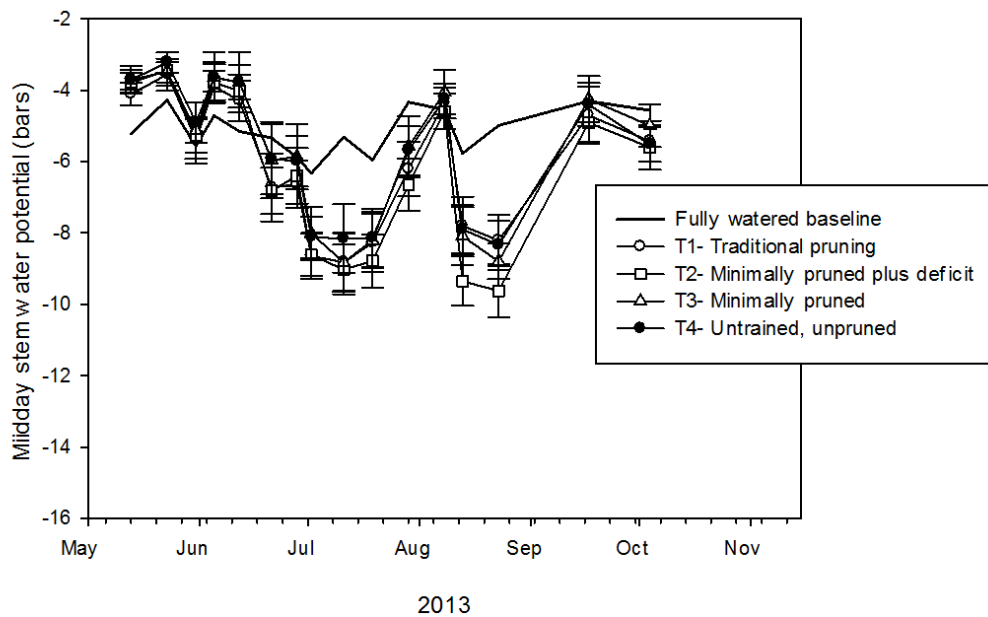


Figure 8. Midday stem water potential (bars) for the Chandler pruning trial by pruning treatment for the 2013 season.

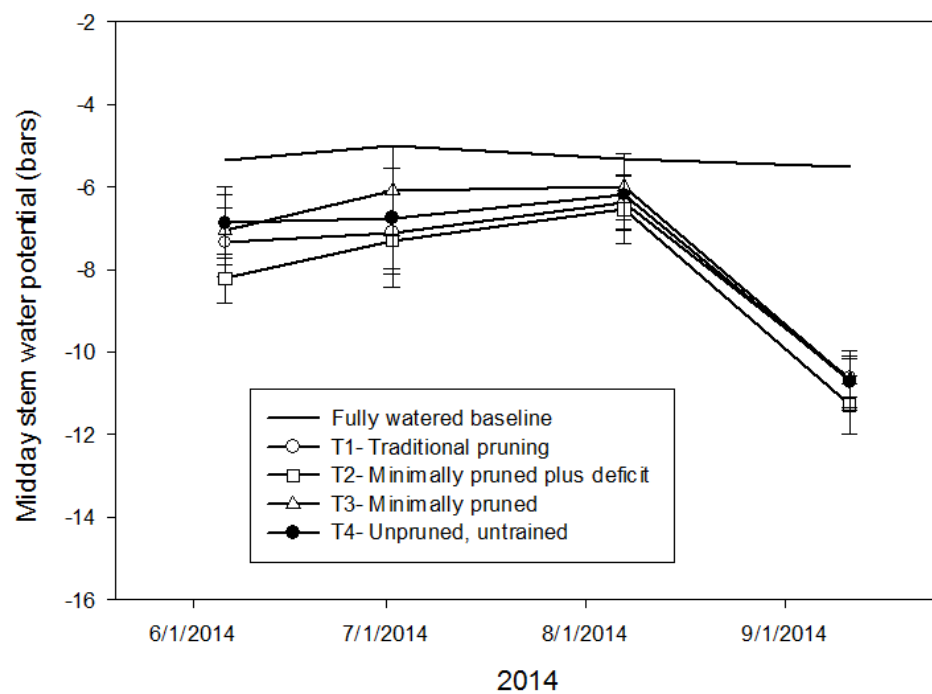


Figure 9. Midday stem water potential (bars) for the Chandler pruning trial by pruning treatment for the 2014 season.



Fig. 10. Images of minimally pruned tree (left) and unpruned tree (right) on April 1, 2011, September 22, 2011, September 11, 2012, September 12, 2013 and September 8, 2014. Note that minimum pruned tree is farther from camera.