

Description of the Three Training/Pruning Styles Compared in the Chandler Pruning/No Pruning Trial (NSL)

	Heavily Pruned (T1-Green)	Minimal/deficit irrigation (T2- Pink)	Minimally pruned (T3- Yellow)	No Pruning (or heading) (T4-Blue)
At planting 2008/first growing season	Trees in all treatments were planted and headed at 4-5 healthy strong buds above graft union on the scion. One strong leader was selected for the trunk and tied to a short stake (4.5 feet above soil). A few lower shoots above the graft union were kept shorter than the leader but allowed to grow longer than is typical to take some vigor from the leader to avoid breakage. (Note: if trees had been traditionally spaced, they would have been planted with 10 foot stakes where 2 feet of stake is in the ground)*			
First year Dormant pruning 2009	At the end of the dormant season in March, the leader was headed at 6 feet. Lower limbs below 3 feet were removed. (Note: if trees had been traditionally spaced, they would have been headed at 8 feet)	At the end of the dormant season in March, the leader was headed at 6 feet. Lower limbs below 3 feet were removed.		At the end of the dormant season in March, the leader was not headed. Lower limbs below 3 feet were removed. A long stake extension was placed to support the unpruned leader.
Second year delayed dormant pruning 2010	Selected and headed a central leader by 1/3 of length of current growth. Selected 4-6 primary scaffolds and headed each by 1/3. Heights of scaffolds were maintained below the height of the central leader. All unselected branches were removed if they were likely to compete with chosen scaffolds. Forked branches were reduced to a single branch. All remaining branches were tipped or removed. Lowest branch left at about 4 feet above berm in the row.	Central leader selected and 1/3 of current growth was removed. 4-6 primary scaffolds were selected and headed below the height of the central leader. These heading cuts removed 1/4 to 1/3 of the length of current 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. Lowest branch left at about 4 feet above berm in the row.		No pruning or heading unless lower branches needed to be removed for reasons of safety or ease of maintenance and harvest.
Third year delayed dormant pruning 2011	The central leader from previous year was examined and if chocked out by a stronger branch, a new central leader was chosen. The chosen central leader had 1/3 of the growth from current 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 and headed by 40% making sure no secondary scaffold was taller than central leader.	The strongest, tallest scaffold was chosen as the leader and 1/3 of the current 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 was headed removing 1/3 of the current growth. Forked branches were left but twisted, rubbing or overlapping branches were removed.		No pruning or heading unless lower branches needed to be removed for reasons of safety or ease of maintenance and harvest.

	Heavily Pruned (T1-Green)	Minimal/deficit irrigation (T2- Pink)	Minimally pruned (T3- Yellow)	No Pruning (or heading) (T4-Blue)
Fourth year dormant pruning 2012	The leader was once again found within the tree structure. 1/3 of the new extension growth from last season was cut off. All other scaffolds and branches were also headed 1/3 of the new extension growth from last season making sure that no scaffold was higher than the heading cut on the central leader. Thinning cuts were used to remove forked branches that were close to leader or were on weak limbs. All twisted, crossed or rubbing branches were removed. The demonstration tree had 38 cuts made on it.	The top of tree was left alone. No pruning cuts were made on upright scaffolds or the central leader. The growth on the sides of the trees, in row and between rows, was evaluated for how much area was still unfilled between the trees. It was decided that pruning on the side of the tree would encourage the space to be filled. One or two scaffolds in each cardinal direction were headed removing only a small amount of length (approximately 12-24 inches, cutting into mature round wood.) A total of 3-5 cuts were made per tree.	No pruning or heading unless lower branches needed to be removed for reasons of safety or ease of maintenance and harvest.	
Fifth year 2013	No pruning or heading unless lower branches needed to be removed for reasons of safety or ease of maintenance and harvest.			

*The Chandler pruning/no pruning trial is a hedgerow at a spacing of 15 ft. x 22 ft. In the early training (1st- 4th years), this has not affected our pruning treatments other than the first dormant pruning where trees were headed at 6 ft. for a hedgerow rather than 7-8 ft as would be done in a standard spaced orchard, and in the second dormant pruning, the lowest limb would be 5.5-6 ft. above berm in a standard spaced orchard rather than at 4 ft for a hedgerow. Even though the soil is more marginal for walnuts and therefore a closer spacing would be recommended, planting the Chandler variety in a hedgerow is not recommended. Chandler is a vigorous variety and the lateral buds take three years to fully develop fruiting wood on lateral shoots. Therefore, production will be lost the first and second year after hedging a Chandler. We recommend planting this variety in a standard spaced orchard for long-term maximum yields (e.g. a minimum spacing on poorer soils would be 25 ft. x 25 ft. with wider spacing on better soils).

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

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

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

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

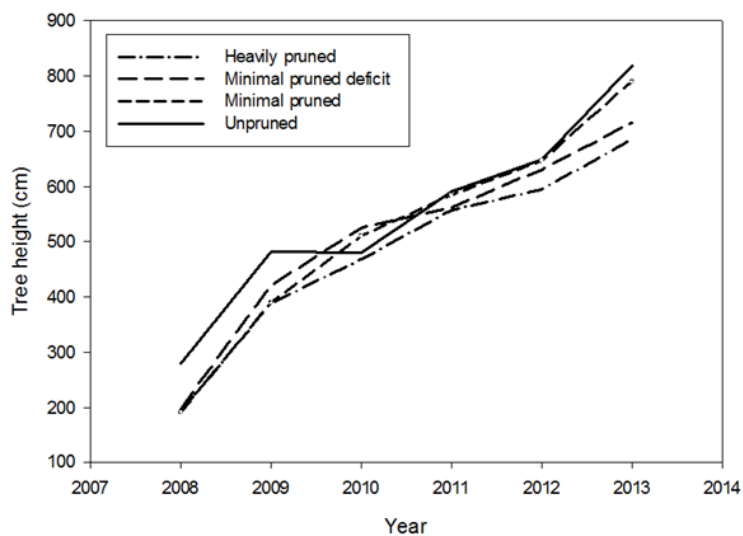


Table 3. Average canopy PAR interception, yield, yield per unit PAR intercepted and cumulative yield for Chandler pruning trial from 2011 to 2013.

Treatment	2011 PAR intercept. (%)	2011 yield (tons/acre)	2011 yield per unit PAR intercepted	Cumulative yield to 2011 (tons/acre)
Heavily pruned (T1)	32.4 a	1.64 b	0.051 b	1.79 c
Minimal/deficit irrigation (T2)	39.0 a	2.41 a	0.062 ab	2.79 a
Minimally pruned (T3)	38.5 a	2.02 ab	0.052 b	2.36 b
No heading/pruning (T4)	32.8 a	2.23 ab	0.068 a	2.98 a

Treatment	2012 PAR intercept. (%)	2012 yield (tons/acre)	2012 yield per unit PAR intercepted	Cumulative yield to 2012 (tons/acre)
Heavily pruned (T1)	50.4 a	2.08 a	0.041 a	3.87 a
Minimal/deficit irrigation (T2)	54.1 a	2.40 a	0.044 a	5.19 a
Minimally pruned (T3)	55.3 a	2.03 a	0.036 a	4.39 a
No heading/pruning (T4)	51.2 a	1.86 a	0.036 a	4.84 a

Treatment	2013 PAR intercept. (%)	2013 yield (tons/acre)	2013 yield per unit PAR intercepted	Cumulative yield to 2013 (tons/acre)
Heavily pruned (T1)	58.4 a	1.33 a	0.024 a	5.20 a
Minimal/deficit irrigation (T2)	64.9 a	1.57 a	0.024 a	6.77 a
Minimally pruned (T3)	66.6 a	1.54 a	0.022 a	5.93 a
No heading/pruning (T4)	61.3 a	1.67 a	0.027 a	6.51 a

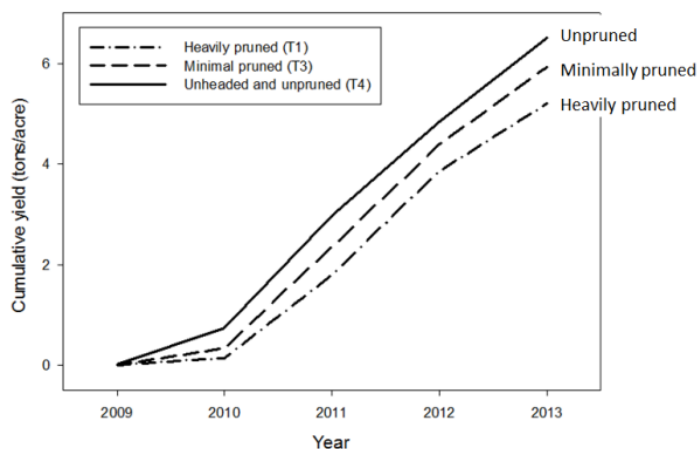


Table 4. Percentage of trees with crown gall and average crown gall size for December 2014 assessment.

Treatment	% of trees with galls	Ave. gall size (% of trunk circumference)
T1- Heavily pruned	15.6 a	44.6 a
T2- Minimum pruned deficit	11.1 a	43.5 a
T3- Minimum pruned	10.0 a	55.0 a
T4- Untrained/unpruned	8.9 a	41.9 a

Summary of Chandler pruning/no pruning study at NSL

Chandler on Paradox seedling rootstock

Negative impacts of pruning

Need labor and expensive to prune

Expensive to dispose of prunings

More broken scaffolds 2-3 years after pruning stops

More dense canopy with increased shading/quality impacts in lower center of tree

Heavy pruning leads to decreased yields in early years of tree development

Potential for disease entry points on pruning cuts (e.g. *Botryosphaeria*).

Heavily pruned trees had more incidence of crown gall but not significantly more

No evidence that pruning cuts were beneficial in this Chandler walnut trial except to cut branches in the way of the shaker and/or tractor access (similar results in earlier 7 year study on Howard walnuts)

Note: All current UC pruning/no pruning trials are on Paradox seedling rootstock. There is a need to test pruning/no pruning in trials on clonal Paradox and black rootstocks.

Bruce Lampinen, UC Extension Walnut Specialist, UC Davis

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A full report of this trial for each year can be found at <http://walnutresearch.ucdavis.edu>