Shoot Growth Characteristics Following Mechanical Hedging and High Limb Pruning in 'Tulare' Walnuts on Two Rootstocks at Two Spacings

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Abstract

Shoot re-growth following mechanical hedging was measured in a 10 year old 'Tulare' walnut orchard planted at two tree spacings on two rootstocks. In addition to the mechanical hedging treatment, high limb pruning, designed to lower overall tree height, was performed on sub-plots each year by selectively removing 1-3 limbs of 5 to 10 cm diameter high in the canopy. The greatest terminal shoot growth occurred in the year following hedging, while the greatest overall growth, including laterals, occurred in the second year following hedging. The number of new branching points formed increased for the second and third year after hedging but decreased by the fourth year. Terminal shoot growth was significantly greater for the wider compared to narrower spaced trees in the first year after hedging and thereafter there were no significant differences. The only impact of the high limb pruning treatments was significantly greater terminal shoot growth for the high limb pruned trees versus the non-high limb pruned trees at the narrow tree spacing. These results suggest that less frequent pruning is likely to increase productivity. In addition, it suggests that cultural practices in the year after hedging have the most potential to control canopy development.

INTRODUCTION

There is a trend toward higher density plantings in walnut with many new orchards being planted as hedgerows. Research on high density plantings has been done in the United States (Ramos et al., 2001), Spain (Aleta and Ninot, 2000) and Chile (Lemus, 2001). However, as these high-density plantings mature, shading in the lower canopy frequently becomes a problem. This results in a shift in production higher up into the canopy and a dieback of lower limbs (Olson et al., 2003). There is concern that this could result in loss of nut production and/or nut quality over time. In addition, as production shifts higher up into the canopy, it can be difficult to get good spray coverage leading to increased insect and disease pressure. In an attempt to remedy these problems, hedging and/or hand pruning regimes are implemented but these have had mixed success, generally resulting in decreases in production.

The objective of this study was to measure shoot growth responses to mechanical hedging and hand thinning of high limbs as influenced by rootstock and tree spacing and to investigate the relation of the shoot growth to canopy light interception and yield.

MATERIALS AND METHODS

The orchard was planted to 'Tulare' walnuts in 1990 on Yolo silty clay loam soil. There were four replications of each rootstock (Northern California Black and Paradox and tree spacing (3.5 x 7.3 and 4.7 x 7.3 m) and two replications of the high limb pruning treatments. Mechanical hedging was done on alternate rows in January 2000 and January

2001. High limb pruning consisted of removing one to two of the most upright and/or most crowded limbs approximately 5 to 10 cm in diameter from the upper canopy. Cuts were made just above a substantial side branch (i.e. thinning cuts) to minimize excessive vegetative growth that would be formed from heading cuts. High limb removal was continued for three dormant pruning seasons (January 2001, 2002, and 2003).

Photosynthetically active radiation (PAR) interception was measured through the season using an 80 cm light bar (Accupar, Decagon Devices). One hundred measurements were taken in a grid pattern covering the area in the center of the plot on the rows from each hedging date for each replication. Shoot growth was measured from a pruning tower during late winter 2004 in the alleyways pruned 3 and 4 years previously. Shoots chosen were from heights of 1.5 to 5.7 meters above the ground on the sides of the hedged wall. Shoot growth was separated into categories of 1, 2, 3, or 4 years after hedging and the number of new branching points formed each year was tallied as well as shoot lengths.

Plots were harvested by mechanical shaking and dry yield as well as nut quality factors were evaluated in 2000 through 2003. Yields were collected separately within each plot for the rows that had been mechanically hedged in the winter of 1999-2000 and those hedged in the winter of 2000-2001.

RESULTS AND DISCUSSION

A diagrammatic representation of the shoot growth patterns for the four years following hedging is shown in Figure 1. Primary shoot re-growth following mechanical hedging was greatest in the first growing season while overall shoot growth was greatest in the second growing season following hedging.

Rootstock

There were no significant differences between the two rootstocks in any of the shoot growth characteristics measured (Fig. 2a-e). Growth of the primary shoot was greatest in the year following hedging, and then decreased in the second through fourth years after hedging for both rootstocks (Fig. 2a). The number of branching points formed increased in both rootstocks during the second and third years after hedging and then began to decrease (Fig. 2b). The total number of branching points increased at a slowing rate in years two through four (Fig. 2c). The total yearly growth, including the terminal and laterals, was greatest in the second year following hedging and then decreased for the 3rd and 4th years (Fig. 2d). The cumulative growth was greatest the year after hedging and then the rate slowed.

Spacing

Trees at the wider spacing had significantly greater growth of the primary shoot in the first year following hedging compared to those at the closer spacing (Fig. 3a). After the first year, there were no significant differences between the tree spacings in growth patterns of the primary shoot. The number of branching points formed and the total number of growing points was similar for the two tree spacings (Fig. 3b,c). The total yearly growth was significantly greater for the wider compared to the closer spacing for the first year following hedging but not in years two through four (Fig. 3d). The cumulative growth was greater for all four years (3d), most likely due to the significant difference in the first year primary shoot growth (Fig. 3a).

High Limb Pruning

There was a tendency toward increased primary shoot growth for the high limb pruned treatment but the effect was only significant for the first year for the closely spaced trees (data not shown). There were no differences canopy light interception, branching patterns or cumulative growth for the high limb pruning treatment compared to the non-high limb pruned treatment (data not shown). These data suggest that the high limb pruning strategy may be effective for managing crowded orchards without impacting yields. In avocado, a more severe high limb pruning treatment led to decreased yields

while a less severe treatment (Thorp and Stowell, 2001). The lack of a negative impact of this treatment was likely because it did not generate substantial vegetative growth as a result of cuts since all cuts were made to a substantial side branch.

Light Interception and Yield

Light interception increased significantly in the second and third year following hedging for all rootstock and spacing combinations (Table 1,2). By the fourth year after hedging, light interception was no longer increasing for any rootstock and spacing combination. Yields followed a similar pattern to light interception increasing significantly in between years one and two and then increasing slightly between years two and three (Table 1,2). The decrease in yield seen in the fourth season following hedging occurred across the entire orchard and was likely due to poor pollination conditions combined with increasing damage from *Phytophthora* root rot in parts of the orchard. Rows that were hedged either three or four years before both had similar decreases in yield this year, again suggesting an orchard wide factor impacting yield rather than hedging treatments. There were no significant differences in PAR interception or yield by rootstock or spacing for any year (Table 1,2). These data agree with previous reports suggesting that mechanical hedging leads to decreased yields (Sibbett and Ramos, 1974; Ramos et al., 1983) or has no effect on yields (Olson et al., 2003).

CONCLUSIONS

In general, primary shoot growth was greatest in the year following hedging while overall growth (including laterals) was greatest in the second year following hedging. This two year period of refilling the canopy removed by the mechanical hedging likely explains the negative impacts of hedging on yield. Canopy light interception and yield for the first year following hedging were significantly lower in all cases and it was not until the third year following hedging that maximum light interception and yields appeared to be reached. This suggests that hedging regimes that cut on a less frequent basis are likely to have the least negative impacts on yield. There were no significant effects of rootstock on any of the measured shoot growth characteristics, PAR interception or yield. Wider spaced trees had significantly more primary shoot growth as well as total yearly growth the year following hedging. Cumulative growth (including primary and lateral growth) was significantly greater for the wider spaced trees in all years. Although there was a tendency towards higher yields in the wider compared to narrower spaced trees, there was not a significant yield difference in any year. The high limb pruning treatment did not significantly impact light interception or yield suggesting this may be a useful strategy to manage crowded hedgerow plantings. These results suggest that if there is an interest in attempting to control vegetative growth with cultural practices such as deficit irrigation, the first and second year after mechanical hedging should be the periods to target.

Literature Cited

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Tables

Table 1. Average photosynthetically active radiation (PAR) interception and yields for Tulare walnuts by hedging year and rootstock.

Year after hedging	Overall both rootstocks		By rootstock NCB		Paradox		lsd	
	PAR intercept (%)	Yield (t ha^{-1})	PAR intercept (%)	Yield (t ha^{-1})	PAR intercept (%)	Yield (t ha^{-1})	PAR intercept (%)	Yield (t ha^{-1})
1	61	4028	60	3662	62	4393	3	910
2	77	5987	76	5695	78	6279	5	874
3	82	6143	83	5813	82	6474	4	780
4	81	3821	80	3618	82	4025	6	1015
lsd	3	610	4	694	5	730		

Table 2. Average photosynthetically active radiation (PAR) interception and yields for Tulare walnuts by hedging year and spacing.

Year after hedging	Overall both spacings		By spacing 3.5m x 7.3 m spacing		4.7m x 7.3 m spacing		lsd	
	PAR intercept (%)	Yield (t ha^{-1})	PAR intercept (%)	Yield (t ha^{-1})	PAR intercept (%)	Yield (t ha^{-1})	PAR intercept (%)	Yield (t ha^{-1})
1	61	4028	60	3772	62	4282	3	958
2	77	5988	75	5546	79	6427	4	788
3	82	6143	81	6005	84	6281	3	853
4	81	3821	80	3613	82	4031	6	1014
lsd	3	610	5	855	3	908		

Figures

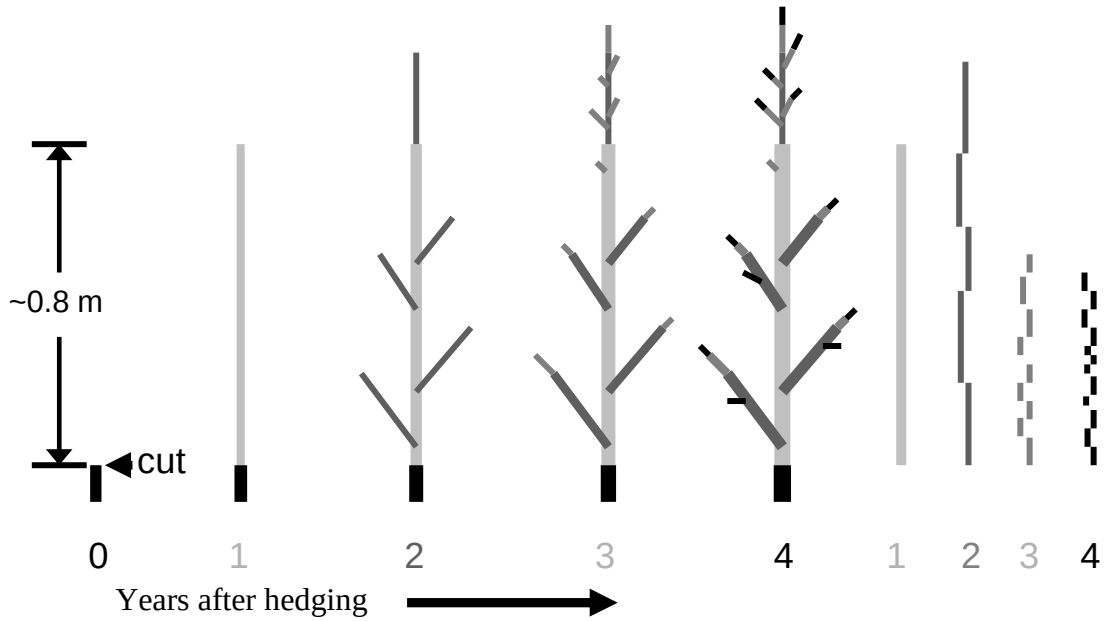

Fig. 1. Pattern of shoot growth following mechanical hedging.

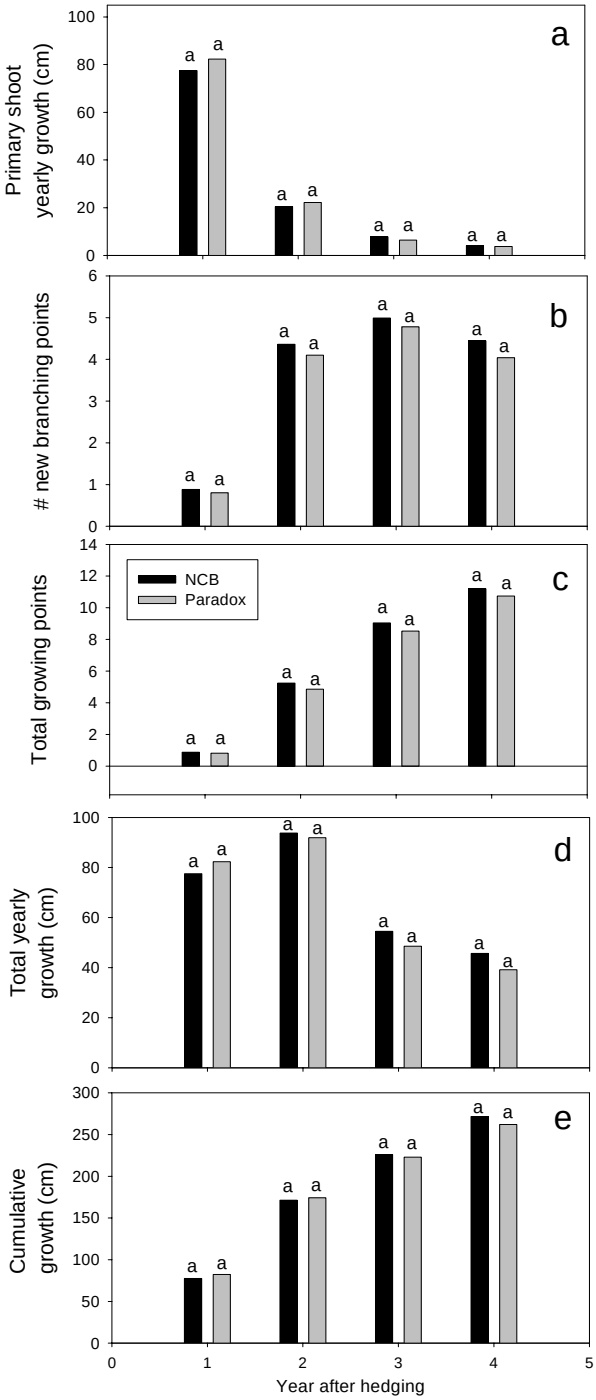

Fig. 2. Pattern of (a) primary shoot growth, (b) number of branching points, (c) total growing points, (d) total yearly growth including side branching, and (e) cumulative total growth by year and rootstock.

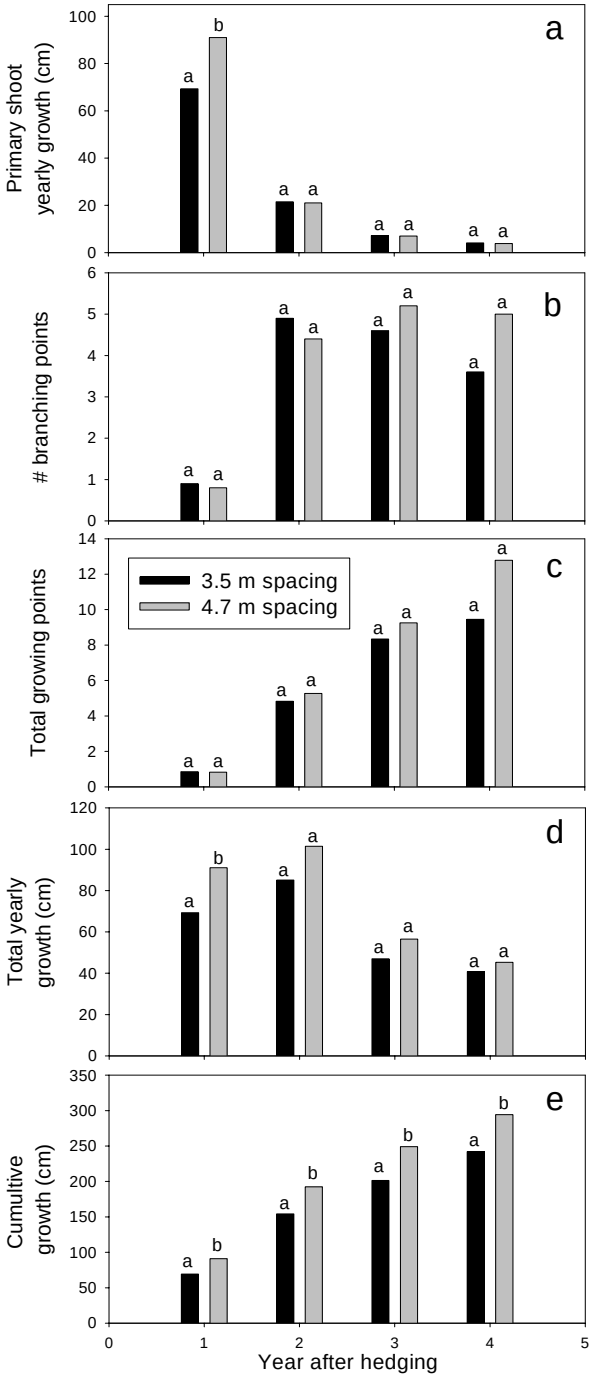

Fig. 3. Pattern of (a) primary shoot growth, (b) number of branching points, (c) total growing points, (d) total yearly growth including side branching, and (e) cumulative total growth by year and tree spacing.