Long-term effects of managed grass competition and two pruning methods on growth and yield of peach trees

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ABSTRACT

Ground cover competition and tree training strongly affect development of newly planted peach trees and eventual productivity of peach orchards. This experiment characterized the long-term interactive effects of three levels of competition and two pruning criteria on yield, fruit size, and marketable yield efficiency. Trees of two cultivars ('Jersey Dawn', JD, and 'Redskin', RS, en Lovell) of peach (Prunus persica (L.) Batsch) were planted in an orchard in 1983 and grown for 14 years in a vegetation free area (VFA) width of 0.6 or 2.4 m. A separate group of trees that were in the 2.4 m VFA had grass seeded beneath them in 1998 to obtain 0 m VFA. All trees were pruned to maintain canopy size with wide-angled scaffold limbs and intense pruning (IP) or upright branch form with reduced pruning (RP). In general, RS had greater yield than JD and yield was greatest in the 2.4 m VFA with IP and least in the 0.6 m VFA with RP. Cumulative marketable (>63 cm) and average annual total yield of both cultivars was similar for RP trees in 0 m VFA and IP trees in 2.4 m VFA's although more of the fruit were in the largest size class (>65 cm) in the IP trees. Reduced pruning increased crop load. Fruit weight decreased with increased crop load more in RS than JD and this response was similar for all VFA's within each cultivar. Grass competition tended to reduce both the number and weight of fruit per tree but the average weight of individual marketable fruit was reduced only in the 0.6 m VFA of RS. Tree size was reduced by grass competition and pruning times measured from 1995 to 2000 were less in RP than IP. Consequently, marketable yield efficiency of marketable fruit (grams fruit >63 cm Trunk cross-sectional area, TCSA) measured from 2004 to 2007 was generally greater in trees with RP than IP and in the 0.6 than the 0 and 2.4 m VFA. The results indicate that persistent competition will reduce total annual yield per tree but with reduced pruning the concomitant increased crop load can help maintain marketable yield.

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1. Introduction

Peach tree size and canopy structure must be managed so the tree can efficiently access resources to sustain productivity and profitability for growers (Marini and Sowers, 2000). Novel approaches to regulate tree size and architecture will be needed as future orchard systems incorporate practices such as mechanization and high density plantings. New and innovative combinations of technologies will undoubtedly help fulfill these needs, including genetically distinct growth habits and size-controlling rootstocks for peach trees (Bassi et al., 1994; Grossman and Dejong, 1998; Scorza et al., 2006). Nonetheless, pruning remains the principle means to control peach tree size and shape in current management systems. Pruning combined with managed competition have been used to control the size of peach trees and enable high density plantings (Bussi et al., 1994; Glenn et al., 1996; Glenn and Welker, 1996). However, while tree size was reduced with managed grass competition, strong water-sprout growth was induced in heavily pruned trees (Tworkoski, 2000; Tworkoski and Glenn, 2001). In addition, grass competition appeared to reduce tree growth and productivity more in young than mature trees but there is limited information on competition, pruning, and tree age (Chalmers et al., 1981). The amount and timing of ground cover competition may substantially affect orchard floor management practices. Coordination of pruning and soil management is necessary to obtain productive tree growth (Fogle et al., 1965).

In the eastern United States, peach trees are often trained with wide-angled scaffold limbs and an open center which requires substantial pruning that can cause undesirable consequences. Early yields can be reduced. Repeated, intense pruning promotes dense proliferation of shoots in the crown that (a) limit light penetration late in the season, (b) reduce penetration of pesticide sprays, and (c) increase humidity that can facilitate disease development (Myers, 1993). Reduced vegetative growth and increased light penetration can result from improved training and pruning systems (Grossman and Dejong, 1998).
Fig. 1. Peach trees grown in 2.4 m wide (A and B) and in 0.6 m wide (C and D) vegetation-free areas (VFA). Trees were heavily pruned to a wide-angled branching structure (IP) with an open center (B and D) or lightly pruned to an upright branching structure (RP) (A and C).

Williamson et al. (1992) reduced vegetative growth and flowering of peach trees with ground cover competition in a young, high density orchard. Although competition reduced tree size, pruning would likely be necessary to help manage tree size and shape as the orchard matured. We have used orchard floor management to reduce peach tree size but intense pruning of small pot-grown trees still resulted in dense regrowth as sprouts (Glenn and Welker, 1996; Tworkoski, 2000). The dense regrowth appears to result from the release of suppressed buds from correlative inhibition. Leaving an apical meristem, particularly on a shoot with a vertical orientation, reduces the vigorous growth of such buds (Wareing, 1970). A combination of grass competition and modified pruning could control canopy growth and maintain yield while avoiding the undesirable dense regrowth. Glenn and Newell (2008) demonstrated that pruning practices must be modified to leave more bearing wood in mature peach trees to maintain yield potential when sod competition is used to control vegetative growth. Shoots developing from branches with horizontal orientation (e.g. wide-angled limbs) tend to be longer than shoots developing from branches with more vertical orientations (Dann et al., 1990). The objective of the research was to determine the growth and yield of peach trees managed with grass competition, imposed at two times in the span of an orchard life, and to two pruning methods designed to stimulate or reduce excessive vegetative growth.

2. Materials and methods

2.1. Site preparation and planting

The experimental site was planted in tall fescue (Festuca arundinacea Schreber) five years prior to peach orchard establishment. Grass was killed with 2 kg ha⁻¹ glyphosate (N-(phosphonomethyl) glycine) 6 months prior to planting trees to establish the 0.6 and 2.4 m VFA's. Trees of two cultivars ('Jersey Dawn' (JD) and 'Redskin' (RS) on 'Lovell' rootstock) of peach (Prunus persica (L.) Batsch) were planted through the killed sod on April 18, 1993 with a 4.6 × 6.1 m spacing and grown in VFA width of 0.6 or 2.4 m. Planting rows were kept vegetation-free with 2 kg ha⁻¹ oryzalin (4-(dipropyramino)-3,5-dinitrobenzenesulphonamide) applied each spring in 1993, 1994, and 1995. Combinations of 1 kg ha⁻¹ terbacil (5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4(1H,3H)-pyrimidineone) and 1 kg ha⁻¹ diuron (N-(3,4-dichlorophenyl)-N,N-dimethylurea) were used for vegetation control each spring from 1996 to 2007. Grass was re-established beneath half the trees grown in the 2.4 m VFA in the spring of 1998 to establish the 0 m VFA. Fertilizer (10 N-0.44 P-0.83 K) was applied at 136 kg/ha in June 1993 and 1994 and at 160 kg/ha each June 2001 through 2007. Insect and disease pests were managed using regional recommendations (Pfeiffer, Bulletin coordinator, 2010). Tall fescue-covered travel alley between tree rows were mowed twice each season throughout the experiment. Fruit were hand thinned to 10-cm spacing when they were 1–2 cm in diameter.

2.2. Pruning criteria

Trees were pruned to maintain canopy size with wide-angled scaffold limbs and intensive number of pruning cuts (IP) or with upright-angled scaffold limbs and reduced number of pruning cuts (RP) (Fig. 1). The pruning methods contrasted a method (IP) that was likely to promote vigorous water sprouts with a method (RP) that was likely to have fewer and less vigorous water sprouts.

The RP used the following criteria: (a) cuts were made on upright branches (usually fewer than 12 per tree) from 1.8 to 2.4 m above the ground. These cuts were always above an existing lateral branch.
with an orientation of 45° or less from the vertical. These lateral branches were left to re-establish apical dominance with reduced incidence of water sprouts. (b) Dead branches or branches in danger of breaking were removed. (c) Few heading cuts were made and no more than 1/3 of the previous season’s growth was pruned off from branches growing with an orientation greater than 45° from the vertical. As with upright branches, cuts were made above a lateral branch so that apical dominance would be re-established within the branch.

Pruning for the IP trees used the following criteria: (a) Weak and dead shoots, water sprouts, and nearly all upright branches in the crown center were removed. (b) All 1-yr-old wood was headed to 1/2 of the previous season’s growth to promote stem strength and no attempt was made to cut above a lateral branch. All branches were pruned up to 2.1 m above the ground.

### 2.3. Experimental layout and design

The experimental design was a split-split plot nested design with VFA (0, 0.6, and 2.4 m width) as the main plot, pruning systems (IP vs. RP) as the subplot and cultivar (‘Redskin’ vs. ‘Jersey Dawn’) as the split-split plot. Each subplot block contained 12 trees and there were 5 replicated blocks. Each cultivar-by-pruning split-plot plot consisted of 6 trees comprising two guard trees either side of the two trees that provided data. Overall statistical analysis used GLM with repeat measure analysis and in a separate analysis with year as a main effect (SAS Institute, 2001). Analysis of covariance and linear regressions were calculated to determine relationships among components of yield using fruit number per tree as the independent covariate.

Fruit were harvested, usually in two pickings, and fruit were classified by number and weight for size classes using an Omni-Sort weight-size grader (Durand-Wayland, Inc., La Grange, GA). Annual fruit weights and average annual total and marketable fruit weights per tree are reported from 1998 to 2007, after all VFA treatments were installed. Fruit weight frequency distributions, average fruit weights, and marketable yield efficiencies were calculated for each cultivar-grass-pruning combination for each of the final four years of the experiment (2004–2007) and data for 1998–2003 are not presented. Marketable fruit yield efficiency was calculated as the weight of marketable fruit per tree divided by the trunk cross-sectional area (TCSA) of the tree. For all years, fruit were classified as marketable when it had yellowish-green ground color and was 6.35 cm in diameter. At the end of the growing seasons 1995–2000 and 2004–2007, trunk diameter (10 cm above the graft union) was measured. Relationships between average weight of marketable fruit, percent of the crop that was marketable and total number of fruit per tree (i.e., crop load) were developed for each VFA over the time from 1998 to 2007. From 1995 to 2000, canopy width was calculated as the area of a circle using the distance from the trunk to the canopy drip line as the radius. Each tree was pruned in March or April by the same person from 1995 to 2000 and the same two people in 2000–2007. Consistency of personnel helped ensure uniformity for the IP and RP treatments which were verified by counting the number of cuts of all trees and from 1995 to 2000, pruning time per tree, and pruning weight per tree for trees in the 0.6 and 2.4 m VFA's.

### 3. Results

#### 3.1. Grass competition and pruning effects on yield and trunk diameter

Overall analysis of variance indicated that the size of VFA, pruning intensity, and their interaction significantly affected the weight of total and marketable fruit (data not shown). The 2.4 m RP treatment had the greatest and 0.6 m IP had least yield of marketable fruit (Figs. 2 and 3). Yield was intermediate for the other treatments and was numerically greater in the 2.4 m IP and both 0 m VFA's than the 0.6 m RP treatment (Figs. 2 and 3). Within each pruning treatment trees had increasing cumulative marketable yield and average annual total and marketable yields from 0.6 to 2.4 m VFA.

When established in 1998 beneath mature trees a complete grass cover generally reduced weight of marketable fruit per tree for each pruning treatment (Figs. 2 and 3). By 2007, grass in 0 m VFA reduced cumulative number of fruit on average by 21%, 23%, 36%, and 20% in RS–RP, RS–IP, JD–RP, and JD–IP, respectively compared to the 2.4 m VFA (Figs. 2 and 3). Trunk diameters also were decreased by grass but were not affected by pruning treatments and there was no competition–by-pruning interaction (Fig. 4, ANOVA not shown). By 2007, grass in 0 m VFA reduced tree trunk diameters on average by 14% and 9% in RS and JD, respectively, compared to the 2.4 m VFA (Fig. 4). Grass in 0.6 m VFA reduced tree trunk diameters on average by 20% and 22% in RS and JD, respectively, compared to the 2.4 m VFA (Fig. 4).
Table 1
Regressions of weight and yield of marketable (≥ 6.35 cm) fruit with crop load (total no. fruit/tree) from 1998 to 2007 of ‘Jersey Dawn’ (JD) and ‘Redskin’ (RS) peach trees that were pruned to a wide-angled branching structure (IP) or to an upright branching structure (IP) and grown in 0, 0.6, or 2.4 m vegetation-free areas (VFA). Trees had heavier and lighter crop loads with RP and IP, respectively, and crop load analyses used data pooled over the pruning treatments.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>VFA (m)</th>
<th>a ± std dev</th>
<th>b ± std dev</th>
<th>r²</th>
<th>Mean±</th>
</tr>
</thead>
<tbody>
<tr>
<td>JD</td>
<td>0</td>
<td>187 ± 2</td>
<td>-0.15 ± 0.01</td>
<td>0.44±</td>
<td>162 a</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td>170 ± 3</td>
<td>-0.15 ± 0.02</td>
<td>0.22±</td>
<td>149 b</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>180 ± 3</td>
<td>-0.11 ± 0.01</td>
<td>0.44±</td>
<td>154 b</td>
</tr>
<tr>
<td>RS</td>
<td>0</td>
<td>242 ± 4</td>
<td>-0.20 ± 0.02</td>
<td>0.46±</td>
<td>201 ab</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td>223 ± 5</td>
<td>-0.19 ± 0.02</td>
<td>0.26±</td>
<td>194 b</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>252 ± 3</td>
<td>-0.19 ± 0.01</td>
<td>0.64±</td>
<td>203 a</td>
</tr>
</tbody>
</table>

*Adjusted mean values of fruit ≥ 6.35 cm per tree using analysis of covariance with fruit number as the independent covariate.

Average weight of marketable fruit (g/tree) = a + b(total no. fruit/tree).

* and ± designate, respectively, significant and nonsignificant regression coefficients.

Within each cultivar, means followed by the same letter do not differ at the 0.05 level of significance.

3.2. Grass competition and pruning effects on crop load, marketable fruit weight and yield

In general, trees had a maximum of 400 fruit per tree resulting from RP and, within a VFA, heavier crop loads reduced the average weight of individual marketable fruit (Table 1). Based on a t-test comparison of the regression slopes (P > 0.05), the rate of change in fruit weight decreased more in the 0 m VFA than the 2.4 m VFA for JD (Table 1). In JD there were 15 and 11 g decreases in weight per fruit for each 100 additional fruit per tree when trees were grown in the 0 and 2.4 m VFA, respectively. In RS the decreases in average weight of marketable fruit with increasing crop load (i.e. the regression slopes) were not significantly different among VFA’s. For both cultivars the average fruit weight from 2004 to 2007 was less in RP, with the heavier crop load, than IP (Table 2).

In RS crop load effects on marketable yield (% of the total number of fruit) did not differ among VFA’s (b coefficients in Table 1) and VFA did not affect the average fruit yield although there were fewer fruit on trees, in general, in the smaller VFA’s (Table 2 and Fig. 6). In JD marketable yield decreased with increased crop load only in the 0.6 m VFA (Table 1) and average fruit weight was smaller in the 0.6 m VFA (Table 2). Using analysis of covariance with fruit number as the independent covariate the marketable yield fruit weight was greater (P > 0.05) for IP than RP in RS (96.4% and 94.5% of total no. fruit per tree) and JD (96.7% and 77.1% of total no. fruit per tree). The adjusted mean values with fruit number as the independent covariate indicated that the average weight of marketable fruit was greater (P > 0.05) for RP than IP in RS (212 and 187 g/fruit) and JD (164 and 146 g/fruit).

The fruit size capacity tended to be larger on RS than JD trees, as indicated by larger y-intercepts values associated with the relationship of individual marketable fruit weight to total fruit number per tree and based on a t-test comparison of the regression intercepts (P > 0.05) (Table 1).

3.3. Grass competition and pruning effects on size distribution of fruit collected from 2004 to 2007

In general for any VFA, there were fewer fruit and a greater percentage of fruit were in the largest size class in RP than trees from

Table 2
Average fruit weight (total weight per tree in grams/total number fruit per tree) from 2004 to 2007 of ‘Jersey Dawn’ (JD) and ‘Redskin’ (RS) peach trees that were pruned to a wide-angled branching structure (IP) or to an upright branching structure (IP) and grown in 0, 0.6, or 2.4 m vegetation-free areas (VFA).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>VFA (m)</th>
<th>Pruning</th>
<th>RP</th>
</tr>
</thead>
<tbody>
<tr>
<td>JD</td>
<td>0</td>
<td>0.6</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>146 a</td>
<td>133 b</td>
<td>142 a</td>
</tr>
<tr>
<td></td>
<td>150 a</td>
<td>156 b</td>
<td>178 b</td>
</tr>
<tr>
<td>RS</td>
<td>0</td>
<td>0.6</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>190 a</td>
<td>191 a</td>
<td>206 a</td>
</tr>
</tbody>
</table>

*Within each cultivar, VFA, and pruning treatment, means followed by the same letter do not differ at the 0.05 level of significance.

Fig. 4. Trunk diameters in 1998 and 2007 of ‘Jersey Dawn’ and ‘Redskin’ peach trees that were pruned to a wide-angled branching structure (IP) or to an upright branching structure (IP) and grown in 0, 0.6, or 2.4 m vegetation-free areas (VFA). Within each year and cultivar bars with the same letter do not differ at the 0.05 level of significance.
both JD and RS (Figs. 5 and 6). In JD fruit distribution among the four size classes smaller than 6.35 cm were variable and together ranged from 15% to more than 60% of all fruit. In RS these four smaller size classes were less variable and were approximately 10% the weight of all fruit. The IP treatment provided a larger percentage of fruit in the largest two fruit size classes but the effect of greater pruning had less impact if the top three size classes (i.e., >5.72 cm) were viewed together (Figs. 5 and 6). Fewer total marketable fruit in the IP trees may reduce the economic advantage of the greater percent of the crop in the larger class sizes.

Within a pruning treatment size of the VFA affected number and weight of fruit per tree but size of VFA had little effect on distribution of fruit among different size classes (Figs. 5 and 6).

3.4. Grass competition and pruning effects on tree canopy growth

Peach tree canopies increased most rapidly from planting in 1993 through 1997 and in 1997 the tree canopy cross-sectional area was approximately 9 and 16 m² in the 0.6 and 2.4 m VFA, respectively (data not shown). During this time growth in the 0 m VFA was the same as in the 2.4 m VFA since grass was planted in 2.4 m VFA’s in 1998. From 1997 to 2000, canopy cross-sectional area did not markedly change in the 2.4 m² VFA and increased slowly (0-1 m² per year) in the 0.6 m VFA (data not shown). The pattern of annual pruning weight paralleled canopy size. Annual pruning weight increased from 1995 to 1997 and from 1997 to 2000 annual pruning weights were stable at 6 and 18 kg per tree.

Table 3

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Year</th>
<th>VFA (m)</th>
<th>Pruning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.6</td>
<td>2.4</td>
</tr>
<tr>
<td>JD</td>
<td>2004</td>
<td>48.8 b</td>
<td>84.0 a</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>59.1 b</td>
<td>85.0 a</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>66.7 c</td>
<td>141.4 a</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>45.8 c</td>
<td>109.2 a</td>
</tr>
<tr>
<td>RS</td>
<td>2004-07</td>
<td>137.9 b</td>
<td>173.0 a</td>
</tr>
</tbody>
</table>

*Within each cultivar, year, VFA, and pruning treatment, means followed by the same letter do not differ at the 0.05 level of significance.*
per year in the 0.6 and 2.4 m VFA, respectively (significantly different at \( P > F = 0.05 \)). From 1995 to 2000, canopy size and pruning weights did not differ between IP and RP trees within each VFA (data not shown). Trees in the 0.6 and 2.4 m VFA required an average pruning time of 4.9 and 11.2 min per tree per year, respectively (significantly different at \( P > F = 0.05 \)).

3.5. Grass competition and pruning effects on marketable yield efficiency from 2004 to 2007

There was no interactive effect of pruning intensity and size of VFA on marketable yield efficiency for either cultivar. Year by pruning and year by VFA interactions occurred for marketable yield efficiency in JD but not RS (ANOVA not shown). In general, marketable yield efficiency of both cultivars was greatest in trees in the 0.6 m VFA (Table 3). Marketable yield efficiency was numerically lowest in trees in the 0 m VFA. In RS marketable yield efficiency was greatest in trees receiving RP than IP. In JD marketable yield efficiency was greatest in trees receiving RP than IP in 2004 and 2006. By 2007 trunk diameter was reduced by grass competition but was not affected by pruning treatment (Fig. 4).

4. Discussion

'Redskin' trees consistently had greater average fruit weight and higher crop loads than JD trees, coinciding with previous reports that yield increased in later-maturing cultivars (Johnson and Handley, 1989; Plénet et al., 2008). Smaller yield in early-maturing cultivars may be associated with resource limitations that cannot support high fruit growth rates and within-fruit sink competition (Pavel and Dejong, 1993; Grossman and Dejong, 1995a,b).

Resource limitations may have caused reduced fruit size at high crop loads (Table 1). Nonetheless, more of the crop load was marketable in the later-maturing RS, even at high crop loads (Table 1, Figs. 5 and 6).

Cultivar and pruning interacted in affecting yield with more marketable fruit obtained with RP than IP, particularly in RS trees (Figs. 2 and 3). The RP pruning was similar to “thinning-out” and “long dormant pruning” of Westwood and Gerber (1958) and Kappel and Boutheiller (1965), respectively. As in those studies, the greater fruit load from reduced pruning in the current study resulted in reduced fruit size although a high percent of the fruit was marketable (Table 1). Light pruning such as RP in the current study has provided greater early productivity that can be advantageous in high density orchards albeit with reduced but commercially acceptable fruit size (Day and Johnson, 1999; Mitchell, 1977) (Figs. 2, 3, 5 and 6).

For both cultivars the greatest yield was with RP trees grown in 2.4 m VFA. In general, higher yield was due to greater fruit number in trees with fewer pruning cuts (RP). Fruit number per fruiting branch was not counted but observationally, there were fewer and longer fruiting branches in RP than IP trees. Lowest yield was associated with IP trees grown in 0.6 m VFA (Figs. 2 and 3). However, average fruit weight was consistently greater in IP than RP trees, likely due to lower crop loads (Table 2). The analysis of covariance indicated that for comparable crop loads in RS, the 0.6 VFA would have smaller fruit than the 2.4 VFA (Table 1). Belding et al. (2004) found weed competition reduced size and yield of young trees without affecting individual fruit size but their trees had a light crop load with fewer than 90 fruit per tree. In the current study grass generally if not uniformly reduced the total number of fruit per tree (Figs. 5 and 6).
Although grass tended to reduce the fruit weight per tree, grass generally had no effect on the relationships between crop load and percent of the crop load that was marketable or on individual fruit weight (Table 1). Only with JD in the 0.6 m VFA did grass reduce marketable fruit yield with increasing crop load.

From a management perspective, growing trees with reduced pruning, such as RP in this experiment, and managed grass competition appeared to provide opportunities as well as important challenges. During the first five years after planting pruning weights (a measure of pruning efforts) were greatest for IP trees grown in 2.4 m VFA and least for trees grown in 0.6 m VFA (data not shown). Training scaffold branches of IP trees to a wide branch angle required more extensive pruning which appeared to stimulate vegetative growth. By 1998, pruning weights of RP trees did not differ from IP trees (approximately 18 kg f.w./tree/y). However, pruning time was always significantly less in the RP than the IP trees (approximately 5 min./tree/y vs. 11 min./tree/y, respectively). The RP trees in the current experiment were initially pruned lightly, similar to the "long" pruning used by Kappell and Southillier (1995). Our results are similar in that cumulative yield was greater and pruning time was reduced with reduced pruning. We did not measure time for fruit thinning throughout the experiment but our observations were that thinning required more time in RP than IP trees, particularly with younger trees in the 2.4 m VFA. In older trees thinning times were similar for both pruning treatments and VFA's. Kappell and Southillier (1995) required 24% more time to hand thin blossoms of their reduced-pruned trees. It is quite possible that additional fruit-thinning time required in the RP trees may offset the management benefits from reduced pruning time.

Heavy water sprout growth can shade the fruiting zone of a peach tree canopy and reduce fruit size and quality (Myers, 1993). In the current experiment, there were fewer fruit and there appeared to be more water sprouts growing in IP than RP trees. The latter observation is supported by the number of pruning cuts per IP tree. In 2.4 m VFA from 1995 to 2000 there were five-to-six times more pruning cuts per IP than per RP tree (significant pruning treatment effect, *P* = 0.05). It is possible that the greater number of cuts in the IP-pruning released buds from competitive inhibition. In addition to shade effects, the large number of vegetative sinks may compete with fruit for limited resources such as carbohydrate and nitrogen (Costa and Vizzotto, 2000; Tworkoski et al., 1997). Vigorous vertical shoots can grow from peach branches trained to a horizontal position as the IP trees in the current study and cordon-trained trees with Grossman and Dejong (1986). Such vigorous upright shoot growth effectively intercepts light but it competes with fruit resulting in reduced yield (Chalmers et al., 1981; Grossman and Dejong, 1998). In the current study, reduced yield in IP trees appeared to be associated with reduced crop load which may have been the result, in part, of competition between fruit and vegetative sinks and the removal of too much fruiting wood.

Marketable yield efficiency was improved by grass competition with trees maintained in 0.6 compared with 2.4 m VFA's (Table 3). One explanation is that grass reduced trunk diameter and branch growth but did not cause a proportionate decrease in fruit yield. In contrast marketable yield efficiency was decreased (but not always significantly) by grass competition when trees were maintained in 0 compared with 2.4 m VFA's. The trees were 5 years old and substantially developed when grass was installed to impose the 0 m VFA in 1998. When grass competition occurred with these more mature trees, fruiting apparently was more greatly suppressed relative to trunk diameter growth. Reduced pruning increased marketable yield efficiency for all RS compared from 2004 to 2007 and for JD in 2004 and 2006. The RP and 0.6 m VFA appeared to be a viable combination to increase marketable yield efficiency in both cultivars.

5. Conclusion

It is evident that reduced pruning can significantly increase number and weight of marketable fruit but individual fruit size decreases due to the greater crop load. In comparison, grass and presumably other ground covers can significantly reduce crop load while maintaining average fruit weight. It is possible that a level of pruning and competition could be developed to help manage tree size and crop load without sacrificing consumer-acceptable fruit size. This conclusion must be taken with the obvious caveat that the findings represent treatments in a mesic environment. Under more xeric conditions or nutrient-poor soils, ground covers may reduce average fruit weight as well as the marketable crop load. An analysis of modified pruning and managed competition on fruit size class distribution and on costs is necessary but the current work suggests that pruning intensity and the resulting tree form can be designed to accommodate ground cover competition.

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References


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