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# Summer Pruning Affects Fruit Quality and Light Penetration in Young Peach Trees

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**Abstract.** Two-year-old peach trees [*Prunus persica* (L.) Batsch cv. Candor] on 'Lovell' rootstock were summer-pruned (selective thinning and heading of current season's growth) 23 days before harvest. Pruning did not affect fruit quality. Summer pruning increased yield the subsequent year, apparently by increasing fruiting wood in the center of the tree. Summer pruning vigorous 3-year-old 'Loring' peach trees 8 weeks before harvest increased PAR through the canopy, 1 m above the ground, immediately after pruning and when measured at harvest. Fruit from summer-pruned 'Loring' were firmer, with lower soluble solids than those not summer-pruned.

The effects of summer pruning deciduous fruit trees has been well-documented over the past decade. Much of the attention has been directed toward apple, but recent investigations have focused also on peach (1, 5, 6, 10, 11). A number of reasons have been given to support the practice of summer pruning for peaches. Summer pruning was reported to reduce vegetative growth, decrease time required for dormant pruning, improve light penetration, enhance fruit quality, concentrate fruit maturity, increase the number of fruit buds formed, and increase yield (2, 3, 10, 11).

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However, not all reports on summer pruning of peach have been favorable (1, 5, 6, 9). Chalmers et al. (1) reported that hedging (nonselective pruning back of shoots with cutter-bar mower or special circular saw) reduced fruit number and yield by more than half compared to a light summer pruning (selective thinning and heading of shoots). Marini (6) reported that summer pruning or topping (removing about half of current season's growth on top of the tree) of 3-year-old 'Cresthaven' trees in June or June and July resulted in more shoot growth the following year than when trees were only dormant pruned. Light levels were increased at the center of these young trees immediately after summer pruning but not always after topping. He did not report the effect on yield. In a subsequent study, Marini and Rossi (9) found no economic or horticultural advantage for summer pruning or topping over dormant pruning of 11-year-old 'Sunqueen' peach trees.

Except for Marini's report on 3-year-old

trees (6), little information is available concerning the effect of summer pruning on young peach trees planted under field conditions at wide spacings and just beginning to bear fruit. Summer pruning may seem impractical for these trees, since one of the objectives at this stage is to encourage vigorous growth to fill the allotted space with fruiting canopy (mantle). However, excessively vigorous growth frequently is produced, resulting in dense shade in the lower center portion of the tree even in the second year. Less vigorous shoots that cannot compete are soon shaded-out and become weak, small-diameter shoots (4) that may die. Eventually the fruiting mantle is found only on the periphery of the tree. Summer hand pruning to remove or suppress selectively the most vigorous shoots might increase light adequately to maintain bearing wood throughout the canopy. The present study was designed to examine this hypothesis on young, vigorous peach trees in a low density (298 trees/ha) planting.

**Expt. 1.** Two-year-old 'Candor' peach trees on 'Lovell' rootstock planted 5.5 × 6.0 m and oriented in northeast-southwest rows were trained to an open center system using standard dormant pruning methods. Trees were vigorous, averaging 2 m in height with a 2-m canopy spread, and had set a crop of fruit. All trees were hand thinned to space fruit 15 to 20 cm apart. A single summer pruning treatment was imposed on 16 June 1982 (early stage III), 23 days before the first harvest. Summer pruning consisted of thinning cuts to remove vigorous, upright, current season shoots, and severely heading back current season shoots to about 10-cm stubs in the top and center of the tree. Fresh weight of summer prunings was not recorded; however, ≈60% of the current season's shoot growth was removed by the summer-pruning treatment. An effort was made to maximize light penetration while maintaining a sufficient number of new shoots for next year's crop and future canopy/mantle development. Experimental design was a randomized com-

Table 1. Yield and quality of fruit harvested at two dates from 2-year-old 'Candor' peach trees as affected by summer pruning.

Harvest date	Summer treatment <sup>a</sup>	Percent acceptable fruit in size class:			Total acceptable fruit harvested (%)	Yield tree (kg)	Flesh firmness (N)
		<57 mm	57 to 63 mm	>63 mm			
8 July 1982	Pruned	25 a <sup>y</sup>	59 a	16 a	57 a	16.8 a	58 a
	Unpruned	18 a	67 a	14 a	52 a	10.8 b	61 a
12 July 1982	Pruned	22 a	43 a	35 a	95 a	18.6 a	15 a
	Unpruned	13 a	39 a	48 a	95 a	11.3 b	15 a

<sup>a</sup>Trees summer pruned 16 June 1982.<sup>y</sup>Percentage of data analyzed after log transformation. Mean separation in columns within each harvest date by F test, 5% level.

Table 2. Quality of 'Candor' peaches harvested in 1983 from four positions in the canopy for trees summer pruned in 1982.

Treatment	Fruiting zone distance from tree center (cm)	Mean fruit rating for <sup>a</sup>		Flesh firmness (N)
		Ground color (1, 2)	Size classes (1-4)	
Summer treatment				
	Pruned	0-120	1.5 a	92.5 a
	Nonpruned	0-120	1.2 b	91.6 a
Fruiting zone <sup>y</sup>	Center	0-30	1.6 a	102.6 a
		30-60	1.4 b	93.9 b
		60-90	1.3 b	91.2 b
	Periphery	90-120	1.0 c	79.9 c

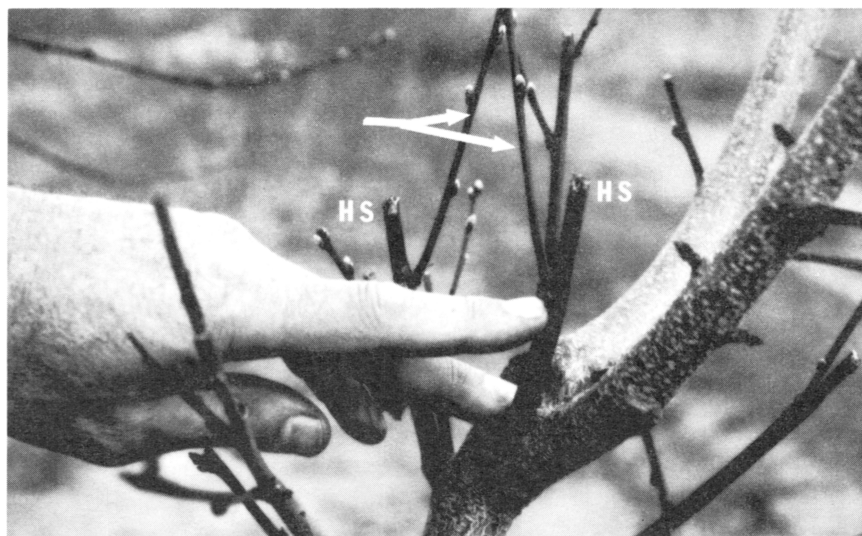
<sup>a</sup>Fruit ground color rating: 1, yellow and 2, green. Fruit size class rating: 1, <51 mm; 2, 51 to 57 mm; 3, 58 to 64 mm; and 4, >64 mm in diameter.<sup>y</sup>Fruit harvested from designated area measured radially from tree center in the southwest quadrant.<sup>a</sup>Mean separation within columns and for main effects after log transformation, Duncan's multiple range test, 5% level. Flesh firmness data not transformed.

Fig. 1. Shoot growth produced following summer pruning of 2-year-old 'Candor' peach tree 23 days before harvest. Thinning and heading cuts removed excessively vigorous growth in the top and center of the canopy. Note short shoots (arrow) produced on headed shoots (HS).

plete block with four-tree plots and eight replications. On 8 July 1982, 16 trees in each treatment were stripped of all fruit. Initial harvest date was selected when at least 25% of the fruit were considered mature enough for commercial harvest as determined by visual inspection. The number and weight of fruit from each tree were recorded. Fruit was sized into three classes using a metal sizing ring (Michigan Orchard Supply, St. Joseph): <57 mm, 57 to 63 mm, and >63 mm. Size was considered the minimum fruit diameter to pass through the ring measured perpendicular to the suture. Fruit in each size class were graded as commercially acceptable or

unacceptable for harvest based on ground color as defined by USDA grade standards (12). Acceptable fruit were those that had reached the "turning yellow" or "yellow" stage. On 12 July the remaining 16 trees from each treatment were harvested and handled as described.

All trees were dormant pruned in Mar. 1983, as open center peach trees are generally pruned. The summer-pruned trees required only minor dormant pruning, generally a few major thinning cuts to eliminate crowding and to provide points for renewed growth. No summer pruning was done in 1983. During stage I of fruit development,

three previously summer-pruned trees and three non-summer-pruned trees with similar crop loads were selected and the southwest quadrant was divided into 4 concentric zones beginning at the trunk and extending outward at 30-cm intervals. All fruit were harvested from each section of the quadrant on 12 July, and 10 fruit from each zone were separated into four size classes (1, <51 mm; 2, 51 to 57 mm; 3, 58 to 64 mm; and 4, >64 mm). Ground color was rated in two categories (1 = green and 2 = turning yellow or yellow), and flesh firmness was determined from paired pressure tests on opposite sides of fruit using a hand-held penetrometer with a 11.1-mm tip (Effegi, McCormick Fruit Tree Co., Yakima, Wash.).

Summer pruning 2-year-old 'Candor' peach trees did not reduce the yield per tree in the year of pruning (Table 1). Differences in fruit weight per tree could not be attributed to more fruit in the large size classes ( $\geq 57$  mm), but apparently were due to differences caused by initial crop load. Individual fruit weights were not recorded, so differences could be attributed to "heavier" fruit that could have resulted from increased light levels. Sample size was considered adequate based on the report by Marini and Trout (8). Summer pruning did not increase the percentage of acceptable fruit at the first or second harvest in 1982. Summer pruning did not affect fruit firmness.

'Candor' peach trees summer pruned in 1982 had significantly higher yields (39.9 kg/tree) than did nonpruned trees (28.4 kg/tree, LSD = 4.8,  $P = 0.05$ ) in 1983. This increase in yields was attributed to flower buds formed and subsequent increased fruit set on regrowth after heading cuts were made,

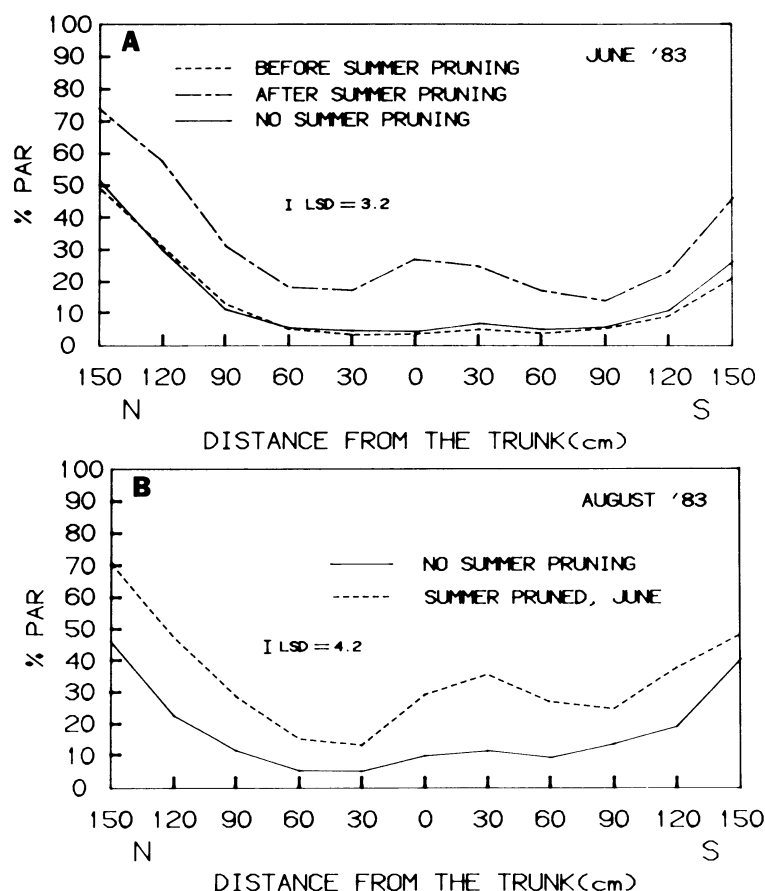


Fig. 2. Percentage of available photon flux density of PAR in 3-year-old 'Loring' peach trees as affected by summer pruning. Measurements made 1.0 m aboveground at 0, 30, 60, 90, 120, and 150 cm from the trunk along a north-south transect. Each point is the mean of 15 trees. Analysis performed on data transformed to the arcsin of the square root of the proportion. (A) PAR levels immediately before and after summer pruning on 28 June 1983. (B) PAR readings on 23 Aug. 1983, 8 weeks after summer pruning.

Table 3. Quality of 'Loring' peaches as affected by summer pruning 3-year-old trees.

Treatment <sup>a</sup>	Soluble solids (%)	Flesh firmness (N)	Fruit graded acceptable (%)
Pruned	11.43 b <sup>y</sup>	49.4 a	96.7 a
Nonpruned	12.41 a	36.5 b	92.6 b

<sup>a</sup>Summer pruned, 28 June 1983; harvested 25 Aug. 1983.

<sup>y</sup>Mean separation in columns by F test, 5% level.

particularly on shoots in the center of the tree (Fig. 1). Previous season's summer-pruning treatments and fruit location within the canopy measured in 1983 did not interact to affect fruit quality. Fruit harvested 12 July 1983 from trees pruned in June 1982 were rated greener (ground color) and larger than fruit from the nonpruned trees (Table 2). Summer pruning in 1982 did not affect peach firmness in 1983. Fruit harvested from the periphery (90 to 120 cm from center) of the canopy had more yellow ground color and were larger and softer than fruit from the center (0 to 30 cm) of the canopy. The data indicate that growth of summer-pruned trees increases the year after summer pruning, resulting in reduced light levels that delay ripening. Marini (6) reported a stimulation of shoot growth on young 'Cresthaven' trees the year following summer pruning. Delayed ripening also could be due to increased crop load.

Time required for dormant pruning was

not recorded; however, summer-pruned trees required almost no dormant pruning (generally <1 min/tree), but nonpruned trees required several minutes to remove vigorous watersprouts, dead and weak shoots, and to lower the canopy height. Total pruning time per tree (dormant + summer) was estimated to be about equal between the two treatments.

**Expt. 2.** In June 1983, a group of uniform 3-year-old 'Loring' peach trees on 'Lovell' rootstock planted in the same orchard as Expt. 1 trained as open center trees was selected. Average tree height was 2.2 m with a 3-m canopy spread. Trees were blocked into five replicates of six trees each. Three trees per block were summer pruned as previously described on 28 June 1983 (early stage II), 58 days before harvest, and three trees were nonpruned. The day prior to pruning, the radiant flux density of photosynthetically active radiation (PAR) was measured between 1030 and 1400 HR within each tree canopy.

Skys were overcast. Measurements were taken on a north-south transect 1 m above the ground and at 30-cm intervals through the canopy. PAR was recorded with a Lambda LI-188 light meter by placing a Lambda LI-190SB quantum sensor facing skyward at each interval along an aluminum rod inserted through the canopy. The quantum sensor was affixed to the end of a meter stick for ease of inserting into the canopy. PAR penetrating the canopy was expressed as the percentage of available PAR measured at the center of the tree row 2 m from the edge of the canopy. PAR readings were taken the day after (29 June) summer pruning and again on 23 Aug. 1983, 2 days before harvesting both treatments. Sky conditions were overcast on each day PAR was measured (average, unobstructed PAR =  $650 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$  on 29 June and  $195 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$  on 23 Aug.).

Fruit were harvested on 25 Aug. to determine yield per tree. Fruit were graded as commercially acceptable or unacceptable based on ground color (as described in Expt. 1) and sized into the following classes: 1, <61 mm; 2, 61 to 68 mm; 3, 69 to 73 mm; 4, >73 mm. A random sample of 10 fruits was taken from the "acceptable" lot of size class 2 or above fruit for soluble solids and flesh firmness measurements. Percentage of available PAR was transformed to the arcsin of the square root for analysis. Analysis of variance and mean separation techniques were used to determine treatment differences.

Summer pruning in late June increased light levels in 3-year-old 'Loring' peach trees (Fig. 2A). Light profiles 1 m above the ground on a north-south transect followed typical parabolic patterns previously reported for peach (6, 7). PAR was highest on the periphery of the canopy and lowest midway between the center of the tree and the periphery. Light intensities increased at the center of the tree from 5% to 27% as a result of summer pruning in June. PAR measurements on 23 Aug., 56 days after pruning, showed that light intensities were still higher in summer-pruned trees (Fig. 2B). Light intensity profiles within the canopy were similar to those measured in June for treated and control trees.

Summer pruning increased fruit firmness but decreased soluble solids. Summer pruning did not affect yield or fruit size (data not presented). The increased percentage of fruit showing yellow ground color, by summer pruning, increased the percentage of fruit acceptable for commercial harvest.

A severe winter freeze ( $-25^{\circ}\text{C}$ ) in Jan. 1984 eliminated the 1985 crop. However, severely headed shoots had developed short, apparently fruit-bearing shoots with what appeared to be flower buds similar to those observed on the 'Candor' trees in Expt. 1. In both experiments, summer pruning reduced the number (four or less) of small, dead shoots in the lower center portion of the mantle. Nonpruned trees had numerous dead shoots (12 or more per tree).

These results indicate that summer pruning young, vigorous peach trees in widely spaced plantings may be beneficial for in-

creasing light levels and stimulating fruit bud development in the inner portions of the fruiting canopy (mantle). Any increase in marketable fruit at this stage of tree development should improve the economics for peach growers. The method of summer pruning used has little or no effect on fruit quality from young trees. Summer pruning may, however, increase fruit flesh firmness and delay maturity if done 6 to 8 weeks before harvest. Marini (6) reported increased flesh firmness following summer pruning. My experience indicates that peach growers should consider summer pruning as a standard cultural technique in the early development of young peach trees.

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## Computer-assisted Determination of Apple Tree Canopy Volume

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*Additional index words.* *Malus domestica*, fruit, tree size, computer analysis

**Abstract.** A method for determining canopy volume of apple trees is described in which a graphics computer is used to digitize photographs of young trees. Volume is calculated from a formula based on the first theorem of Pappus. Volumes obtained compare favorably with the laborious, detailed hand-measurement methods. Canopy volumes determined from defined geometric shapes were generally less than those from hand- or computer-generated methods. Both of the latter methods correlated with trunk circumference and trunk cross-sectional area. Geometrically determined canopy volumes did not correlate with trunk size.

The volume of space occupied by the canopy of a fruit tree provides a parameter to estimate potential yields, measure growth response to various cultural treatments, develop orchard plans, and determine optimum spray application. Developing simple non-destructive, accurate technique for determining tree volumes has interested fruit researchers for many years (5). Nondestructive methods have been described that relate trunk size to tree mass or volume (2, 4, 8, 10, 12), but this relationship is not adequate for present needs. In a study with peach, apricot, and plum, Deist et al. (2) showed

that trunk diameter and/or circumference is not linearly related to tree mass. Westwood and Roberts (12) have shown that trunk cross-sectional area is linearly related to the above-ground weight (mass) of apple trees. They point out, however, that severe pruning can alter this relationship. Because tree trunks are often irregularly shaped, conclusions based on trunk cross-sectional area are subject to error.

As an alternative approach, various investigators have suggested methods that calculate the volume of shapes that approximate those of the canopy (1, 2, 9). The canopy is defined as a set of cones, cylinders, and/or spheres, and the appropriate formulae for these shapes are used to calculate the canopy volume. Actual tree canopies are extremely irregular and rarely, if ever, conform to any Euclidean object. If the canopy is pruned or modified by some other cultural training system, the tree canopy becomes increasingly difficult to subdivide into easily calculated shapes. We propose a computer-assisted method for calculating tree canopy volumes

that consists of digitizing photographs of the canopy.

Four-year-old 'Golden Delicious' and 'Stayman-201' on M.7A rootstock apple trees growing at Kearneysville, W. Va., were used to demonstrate the proposed method. The trees had been trained as freestanding tree forms suitable for mechanical harvesting. There were six distinct canopy forms: 1) central leader (CL), b) modified central leader (MCL), c) modified leader (ML), d) open center (OC), e) double T (DT), and f) natural tree form (NF) (no training) (Fig. 1). Details of the training methods have been presented (7).

A primary objective was to develop a system that was not only accurate but also would require a minimum of field measurements and minimize the time spent in the field collecting data. By photographing the tree canopy, we did not need field measurements, and the field data collection was limited to the time required to photograph each tree. Calculation of the canopy volume was based on the first theorem of Pappus (3), which states that if a planar region R lies on one side of a line L (the axis), the volume of a solid generated by revolving R about L is equal to the product of the area of R and the length of the path described by the centroid of R. The area of R is obtained by taking a cross-sectional view of a tree canopy and calculating its area and dividing by 2. The length of the path travelled during rotation by the centroid is approximate to the circumference of a circle, with a radius equal to one-fourth the canopy diameter (Fig. 2).

In the procedure, the trees to be analyzed were photographed with a 35-mm, automatic camera fitted with a 50 mm f/3.5 macro lens. The procedure for photographing trees was determined from data collected on a single pyramid-shaped canopy CL trained tree. Sixteen photographs were taken about the periphery of the "test tree" at equivalent points on the circumference of a circle with a 5.2-m radius from the tree's trunk. The mean error of these data indicated that two

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