Mechanical Thinning of Peaches is Effective Postbloom

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Abstract. Hand-thinning (*Prunus persica* L. Batsch) “Y”-trained peach trees at bloom and 51 days after full bloom (DAFB) was compared to mechanical fruit thinning 51 DAFB using a spiked-drum and an impact shaker. The spiked-drum shaker removed more fruit from horizontal branches than from vertical branches, yet did not selectively remove either large or small fruit. Bloom thinning by hand increased fruit size compared to postbloom thinning 51 DAFB, and both postbloom mechanical thinning techniques were as effective as postbloom hand thinning. The spiked-drum shaker may be a better thinning technique than the impact shaker because it transfers less shaking energy to the fruit, can be used in high-density plantings, and does not contact the trunk, lessening the potential for tree damage.

Thinning peaches is necessary to ensure marketable fruit size. Blossom thinning generally increases fruit size more than thinning at 40 to 60 days after full bloom (DAFB) (Baughner et al., 1988, 1991; Byers and Lyons, 1984, 1985; Havis, 1962; Johnson and Handley, 1989; Weinberger, 1941). However, the frequent occurrence of frost following bloom thinning may further reduce the crop load, and this risk discourages peach growers from using bloom thinning. Therefore, fruit thinning 40 to 60 DAFB is a common practice in areas with a frost risk, although it produces smaller fruit than bloom thinning. Fruit thinning by hand, the most common thinning practice, is labor-intensive and costly.

There have been many reports of chemical thinning in peaches but only a few reports of mechanical thinning of fruit trees. Chemical thinning in apple (*Malus domestica* Borkh.) production is effective; however, in peach production this approach has been disappointing (Cobianchi, 1971; Martin, 1988). Mechanical thinning of deciduous fruit trees has focused on the inertia shaker for fruit removal. Grausland (1980) used a cherry shaker to thin plums (*Prunus domestica* L.) and found that fruit size was increased, but fruit removal on

the perimeter of the tree was insufficient and required hand thinning. Fitch (1980) recommended the use of tree shaking to thin plum trees in heavy crop years but cautioned about the potential for tree trunk damage. Menzies (1980) used a tree shaker to thin apple and pear (*Pyrus communis* L.) trees, but found it to be nonselective in fruit sizes removed; apples and short peduncle pears were effectively thinned. Berlage and Langmo (1977) reported that machine thinning of peach trees with an inertia trunk shaker produced a 57% time savings but resulted in a 30% reduction in yield due to overthinning. Uneven fruit distribution and smaller fruit were also problems with mechanical thinning.

According to Cobianchi (1975) and Costa (1978), the effectiveness of mechanical peach thinning was related to the shaker type, the tree training system, and the pruning method. Baughner et al. (1988, 1991) developed a rotating rope curtain to thin peach flowers at bloom and reported that it thinned open-centered trees at full bloom as effectively as hand thinning. Hancock et al. (1988) and Bukovac et al. (1963) found that inertial shakers could thin fruit as or more effectively than hand thinning, and the shakers did not selectively remove larger or smaller fruit. The objective of our work was to compare hand thinning of peach with mechanical fruit removal by the spiked-drum canopy shaker and impact trunk shaker systems.

Materials and Methods

In 1991, fifteen 7-year-old ‘Loring’ peach trees were used. Trees were trained to a free-standing “Y” (Horton, 1973) and were pruned by hand, removing four to eight large, misdirected shoots within the tree following mechanical shearing to reestablish the arms of the “Y” form. At the beginning of the experiment, four to seven 2-year-old branches in the central portion of the canopy on a major scaffold were tagged, and the orientation of the branch was categorized as horizontal (315° to 0° to 45° and 135° to 180° to 225°), vertical (45° to 90° to 135°), or downward (225° to 270° to 315°). The number of fruit per branch and the diameter of the branch at the origin were measured. Fruit diameter was measured across the suture. The shoot and fruit measurements were made on 21 May (47 DAFB), and fruit were thinned on 22 May using a vibrating spiked-drum shaker (Peterson et al., 1989) moving at 0.5 km/h (Fig. 1). Each 1-m-diameter drum (spike tip to tip) was made up of nine rod panels spaced 160 mm apart. Each rod panel consisted of 24 16-mm-diameter nylon rods radially spaced at equal angles. The spikes

Fig. 1. Rear view of spiked-drum shaker thinning peaches.

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were uniformly accelerated along their length with a potential displacement of 100 mm at the tips. The axis of the spiked-drum was positioned under and parallel to one arm of the "Y" trellis.

The canopy arm of the "Y"-trained trees was 30 to 45 cm thick. Shaking frequency was 6 Hz. Each tree received two passes of the spiked-drum, one for each arm. On 22 May, after mechanical thinning, the number of fruit per branch was counted and their diameters were measured.

Data were analyzed using a randomized block design with 15 replications (trees). The treatments were the different branch orientations relative to the thinning action of the spiked-drum shaker.

In 1992, a randomized block design with four replicates was established with 10-tree plots of 8-year-old 'Loring' peach. The treatments were 1) hand thinning at full bloom; 2) hand thinning 53 DAFB; 3) tree-trunk impactor (Peterson and Miller, 1989) (Fig. 2) thinning 51 DAFB; and 4) spiked-drum shaker thinning 51 DAFB. Hand thinning spaced fruit 10 to 15 cm on the shoot. The trunk diameter was measured 30 cm above the soil, and the trunk cross-sectional area (XSA) was calculated. A scaffold limb in three trees per plot was tagged, and the number of fruit was counted

before and after mechanical thinning to calculate removal percentage. Fruit were harvested in the 10-tree plots on two pickings and graded by weight on a Durand Wayland (LaGrange, Ga.) sorting line.

An accelerometer was attached to a 25-mm branch (spiked-drum shaker) and 37-mm branch (impact shaker) that was oriented perpendicular to the tree row at a 2-m height and 1.2 m from the center of the tree to measure tree vibration during thinning. Data acquisition was by a computerized system developed at the Appalachian Fruit Research Station (Peterson et al., 1993).

In 1993, a randomized block design with eight replicates was established with five-tree plots of 9-year-old 'Loring' peach. The treatments were 1) no thinning; 2) hand thinning 53 DAFB; 3) thinning 53 DAFB using the spiked-drum shaker at a 0.5-km/h ground speed and 6-Hz shaking frequency; 4) thinning 53 DAFB using the spiked-drum shaker at 2.0-km/h ground speed and 6-Hz shaking frequency. The hand-thinning treatment spaced fruit 10 to 15 cm on the shoot. The trunk diameter was measured 30 cm above the soil, and the XSA was calculated. Six fruit-bearing shoots in each of three trees per plot were tagged, and the number of fruit was counted before and after mechanical thinning to calculate removal

percentage. Three shoots were selected on the outer perimeter of the Y-arm and on the inside of the Y-arm. In each group of three shoots, two were horizontally oriented and one vertically. Following thinning, 30 fruit per plot were collected from the ground and their diameter measured. Fruit were harvested in the five-tree plots on three pickings and graded by weight on a Durand Wayland sorting line. The number of broken branches per tree was counted 3 days after mechanical thinning.

Fruit size data in 1992 and 1993 were tested using analysis of covariance with total number of fruit per XSA as the covariant. This covariant reflected the tree size and potential crop load capacity. Removal data expressed as percentages were square root-transformed before analysis of variance.

Results and Discussion

The orientation of shoots in canopies of Y-trained peach trees significantly affected mechanical peach-thinning efficiency in 1991 and 1993 when the spiked-drum shaker was used (Tables 1 and 2). Shoots oriented vertically, either up or down, had fewer fruit removed than did horizontal shoots based on linear contrasts, presumably because of the long contact period between the horizontal shoot and the rolling spiked-drum. The spiked-drum shaker did not selectively remove either large or small fruit since the change in fruit diameter following thinning was nonsignificant in 1991 (Table 1), nor the size of fruit removed in 1992 (hand-thinned; spiked-drum

Fig. 2. Impact shaker schematic: (a) top view—mass spring loaded; (b) side view—mass spring loaded; (c) side view—mass just before impact.

Table 1. Effect of limb orientation [vertical (vert.) vs. horizontal (horz.) vs. downward (down.)] on fruit size and mechanical thinning efficiency using a spiked-drum shaker 47 DAFB in 1991.

Limb orientation	Fruit size (mm)		Change in fruit diam (mm)	
	Before thinning	After thinning	following thinning	Removal (%)
Vert.	27.1	28.3	1.2	41 B ²
Horz.	26.2	26.9	0.7	53 A
Down.	25.8 ^{ns}	6.9 ^{ns}	1.1 ^{ns}	35 B

²Mean separation using Duncan's multiple range test ($P \leq 0.05$).

^{ns}Nonsignificant.

Table 2. Effect of limb orientation [vertical (vert.) vs. horizontal (horz.)] and canopy position on thinning efficiency using a spiked-drum shaker 53 DAFB in 1993. Data are averaged over the 0.5- and 2-km/h ground speeds.

Limb position	Limb orientation	Removal (%)
Outside perimeter	Vert.	81 A ²
	Horz.	89 A
Inside perimeter	Vert.	9 B
	Horz.	19 B
Linear contrast		
Horz. vs. vert. orientation		**
Outside vs. inside canopy perimeter		**

²Mean separation using Duncan's multiple range test ($P \leq 0.05$).

**Significant at $P \leq 0.05$.

shaker at 0.5 and 2.0 km/h; 29.7, 30.9, and 30.5 mm, respectively). The spiked-drum shaker created a gradient of fruit removal with more removal occurring on the outside than on the inside of the Y-shaped canopy (Table 2). The 1991 data collected from the interior of the canopy (Table 1) represented an intermediate level of fruit removal. Operating the spiked-drum shaker on both planes of the canopy would produce more uniform thinning throughout the canopy.

In 1992, the effect of hand (bloom and 51 DAFB) and mechanical thinning (tree shaker vs. spiked-drum shaker) 51 DAFB supported the conclusion that bloom thinning increases fruit size more than postbloom thinning. The weight of large fruit adjusted for tree size and crop load was highest for bloom thinning and less for the postbloom thinning treatments. There was no significant effect of thinning method on fruit that attained 51 to 76 mm in diameter at harvest, even at $P \leq 0.10$ (Table 3, 1992). The yield of fruit >76 mm in diameter was significantly increased by hand bloom thinning; however, no differences occurred among the postbloom thinning treatments.

The spiked-drum shaker removed more fruit from horizontal branches than vertical branches, yet the two mechanical thinning techniques were comparable to hand thinning postbloom in their ability to thin peaches and increase fruit size (Table 3). Each approach exerts force on the tree to move the branches and dislodge the fruit in a different manner. The impactor shakes the limbs (over a short time interval) three times, each time with greater force (Fig. 3) as described by Peterson and Miller (1989). The spiked-drum shaker has comparable limb displacement but more cycles with a much lower acceleration than the impactor (Fig. 4). The spiked-drum shaker may be a better thinning tool than the impact shaker because it a) transfers less shaking energy to the fruit; b) does not contact the trunk like the impactor, which may damage the bark (Hancock et al., 1988); and c) could be used in high-density plantings.

Yield potential was higher in 1993 than in 1992 due to favorable weather conditions; consequently, little or no thinning was needed for maximum yield of fruit >76 mm in diameter (Table 3). The nonthinned control had the highest yield of small fruit and the same yield of fruit >76 mm in diameter as provided by hand thinning. Hand thinning fruit to a 10- to 15-cm spacing resulted in the same adjusted yield of small fruit as the mechanical shaker. Mechanical thinning using the spiked-drum shaker at either 0.5 or 2.0 km/h overthinned the trees and significantly reduced the yield of fruit >76 mm in diameter. We expected that a faster ground speed would reduce the amount of thinning when the shaking frequency was constant at 6 Hz. We found no difference in final fruit size or in fruit removal percentage (data not presented); however, limb breakage appeared to increase due to the higher ground speed (Table 3).

In summary, bloom thinning increased fruit size compared to postbloom thinning, and postbloom mechanical thinning techniques

Table 3. Effect on fruit size and limb breakage of bloom thinning and postbloom thinning using hand and mechanical techniques.

Thinning method	Fruit wt (kg/tree)				Limb breakage (no./tree)
	Fruit diam				
	>51 ≤76 mm		>76 mm		
	Mean	Adjusted ²	Mean	Adjusted ²	
1992					
Hand, bloom	24.8	22.0	14.4	19.3 A ^y	ND ^x
Hand, 51 DAFB	21.5	22.7	18.4	16.3 B	ND
Impact shaker, 51 DAFB	21.4	22.7	16.4	14.3 B	ND
Spiked-drum shaker, 51 DAFB	23.0	23.4 ^{NS}	15.8	15.2 B	ND
1993					
None (control)	13.1	8.7 A	57.2	54.4 A	ND
Hand 53 DAFB	2.7	2.0 B	55.0	54.6 A	ND
Spiked-drum shaker, at 0.5 km/h 53 DAFB	4.6	6.2 AB	34.2	37.0 B	0.8
Spiked-drum shaker, at 2.0 km/h 53 DAFB	1.7	5.3 AB	35.1	35.6 B	1.6

²Adjusted means based on analysis of covariance using number of fruit per tree per trunk cross-sectional area; $P \leq 0.10$ for 1992, $P \leq 0.05$ for 1993.

^yMean separation based on Duncan's multiple range test; $P \leq 0.10$ for 1992, $P \leq 0.05$ for 1993.

^xNo data collected.

^{ns}Nonsignificant.

Fig. 3. Typical limb response using impact shaker (A) acceleration and (B) displacement (showing one of three impacts).

Fig. 4. Typical limb response using spiked-drum shaker (A) acceleration and (B) displacement. G = force of gravity.

were as effective as postbloom hand thinning in 1 year but not in a second year of study. The spiked-drum shaker is a potentially useful postbloom mechanical thinner if trees are trained to accommodate the equipment. This method is applicable on any training system with a relatively flat production surface, such as the Italian palmetta or vertical hedge. Applying the spiked-drum shaker to a narrow canopy system will require thinning on both

sides of the canopy and refinement of the optimal shaking frequency and ground speed for local conditions.

Literature Cited

- Baughner, T.A., K.C. Elliott, S.H. Blizzard, S.I. Walter, and K.A. Keiser. 1988. Mechanical bloom thinning of peach. *HortScience* 23:981-983.
 Baughner, T.A., K.C. Elliott, D.W. Leach, B.D. Horton, and S.S. Miller. 1991. Improved meth-

- ods of mechanically thinning peaches at full bloom. *J. Amer. Soc. Hort. Sci.* 116:766-769.
 Berlage, A.G. and R.D. Langmo. 1977. Comparison of hand and mechanical thinning of peaches. *Amer. Soc. Agr. Eng. Paper* 77-1528. *Amer. Soc. Agr. Eng.*, St. Joseph, Mich.
 Bukovac, M.J., H.P. Gaston, S.L. Heddon, and J.H. Levin. 1963. Fruit thinning of peaches with machines. *Quarterly Bul. Michigan State Univ. Agr. Expt. Sta.* Feb. 45(3):518-532.
 Byers, R.E. and C.G. Lyons. 1984. Flower thinning of peach with desiccating chemicals. *HortScience* 19:545-546.
 Byers, R.E. and C.G. Lyons. 1985. Peach flower thinning and possible sites of action of desiccating chemicals. *J. Amer. Soc. Hort. Sci.* 110:662-667.
 Cobiachi, D. 1971. La sperimentazione sul diradamento chimico del pesco. *Atti del XI Convegno peschicolo romagnolo*. Ravenna, 19-20 giugno, 1971. XIII:71-76.
 Cobiachi, D. 1975. Considerazioni sul diradamento meccanico dei frutticini nel pesco. *L'informatore Agrario* 29.
 Costa, G. 1978. Chemical and mechanical thinning of peach fruits. *Rivista della Ortofloro-frutticoltura Italiana* 62:63-86.
 Fitch, L.B. 1980. *Crop Control Diamond/Sunsweet News* 2:4-5, 41.
 Grausland, J. 1980. Fruit thinning. V. Experiments with chemicals and mechanical thinning of plums. *Tideskrift for Planteavl* 84:519-529.
 Hancock, B.G., A.A. Powell, and J.W. Worthington. 1988. Mechanical thinning of peaches, p. 667-672. In: N.F. Childers and W.B. Sherman (eds.). *The peach*. Hort. Publ., Gainesville, Fla.
 Havis, A.L. 1962. Effect of time of fruit thinning of 'Redhaven' peach. *Proc. Amer. Soc. Hort. Sci.* 80:172-176.
 Horton, B.D. 1973. Training peach trees for mechanization. *Proc. 9th Annu. Mtg. Ark. State Hort. Soc.* p. 93-96.
 Johnson, R.S. and D.F. Handley. 1989. Thinning response of early-, mid-, and late-season peaches. *J. Amer. Soc. Hort. Sci.* 114:852-855.
 Martin, G.C. 1988. Peach thinning in California, p. 665-666. In: N.F. Childers and W.B. Sherman (eds.). *The peach*. Hort. Publ., Gainesville, Fla.
 Menzies, A.R. 1980. Timing, selectivity, and varietal response to mechanical thinning of apples and pears. *J. Hort. Sci.* 55:127-131.
 Peterson, D.L., D.M. Glenn, and S.D. Wolford. 1993. Tensiometer irrigation control valve. *Appl. Eng. Agr.* 9(3):293-297.
 Peterson, D.L. and S.S. Miller. 1989. Advances in mechanical harvesting of fresh market quality apples. *J. Agr. Eng. Res.* 42:43-50.
 Peterson, D.L., F. Takeda, and T.S. Kornecki. 1989. New shaking concept for brambles. *Trans. Amer. Soc. Agr. Eng.* 32(4):1165-1168.
 Weinberger, J.H. 1941. Studies on time of peach thinning from blossoming to maturity. *Proc. Amer. Soc. Hort. Sci.* 38:137-140.