Summer Pruning Young 'Sweetheart' Sweet Cherry Trees Affects Yield and Tree Size

Frank Kappel, Michel Bouthillier, and Rob Brownlee

Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, Summerland, BC V0H 1Z0

Additional index words. *Prunus avium*, fruit size, trunk cross-sectional area, ground area covered, cumulative yield, yield efficiency, heading cuts

Abstract. 'Sweetheart' sweet cherry trees (*Prunus avium* L.) were summer-pruned for four summers (1991-94) either before or after harvest and at two levels, removing 1/3 or 2/3 of current-season growth by heading cuts. In an additional postharvest treatment, some current-season growth was removed by thinning cuts. The preharvest 1/3 treatment had the highest cumulative yield during the experiment. Higher yields were obtained following preharvest than postharvest treatments, and following less severe treatments (removing 1/3 of current-season growth) than more severe (removing 2/3) treatments. These increased yields were for the early stages of orchard production. Average fruit mass was not affected by any of the treatments. The summer-pruned trees had smaller trunk cross-sectional area (TCSA) increments over the trial and their final TCSA was smaller than that of the control trees.

Sweet cherry growers are interested in developing training systems that use smaller trees to increase planting densities, precocity, and labor efficiency. At present, no dwarfing rootstocks can be recommended with any confidence to sweet cherry growers to reduce tree size for commercial planting. Therefore, growers are interested in using other techniques to limit tree size. Increasing plant density without the use of dwarfing rootstocks has been attempted to reduce tree size by inter-plant competition and to increase yields (Ystaas, 1989), and summer pruning has been used in other crops to reduce tree size. In a trial at Summerland, summer pruning of peach trees increased trunk cross-sectional area and reduced tree height without affecting yield, and increased slightly the percentage fruit area covered by red blush (Kappel and Bouthillier, 1995). Marini and Barden (1987) suggested that summer pruning is no more effective than a similar type of dormant pruning to control tree size and growth, but little data exist on summer pruning of sweet cherry trees. The objective of this trial was to use summer pruning to limit tree size and improve yields of young trees in the early life of the orchard without reducing fruit size.

Materials and Methods

Thirty 'Sweetheart' (previously known as 13S-22-8) trees on mazzard seedling root-

Received for publication 30 Sept. 1996. Accepted for publication 2 Jan. 1997. Summerland Research Centre contribution no. 993. We acknowledge the support of Hugh Dendy who provided the trees for this study. We thank J. Hall for statistical advice and C. Hampson for editorial advice. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

stock, planted in 1988, were selected at a grower's orchard in Kelowna, British Columbia, Canada, during the winter of 1990-91. The spacing of the trees was 6.7 m between rows and 2.7 m within the row. Treatments consisted of removal of the terminal portions of all current-season shoots as follows: a) one-third removed preharvest (pre-1/3); b) two-thirds removed preharvest (pre-2/3); c) one-third removed postharvest (post-1/3); and d) two-thirds removed postharvest (post-2/3). Additional treatments were: e) postharvest thinning cuts (post-t), and f) control (no summer pruning). Preharvest treatments were applied 10 to 14 days before the estimated harvest (usually mid-July) and postharvest treatments 7 to 10 days after harvest (usually early to mid-Aug). The post-t treatment consisted of removing whole shoots of current-season growth, mainly vertical shoots or those crossing other shoots (i.e., shoots that would normally be removed during the dormant pruning). During the winter all trees were dormant pruned following local practices, including thinning cuts

to open the canopy to allow light penetration and access for harvesting, reducing tree height where possible, and removal of the terminal one-half of most current-season shoots if this was not done during the summer (control and post-t treatments).

Data were collected on trunk cross-sectional area (TCSA) at the start of the experiment and at the end of each growing season, tree height and spread at the end of the 1992-94 growing seasons, time required for dormant pruning after the 1993 and 1994 growing season, annual yield per tree, and fruit size (expressed as average fruit mass). Yield efficiency ($\text{kg}\cdot\text{cm}^{-2}$) was calculated by dividing cumulative yield (1991 to 1994) by the final TCSA.

The experiment was treated as a randomized complete-block design with five blocks where initial TCSA was used to block the trees. Treatments were applied to single-tree replicates. The data were analyzed using repeated measures (SAS Institute, 1990) to account for year effects except for cumulative yield, cumulative yield efficiency, TCSA increase, and final TCSA. Treatment degrees of freedom were partitioned into single degrees of freedom using the following contrasts: (Q_1) control vs. summer pruning; (Q_2) preharvest treatments vs. postharvest treatments; (Q_3) removing 1/3 vs. removing 2/3 of current-year's growth; and (Q_4) thinning summer pruning cuts (post-t) vs. heading summer pruning cuts.

Tests for sphericity suggested that the H-F condition (Littell, 1989) did not hold for yield, average fruit mass, TCSA, and tree height; therefore the repeated measures analysis with polynomials in time was appropriate. The Greenhouse-Geisser (G-G) adjustments for the univariate test were also evaluated (Littell, 1989; Marini et al., 1995).

Results

Cumulative yield over the experiment (1991 to 1994) was affected significantly by summer pruning, with pre-1/3 having the highest yields ($\approx 50\%$ greater than control) (Table 1). Preharvest treatments had 24% higher yields than the postharvest treatments (Q_2). Furthermore, 1/3 removal of current-season growth

Table 1. Summer pruning timing and severity effects on 'Sweetheart' sweet cherry cumulative yield and trunk cross-sectional area (TCSA).

Treatment	Cumulative yield/tree (1991-94) (kg)	Cumulative yield efficiency ($\text{kg}\cdot\text{cm}^{-2}$)	TCSA increase (1991-94) (cm^2)
Control	51.2	0.38	103.0
Preharvest-1/3	76.7	0.65	82.3
Preharvest-2/3	53.1	0.58	57.3
Postharvest-1/3	63.6	0.61	70.8
Postharvest-2/3	45.9	0.42	74.4
Postharvest-thinning	47.1	0.49	71.2
Standard error of mean ²	5.8	0.06	7.2
Contrasts (P value)			
Control vs. summer	0.356	0.034	0.006
Preharvest vs. postharvest	0.027	0.076	0.726
1/3 vs. 2/3	0.002	0.054	0.153
Thinning vs. heading	0.065	0.304	1.000

²Standard error of mean based on error mean square from analysis of variance.

Table 2. Main effects for yield, average fruit mass and trunk cross-sectional area (TCSA) of summer-pruned 'Sweetheart' sweet cherry trees.

Treatment	Yield/tree (kg)	Avg fruit mass (g)	TCSA (cm ²)
Year			
1991	1.7	9.1	58.5
1992	8.2	7.3	78.2
1993	24.1	8.0	97.6
1994	22.3	8.3	110.6
Standard error of mean ²	0.8	0.2	1.2
Significance ³	0.0001	0.0002	0.0001
Pruning			
Control	12.8	8.4	98.7
Preharvest-1/3	19.2	8.0	92.0
Preharvest-2/3	13.3	8.1	74.1
Postharvest-1/3	15.9	7.8	83.8
Postharvest-2/3	11.5	8.3	84.0
Postharvest-thin	11.8	8.5	84.2
Standard error of mean	1.5	0.2	5.1
Significance ⁴	0.01	0.16	0.08

²Standard error of mean based on error mean square from analysis of variance.

³Adjusted (greenhouse-Geier) *P* value of the univariate test.

⁴*P* value for the main effect from the repeated measures analysis.

produced about 42% higher yields than did 2/3 removal (Q_3). Trees with the two 1/3 treatments (pre- and postharvest) had 66% greater yield efficiencies than did the controls. Summer pruning improved the cumulative yield efficiency by about 45% and reduced the increase in TCSA (Q_1) compared with the control.

Across all treatments, both annual yields (Table 2) and yield per tree (Fig. 1) increased each year of the trial until 1994 when there was a slight decrease. The cubic polynomial trend was significant for year. Treatments significantly affected average annual yield, with pre-1/3 giving the highest yield. Treatment $\times$ year interaction was significant at all levels (linear, quadratic, cubic). Yields of control, post-2/3, and post-thin trees continued to increase throughout the 4-year period, whereas yields of trees receiving the other treatments decreased from 1993 to 1994 (Fig. 1). It is not clear what caused this to happen. The post-2/3 was one of the most severe pruning treatments, yet yield continued to increase. However, post-1/3 (same timing but less severe) produced the largest decrease in yield from 1993 to 1994.

Average fruit mass was also affected by year (significant cubic effect) across all treatments, with fruit in 1992 being the smallest (Table 2). Pruning treatments did not affect average fruit mass, even when the data were analyzed using either annual yield or annual yield efficiency as a covariate to account for crop load.

TCSA was significantly affected by year across all treatments, exhibiting a cubic effect (Table 2). That is, the growth of the trees slowed as the trial continued and the trees began to achieve a balance between vegetative growth and fruiting. Treatment effects and year $\times$ treatment interactions were not significant.

The spread of the tree or area of ground covered increased significantly with time (quadratic trend), regardless of treatment. Summer pruning also significantly affected the spread of the tree, with control and the pre-1/3 trees being the largest and the pre-2/3 and post-2/3

the smallest (Table 3). The year (linear) $\times$ treatment interaction was significant. Trees in all treatments except the control and post-t increased in spread. Control and post-t increased from 1992 to 1993 but then decreased in spread.

Tree height increased significantly as the

trees aged (data not shown) with the quadratic polynomial trend significant. The increase in tree height began to decline as the trees aged. Summer pruning significantly affected height, with control, post-1/3 and pre-1/3 treatments producing the tallest trees, and the two 2/3 treatments the shortest (Table 3). The year (quadratic) $\times$ treatment interaction was significant. Tree height appeared to increase at a greater rate for the post-1/3, pre-1/3, and pre-2/3 than for the other treatments, including control, from 1993 to 1994. It is unclear why these treatments had greater increases in tree height compared to control. The summer pruning treatments caused very little to no regrowth.

The time required for dormant pruning was significantly affected by year and summer pruning (data not shown). Pre-1/3 and control trees required the most time to prune during the winter, whereas the two 2/3 treatments and the post-thin required the least time. There were significant year $\times$ treatment interactions (Table 3); control and post-thin trees took less time, but the trees in other treatments took more time, to prune in 1994 than in 1993.

Discussion

Trees that were summer-pruned before harvest had higher yields than controls or trees

Fig. 1. Effect of pruning treatment on annual yield of summer-pruned 'Sweetheart' sweet cherry trees. pre = preharvest; post = postharvest; 1/3 = terminal 1/3 of shoots removed; 2/3 = 2/3 of terminal shoots removed; post-t = postharvest thinning.

Table 3. Tree size and time required for dormant pruning of summer-pruned 'Sweetheart' sweet cherry trees.

Treatment	Ground area covered (m ²)	Tree ht (m)	Dormant pruning time (min/tree)
Interactions			
1992 × Control	7.7	4.3	---
1992 × Preharvest-1/3	6.7	3.7	---
1992 × Preharvest-2/3	4.1	3.5	---
1992 × Postharvest-1/3	5.9	3.9	---
1992 × Postharvest-2/3	4.4	3.4	---
1992 × Postharvest-thinning	5.3	3.7	---
1993 × Control	8.4	4.4	8.4
1993 × Preharvest-1/3	8.4	3.9	8.4
1993 × Preharvest-2/3	5.1	3.5	5.1
1993 × Postharvest-1/3	7.0	4.2	7.0
1993 × Postharvest-2/3	5.3	3.6	5.3
1993 × Postharvest-thinning	5.9	3.8	5.9
1994 × Control	8.0	4.6	7.8
1994 × Preharvest-1/3	9.6	4.6	9.6
1994 × Preharvest-2/3	5.8	4.1	5.8
1994 × Postharvest-1/3	8.4	4.8	8.4
1994 × Postharvest-2/3	6.0	3.9	6.0
1994 × Postharvest-thinning	5.3	4.1	5.3
Standard error of mean ^a	0.2	0.1	0.6
Significance ^b	0.0001	0.028	0.0005

^aStandard error of mean based on error mean square from analysis of variance.^bAdjusted (Greenhouse-Geier) *P* value of the univariate test.

summer-pruned after harvest, which is contrary to earlier reports that both early and late summer pruning reduce yield (Crane, 1931). Looney (1989) reported that pruning in June and continually removing any regrowth had no effect on final fruit set in cherry. The lower yields for the postharvest pruning treatments may be related to reduced carbohydrate accumulation after harvest, because of the shorter time between summer pruning and leaf fall for those trees. Accumulation of reserve carbohydrates occurs predominantly after harvest (Keller and Loescher, 1989). Carbohydrate reserves in roots are sensitive to stress late in the season (Loescher et al., 1990) and play a role in fruit and tree growth and development the following season. Loescher et al. (1990) further suggest, however, that summer pruning removes sinks; this may alter the allocation of carbohydrate reserves and complicate any explanation of the results.

Trees pruned less severely (removing 1/3 rather than 2/3 of the current-season growth) had higher yields. Sweet cherries produce fruit at the base of 1-year-old wood and on spurs that develop on older wood. If the current-season growth is shortened by 2/3, fewer spurs probably would develop. The severe pruning may also affect production and allocation of carbohydrate reserves.

The significant interactions between year and treatments for annual yield suggest that

results may vary from year to year. However, cumulative yield was higher for the pre-1/3 and post-1/3 treatments than for the control trees.

Fruit size was unaffected by any of the treatments. Webster and Shepherd (1984) reported that summer tipping of the extension shoots of 'Van' and 'Merton Glory' did not reduce fruit size measured either by fruit diameter or mass. Fruit size is related to crop load and the leaf : fruit ratio (Proebsting, 1990). Reducing leaf area by preharvest summer pruning did not reduce average fruit mass, suggesting that crop load was below the critical level where a reduction in leaf area would cause a reduction in fruit size.

The reduction in canopy size following some of the treatments could allow increased planting density. Size of the canopy in this trial suggests that the theoretical planting density could be 568, 568, 833, 628, 784, and 784 trees per ha for control, pre-1/3, pre-2/3, post-1/3, post-2/3, and post-t treatments, respectively. These planting densities were calculated using the canopy size of the trees at the end of this trial (7-year-old trees). The trees have not yet matured and will still increase in size. Cumulative yields can be used to calculate theoretical yields of 29.1, 43.6, 44.2, 39.9, 36.0, and 36.9 t·ha⁻¹, respectively, for these young trees at these densities. Either of the two preharvest treatments would increase yields per hectare

without reducing fruit size. Increased yield of pre-1/3 trees was accomplished without increasing tree density, and therefore establishment costs would not be increased, making this a potentially more economical system.

In summary, summer pruning tended to reduce canopy size and TCSA for younger trees, but did not affect average fruit mass. The preharvest treatments gave higher yields than postharvest treatments, and less severe heading was better than 2/3-heading. However, this work was conducted with young trees during their fourth to seventh year after planting. The usefulness of these treatments for older, mature trees is unknown. Also, any long term benefits or problems remain to be determined.

Literature Cited

- Crane, H.L. 1931. Effects of pruning on growth and yield of cherry trees. West Virginia Agr. Expt. Sta. Bul. 415.
- Kappel, F. and M. Bouthillier. 1995. Rootstock, severity of dormant pruning, and summer pruning influences on peach tree size, yield, and fruit quality. Can. J. Plant Sci. 75:491-496.
- Keller, J.D. and W.H. Loescher. 1989. Nonstructural carbohydrate partitioning in perennial parts of sweet cherry. J. Amer. Soc. Hort. Sci. 114:969-975.
- Littell, R.C. 1989. Statistical analysis of experiments with repeated measurements. HortScience 24:37-40.
- Loescher, W.H., T. McCamant, and J.D. Keller. 1990. Carbohydrate reserves, translocation, and storage in woody plant roots. HortScience 25:274-281.
- Looney, N.E. 1989. Effects of crop reduction, gibberellin sprays, and summer pruning on vegetative growth, yield, and quality of sweet cherries, p. 39-50. In: C.J. Wright (ed.). Manipulation of fruiting. Butterworths, Borough Green Seven Oaks, Kent, England.
- Marini, R.P. and J.A. Barden. 1987. Summer pruning of apple and peach trees. Hort. Rev. 9:351-375.
- Marini, R.P., D.S. Sowers, and M.C. Marini. 1995. Tree form and heading height at planting affect peach tree yield and crop value. HortScience 30:1196-1201.
- Proebsting, E.L. 1990. The interaction between fruit size and yield in sweet cherry. Fruit Var. J. 44:169-172.
- SAS Inst. 1990. SAS/STAT user's guide, version 6, 4th ed., vol. 2. SAS Inst., Cary, N.C.
- Webster, A.D. and U.M. Shepherd. 1984. The effects of summer shoot tipping and rootstock on the growth, floral bud production, yield, and fruit quality of young sweet cherry. J. Hort. Sci. 59:175-182.
- Ystaas, J. 1989. The influence of tree density on tree size, yield, and fruit quality of 'Van' sweet cherries. Acta Hort. 243:327-330.