

# Timing and Severity of Summer Pruning Affects Flower Initiation and Shoot Regrowth in Sweet Cherry

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*Additional index words.* flower quality, vigor control, high density, paradormancy, *Prunus avium*

**Abstract.** To examine the effect of timing and severity of summer pruning on flower bud initiation and vegetative growth, 4-year-old 'Bing' cherry trees (*Prunus avium* L.) were pruned at 31, 34, 37, 38, or 45 days after full bloom (DAFB) with heading cuts 20 cm from the base of current-season lateral shoot growth, or at 38 DAFB by heading current-season lateral shoot growth at 15, 20, 25, or 30 cm from the base of the shoot. The influence of heading cut position between nodes also was examined by cutting at a point ( $\approx 20$  cm from the shoot base) just above or below a node, or in the middle of an internode. Summer pruning influenced the number of both flower buds and lateral shoots subsequently formed on the shoots. All of the timings and pruning lengths significantly increased the number of both flower buds and lateral shoots, but differences between pruning times were not significant. There was significantly less regrowth when shoots were pruned just below a node or in the center of an internode, rather than just above a node, suggesting that the length of the remaining stub may inhibit regrowth somewhat. The coefficient of determination ( $r^2$ ) between flower bud number and regrowth ranged from  $-0.34$  to  $-0.45$ . In young high-density sweet cherry plantings, summer pruning may be useful for increasing flower bud formation on current-season shoots. The time of pruning, length of the shoots after pruning, and location of the pruning cut can influence subsequent flower bud formation and vegetative regrowth.

Management practices that favor floral development are important for orchard success. In traditional orchards, sweet cherry trees grow vigorously and often fail to produce significant quantities of fruit until their fifth or sixth year. One reason for this lack of early fruitfulness is that few or no flowers develop on 1-year-old wood. Flowers normally are borne on second-year shoots or on spurs from older wood (Webster and Shephard, 1984; Westwood, 1993). With innovations in orchard system design and vigor management, sweet cherry trees could start producing fruit in the third or fourth year (Jacyna, 1992; van den Ende et al., 1987). Increasing the proportion of fruit on 1-year-old shoots, relative to

spurs, is desirable because these fruit usually are of higher quality (Faust, 1989; Roper and Loesch, 1987). Young shoots usually are better exposed to light than are fruiting spurs on older wood and therefore provide more photoassimilates for fruit growth and higher total soluble solids (Ryugo, 1986). Single flower buds on young shoots also will have higher leaf : fruit ratios than the flower bud clusters common on spurs.

Pruning is used to manage vegetative growth in fruit trees (Faust, 1989; Ferree et al., 1992; Flore, 1992; Forshey and Elfving, 1989; Mika, 1986), but some studies show that summer pruning can also increase flowering on young shoots (Kesner et al., 1981; Miller, 1982; Webster and Shepherd, 1984). However, summer pruning can either reduce (Faust, 1989; Mika and Piatkowski, 1989; Rom and Ferree, 1984; Webster and Shepherd, 1984) or increase (Ferree et al., 1984) subsequent shoot growth, depending upon species, cultivar, timing, pruning severity, the type of pruning cut (Forshey and Elfving, 1989), and the treatments used for comparison (unpruned, dormant pruned, or dormant plus summer pruned) (Marini, 1997).

Timing of summer pruning is critical (Faust, 1989). The earlier that summer pruning is performed on apple (*Malus domestica* Borkh.), the greater the amount of regrowth

that occurs (Faust, 1989; Ferree et al., 1984; Forshey and Elfving, 1989; Miller, 1982; Myers and Ferree, 1983). Miller (1982) also reported that early pruning increased flowering more than did later pruning. There has been less research on summer pruning of stone fruits. Summer pruning of mature peach [*Prunus persica* (L.) Batsch.] trees in June resulted in more vigorous regrowth than pruning in July during one season, but not the subsequent one (Marini, 1985). Webster and Shepherd (1984) reported that more shoots developed on 'Merton Glory' sweet cherry trees on 'Colt' (*P. avium* L.  $\times$  *P. pseudocerasus* Lind.) rootstock when summer pruning was delayed. Tipping also increased the number of floral buds on 1-year-old shoots. Kesner et al. (1981) reported that hedging 'Montmorency' sour cherry (*P. cerasus* L.) trees 40 to 47 d after full bloom (DAFB) reduced shoot length, but increased the number of lateral shoots, leaf area, number of spurs and flower buds, and fruit set and size, thus increasing total yield. Kesner et al. (1977) found that summer hedging of sour cherry trees generally increased yield.

Our purpose was to examine the effects of timing and severity of summer pruning heading cuts on the precocious flowering and vegetative growth of young sweet cherry trees in a high-density orchard system.

## Materials and Methods

Four-year-old 'Bing' sweet cherry trees on Damil (GM 61-1, *P. dawcyckensis* Sealy) rootstock were used. Damil is a dwarfing rootstock, yet it has little effect on precocious flowering in sweet cherry (Druart, 1994). The trees (2716/ha) were planted in double rows and trained to an arched central leader. Each tree was trained as a single leader with no major scaffolds. The leaders of trees in each opposing double row were arched over and tied to each other for support. Lateral shoots arising from the leaders were trained as fruiting wood with the intention of pruning a proportion of them back every 2 to 3 years to renew fruiting sites. The plot was in an irrigated commercial orchard near Moxee, Wash., in the lower Yakima Valley. The orchardist used standard pest management practices and fertilized heavily to promote vigorous vegetative growth. All summer pruning treatments were applied in 1995 to current-season shoot growth of similar vigor and orientation.

*Experiment 1. Time of pruning.* Several timings of summer pruning heading cuts were compared with no pruning. Six treatments, with 20 replications of five shoots each (100 shoots per treatment), were applied to a double row of 200 trees in a completely randomized design (CRD). In all of the summer-pruned treatments, new lateral shoot growth was pruned back to the middle of the internode closest to 20 cm from the origin of the current growth (i.e., shoot base) at 31, 34, 37, 38, or 45 DAFB; control shoots were left unpruned. Accumulated growing degree days (GDD) were calculated, using a base temperature of 10 °C (Eisensmith et al., 1980), for each of the

Received for publication 25 Aug. 1997. Accepted for publication 9 Jan. 1998. This paper is a portion of a thesis submitted by C.M.G. in partial fulfillment of MS degree requirements at Washington State Univ. The authors thank Bob Harris, commercial orchardist, for his generous sharing of ideas and the use of his trees in this study. We also gratefully acknowledge the Washington Tree Fruit Research Commission and the Washington State Univ. College of Agriculture and Home Economics for their financial support of this research. 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.

timings. In Mar. 1996, the flower buds and vegetative laterals were counted on each shoot. The data were tested for normality and found to be skewed to the left (Ott, 1988). Therefore, mean scores were calculated by using rank scores of the data for analysis with SAS (SAS Institute, N.C.), using nonparametric tests of the median and Kruskal–Wallis tests for mean score separation at  $P = 0.05$  (Stokes et al., 1995).

**Experiment 2. Severity of pruning.** The effect of shoot length, after pruning, on subsequent floral initiation and vegetative growth was examined, using five treatments and 20 replications of five shoots per treatment (100 shoots per treatment) applied in a CRD to a 200 tree double row different from that in Expt. 1. The terminal portion of current-season lateral shoot growth was removed at 15, 20, 25, or 30 cm from the shoot base; control shoots were left unpruned. All of the treatments were pruned at 37 to 38 DAFB (25–26 May). In Mar. 1996, the flower buds and vegetative laterals were counted on each shoot. The data were tested for normality, found to be skewed to the left (Ott, 1988), and therefore analyzed as described in Expt. 1 (Stokes et al., 1995).

**Experiment 3. Location of pruning cut.** The effect of location of the heading cut along the internode, i.e., amount of internodal stub remaining after pruning, was examined by removing the terminal portion of current-season lateral shoot growth 20 cm from the shoot base at 37 to 38 DAFB, just below the bud (leaving a long internodal stub, Fig. 1B), just above the bud (Fig. 1A), or in the center of the internode (Fig. 1C); control shoots were left unpruned. Each treatment was applied to 20 replications of five shoots each (100 shoots per treatment) in a CRD using the same 200 trees as in Expt. 2. In Mar. 1996, the flower buds and vegetative laterals were counted on each shoot. The data were tested for normality, found to be skewed to the left (Ott, 1988), and therefore analyzed as described in Expt. 1 (Stokes et al., 1995).

## Results and Discussion

**Experiment 1. Time of pruning.** Summer pruning significantly increased flowering on current season shoots by  $\approx 0.6$  to 1.0 flower buds per shoot; however, the differences between timings were not significant (Table 1A). Although actual fruit set and yield was not measured in this experiment, such an increase would be estimated, based on tree and shoot densities, to increase yields by  $\approx 1 \text{ t}\cdot\text{ha}^{-1}$ . Webster and Shepherd (1984) also reported that summer pruning increased the number of floral buds on 1-year-old shoots of 'Merton Glory' sweet cherry trees. However, in the climate of the United Kingdom, sweet cherry flowers induced on current season shoots generally have short effective pollination periods (A.D. Webster, pers. comm.), which could reduce fruit set relative to that of flowers borne on older wood.

Treatments applied later (37 to 45 DAFB) were significantly more effective in stimulat-

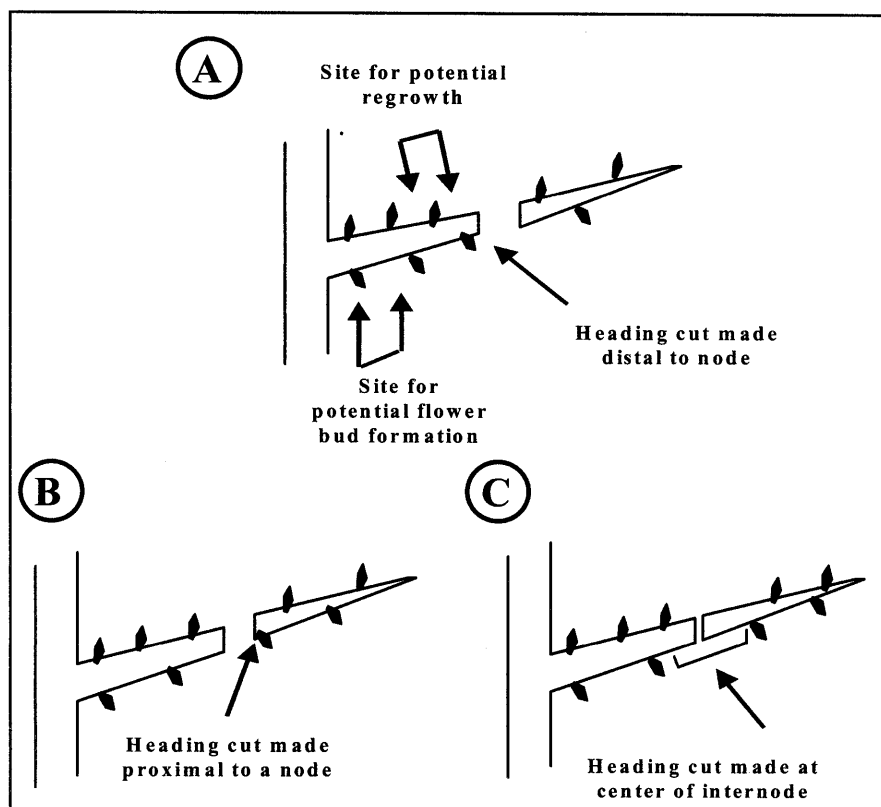


Fig. 1. Three types of pruning cuts made on current-season sweet cherry shoots: (A) distal to a node, (B) proximal to a node, and (C) in the center of an internode.

Table 1. The effects of summer pruning on flower bud initiation and vegetative regrowth in 'Bing' sweet cherry at Moxee, Wash. Effects of A) timing of heading cuts at 20 cm from current-season shoot base (Expt. 1), B) length of shoot after pruning at 37 to 38 d after full bloom (DAFB) (Expt. 2), and C) location of pruning cut made 37 to 38 DAFB and 20 cm from current season shoot base (Expt. 3).

Date	DAFB	GDD <sup>2</sup>	Flower buds		Vegetative laterals	
			no./shoot	CMS <sup>3</sup>	no./shoot	CMS
<i>Time of pruning (Expt. 1)</i>						
19 May	31	143	1.3	551 a <sup>4</sup>	0.2	490 b
22 May	34	170	1.1	511 a	0.3	521 b
25 May	37	201	1.2	537 a	0.4	588 a
26 May	38	209	1.3	558 a	0.4	556 a
2 June	45	319	1.5	570 a	0.5	609 a
Unpruned control			0.5	336 b	0.0	386 c
<i>Severity of pruning (Expt. 2)</i>						
Shoot length (cm) after pruning						
			1.7	263 a	0.4	220 a
			1.6	252 a	0.4	236 a
			1.4	229 a	0.5	254 a
			1.4	223 a	0.5	258 a
			0.7	158 b	0.1	158 b
<i>Location of pruning cut (Expt. 3)</i>						
			1.5	180 a	0.4	194 a
			1.6	188 a	0.5	198 a
			1.8	204 a	0.3	169 b
			0.7	120 b	0.1	135 c

<sup>2</sup>GDD, growing degree day accumulations calculated using a 10 °C base temperature.

<sup>3</sup>CMS, calculated mean scores for statistical analysis, using rank scores of the data.

<sup>4</sup>Mean separation within columns for experiments by Kruskal–Wallis tests at 5%.

ing vegetative laterals than those applied earlier (31 and 34 DAFB) (Table 1A). Unpruned shoots had significantly fewer vegetative laterals, presumably due to apical dominance and uninterrupted inhibition of lateral bud break. Webster and Shepherd (1984) reported similar results in 'Merton Glory' sweet cherry.

Timing of summer pruning based on calen-

dar dates following bloom may not yield consistent results from year to year, since climate is dynamic and highly variable. The potential use of GDD values to characterize changes in physiological development and reproductive responsiveness to timing of pruning may provide a more precise measure. However, since spring 1995 was relatively cool, the GDD

values in Table 1 may not be representative of typical differences between the calendar dates used in this experiment. Repeating these pruning treatments for several years, using both calendar dates and regular GDD intervals, might reveal more precise timings for maximum effects on floral initiation, as well as on actual yields.

*Experiment 2. Severity of pruning.* All pruning treatments significantly increased the number of flower buds per shoot (Table 1B), regardless of the length of shoot left after pruning. Differences between pruning treatments were not significant, suggesting that simply removing the hormonal influence (and resource sink) of the apical meristem plays a larger role in shifting basal meristem determination toward floral initiation than does the shoot length or number of nodes that remain after pruning.

*Experiment 3. Location of pruning cut.* Regardless of the location of the cut, summer pruning increased the number of flower buds (Table 1C). The location of the pruning cut had no significant effect on the number of flower buds produced, but significantly affected regrowth later in the season. Regrowth was greater on shoots pruned above a node or at the center of an internode than on shoots pruned below a node. The stub of internodal tissue that remained following pruning below a node appeared to maintain paradormancy of the subtending lateral buds, although it was not as effective as the intact apical portion of the shoot. This inhibition of growth by the shoot axis itself has been noted similarly in other tree fruits and excised shoot explants (Crabbé and Barnola, 1996; Meng-Horn et al., 1975).

One could hypothesize that the slow senescence of a summer-pruned stub produces ethylene, or other senescence-associated metabolites, that may inhibit subtending vegetative meristem activity or promote basal floral induction. Application of ethephon (2-chloroethyl-phosphonic acid) has increased the number of flower buds formed on young, nonbearing sweet cherry trees up to 6-fold (C.M. Guimond and G.A. Lang, unpublished data). Klein and Faust (1978) measured the levels of ethylene produced from 1- and 2-year-old apple wood, spur buds, and pruned shoots after Lorette pruning. The ethylene produced by the shoot 50 h after pruning was twice that of the unpruned wood.

In all of the pruning treatments, flower bud formation was correlated inversely with the number of vegetative laterals that subsequently

grew. The coefficient of determination ( $r^2$ ) was  $-0.34$  in Expt. 1 ( $P < 0.05$ ) and  $-0.45$  in Expt. 2 ( $P < 0.05$ ). This is consistent with observations in apple that treatments that stimulate vigorous growth, such as severe pruning, generally reduce flowering and fruiting (Forshey and Elfving, 1989).

Ideally, sweet cherry growers would like to increase the number of high-quality flowers on 1- and 2-year-old wood without stimulating new vegetative growth that could shade excessively later in the season or compete with differentiating floral meristems for resources. Based upon our preliminary study, young sweet cherry trees can be pruned about 45 DAFB by heading the shoots to 15 to 20 cm to maximize the benefits of summer pruning on initiating new flowers while reducing overall vegetative vigor. However, further research is required to determine optimum timing and document fully the magnitude of increases in fruit set and yield that might be expected.

#### Literature Cited

- Crabbé, J. and P. Barnola. 1996. A new conceptual approach to bud dormancy in woody plants, p. 83–113. In: G.A. Lang (ed.). *Plant dormancy: Physiology, biochemistry, and molecular biology*. CAB Intl., Oxon.
- Druart, P. 1994. Intensive cherry orchards on the dwarfing 'G.M.' rootstocks: training methods and fruiting performances. *Acta Hort.* 355:183–187.
- Eisensmith, S.P., A.L. Jones, and J.A. Flore. 1980. Predicting leaf emergence of 'Montmorency' sour cherry from degree-day accumulations. *J. Amer. Soc. Hort. Sci.* 105:75–78.
- Faust, M. 1989. *Physiology of temperate zone fruit trees*. Wiley, New York.
- Ferree, D.C., S.C. Myers, C.R. Rom, and B.H. Taylor. 1984. Physiological aspects of summer pruning. *Acta Hort.* 146:243–252.
- Ferree, D.C., S.C. Myers, and J.R. Schupp. 1992. Root pruning and root restriction of fruit trees—Current review. *Acta Hort.* 322:153–166.
- Flore, J.A. 1992. The influence of summer pruning on the physiology and morphology of stone fruit trees. *Acta Hort.* 322:257–263.
- Forshey, C.G. and D.C. Elfving. 1989. The relationship between vegetative growth and fruiting in apple trees. *Hort. Rev.* 11:229–287.
- Jacyna, T. 1992. A concept of high-density planting for sweet cherries. *Acta Hort.* 322:325–334.
- Kesner, C.D., C.M. Hansen, and S.B. Fouch. 1977. Mechanical summer tipping as a method of controlling sour cherry trees: A preliminary report. *Fruit Var. J.* 32:26–28.
- Kesner, C.D., C.M. Hansen, and S.B. Fouch. 1981. Tree training and mechanical pruning of tart cherry in high density plantings. *Compact Fruit Tree* 14:135–139.
- Klein, J. and M. Faust. 1978. Internal ethylene content in buds and woody tissues of apple trees. *HortScience* 13:164–166.
- Marini, R.P. 1985. Vegetative growth, yield, and fruit quality of peach as influenced by dormant pruning, summer pruning, and summer topping. *J. Amer. Soc. Hort. Sci.* 110:133–139.
- Marini, R.P. 1997. Peach tree canopy management to improve yield and fruit quality. *Compact Fruit Tree* 30:81–82.
- Meng-Horn, C., P. Champagnat, P. Barnola, and S. Lavarenne. 1975. L'axe caulinaire, facteur de préséances entre bourgeons sur le rameau de l'année de *Rhamnus frangula* L. *Physiologie Végétale* 13:335–348.
- Mika, A. 1986. Physiological responses of fruit trees to pruning. *Hort. Rev.* 8:337–378.
- Mika, A. and M. Piatkowski. 1989. Controlling tree size in dense plantings by winter and summer pruning. *Acta Hort.* 243:95–102.
- Miller, S. 1982. Regrowth, flowering, and fruit quality of 'Delicious' apple trees as influenced by summer pruning. *J. Amer. Soc. Hort. Sci.* 107:975–978.
- Myers, S.C. and D.C. Ferree. 1983. Influence of time of summer pruning and limb orientation on growth and flowering of vigorous 'Delicious' apple trees. *J. Amer. Soc. Hort. Sci.* 108:634–638.
- Ott, L. 1988. *An introduction to statistical methods and data analysis*. 4th ed. Wadsworth: Belmont, Calif.
- Rom, C.R. and D.C. Ferree. 1984. The influence of summer pruning current-season shoots on growth, floral bud development, and winter injury of mature peach trees. *HortScience* 19:543–545.
- Roper, T.R. and W.H. Loescher. 1987. Relationships between leaf area per fruit and fruit quality in 'Bing' sweet cherry. *HortScience* 22:1273–1276.
- Ryugo, K. 1986. Promotion and inhibition of flower initiation and fruit set by plant manipulation and hormones, a review. *Acta Hort.* 179:301–307.
- Stokes, M., D. Charles, and G. Koch. 1995. Categorical data analysis using the SAS system. SAS Institute, Cary, N.C.
- van den Ende, B., D.J. Chalmers, and P.H. Jerie. 1987. Latest developments in training and management of fruit crops on Tatura Trellis. *HortScience* 22:561–568.
- 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 cherries. *J. Hort. Sci.* 59:175–182.
- Westwood, M.N. 1993. *Temperate-zone pomology: Physiology and culture*, 3rd ed. Timber Press, Portland, Ore.