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Growth, Fruiting, Flowering, and Fruit Quality of Sweet Cherries Treated with Paclobutrazol

T.J. Facteau and N.E. Chestnut
Mid-Columbia Agricultural Research and Extension Center, Oregon State University, Hood River, OR 97031

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Abstract. **Five-year-old 'Napoleon' sweet cherry *(Prunus avium* L.) trees were treated with single-application basal drenches of paclobutrazol (PBZ) in an attempt to regulate growth and flowering. Increasing concentrations of PBZ at 0.05 to 0.30 g·cm^{-1} trunk diameter reduced terminal extension the year of treatment and for at least the following 3 years. Fruit count increased on wood grown before treatment but decreased as annual growth declined following treatment. Fruit/cm growth generally increased, whereas fruit per flower bud decreased as PBZ concentration increased. No differences were found in fruit size, soluble solids concentration (SSC; 13% to 14%), or firmness of cherries harvested at brine maturity. Chemical name used: ß-[(4-chlorophenyl) methyll-α- (l,l-dimethylethyl) -l-H-l,2,4-triazo1e-l-ethanol (paclobutrazol, PBZ).**

The search for tree size control techniques for sweet cherry is being driven by the desire to improve harvest efficiency and to reach commercial production levels earlier in the life of the orchard. No dwarfing rootstock for sweet cherries that are known to produce large fruit size, probably the most important quality trait in fresh fruit production in the Pacific Northwest, are commercially available in North America. However, the need to maintain a large leaf surface and/or a large leaf : fruit ratio is critical in growing good quality fruit (Facteau and Chestnut, 1973; Roper et al., 1987). Treatment with paclobutrazol (PBZ; Cultar, Imperial Chemicals, Surry, U. K.) has been shown to reduce terminal growth while enhancing fruit size (Looney and McKellar, 1987; Webster et al., 1986). Restricted growth implies, however, that most cropping after treatment will be borne on mature spurs (Looney and McKellar, 1987) where fruit quality, either because of shading or because of spur age, is reduced (Patten and Patterson, 1986; Patten and Proebsting, 1986).

The experiments reported herein involved basal drench applications of PBZ to sweet cherry trees not yet in full commercial cropping to investigate flowering and fruiting response to increasing concentrations of PBZ.

Paclobutrazol was applied in aqueous suspension (5 g a.i./fiter) to the base of vigorous, 5-year-old 'Napoleon' sweet cherry trees (on Mazzard rootstock) on 11 Jan. 1984 (plot 1) and to a second set of trees on 1 Apr. 1985 (plot 2). There were four application treatments in plot 1 and five treatments in plot 2 with nontreated controls in each plot.

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Table 1. Terminal growth in years subsequent to PBZ application (11 Jan. 1984, plot 1; 1 Apr. 1985, plot 2) to nonbearing 'Napoleon' sweet cherry trees. Values are means for four limbs per tree, one from each of four quadrants on each treated tree.

PBZ concn (g·cm⁻¹ trunk diam)	Plot 1					Plot 2			
	Year of growth								
	1983	1984[z]	1985	1986	1987	1984	1985	1986	1987
	Growth (cm)								
0	59.0	57.2	39.4	44.5	33.7	61.7	42.9	37.8	31.0
0.05						65.0	42.3	20.9	21.2
0.10	62.1	38.8	21.2	19.7	18.0	63.9	36.7	8.5	12.2
0.20	62.2	36.4	10.9	11.0	8.0	63.4	35.8	4.8	3.9
0.30	62.2	32.5	9.6	14.8	4.0	59.7	36.8	.5.6	3.5
Significance									
Linear	NS	NS	***	***	**	NS	**	***	***
Quadratic	NS	NS	*	***	*	NS	**	***	***

[z]Comparison of no PBZ vs. PBZ, $P \leq 0.01$.

NS,*,**,***Nonsignificant or significant differences at $P \leq 0.05$, 0.01, and 0.001, respectively.

Table 2. Terminal growth for vertical and horizontial position 'Napoleon' sweet cherry limbs for PBZ applied 11 Jan. 1984 (plot 1 only) to 5-year-old 'Napoleon' sweet cherry trees. Values are means for four limbs per tree, one from each of four quadrants on each treated tree.

PBZ concn (g·cm⁻¹ trunk diameter)	Year of growth									
	1983		1984		1985		1986		1987	
	Orientation									
	Vert.	Horz.	Vert.	Horz.	Vert.	Horz.	Vert.	Horz.	Vert.	Horz.
	Growth (cm)									
0	74.0	54.5	76.0	53.2	53.9	38.0	57.1	41.8	52.7	31.4
0.10	70.9	62.4	58.4	40.9	53.7	28.7	45.2	24.5	37.3	21.9
0.20	70.9	58.8	54.1	37.5	34.8	13.6	36.7	15.7	35.1	8.2
0.30	69.2	59.7	39.2	31.1	32.1	10.1	32.6	16.9	28.2	5.4
Significance										
Linear	NS		**		**		**		**	
Quadratic	NS		**		**		**		**	

[z]South and west quadrant limbs only. No interaction present between positions.

NS,*,**,***Nonsignificant or significant differences at $P \leq 0.05$, 0.01, and 0.001, respectively.

There were five single-tree replicates in plot 1 and six in plot 2, both in randomized block designs. We used O, 0.05, 0.10, 0.20, and 0.30 g PBZ/cm of trunk diameter 30 cm above the soil surface. Treatments included two formulations of PBZ (wettable powder, wp; liquid, lq) at the 0.20 g·cm⁻¹ rate; these were used as individual treatments in the experimental design. Mean trunk diameter and standard error was 14.9 ± 0.18 cm. The soil was a Chenowith very fine sandy loam with a cation exchange capacity of 9.6 meq/100 g soil and 0.65% organic matter. Four limbs per tree were selected, one each from the south, east, west, and north quadrants of each tree, during anthesis, 1984. Shoot growth, number of flower buds, spurs, flowering spurs, and fruit were measured for growth years 1986-1988. Each year, measurements were made on separate ages of wood, starting on 1983 wood in plot 1 and 1984 wood in plot 2. Limbs were 1.5 to 2.5 m above the ground and, initially, at a 45° angle. In 1988, upright, more nearly vertical limbs were measured in a similar manner from the south and west quadrants on each tree. The same limbs were counted each year except when lost because of pruning or mechanical injury. At commercial brine harvest, 100 fruit per tree were sampled from the south quadrant and measured for SSC, weight, and firmness (slope of force deformation curve, Instron Universal Testing Machine Model 1000, 5-kg weigh beam, range 20 kg, magnification 5, crosshead speed 20 mm·min⁻¹, 11 mm-flat probe; Instron, Canton, Mass.).

There were no interactions present for anv data between horizontal or vertical limbs and PBZ teatment (1988) or direction and treatment (all years), so only main effects of PBZ treatment are presented. There were no differences between the 0.20 g·cm⁻¹ wp and lq formulations, so these treatments were combined in the analysis. No significant differences in any characteristic were found between plots 1 and 2 and, except for terminal growth, only data for plot 1 are shown.

Soil-applied PBZ significantly reduced terminal growth the year of treatment and for the following 3 years (Tables 1 and 2). Response was greater after the 2nd growth year (Table 1) and there were linear and nonlinear components in both plots. A comparison of more nearly vertical vs. more nearly horizontal limbs (original limbs) in 1988 showed a similar pattern and no interactions between position and treatment (Table 2). Vertical limbs were not reduced in terminal growth to the same extent as the more nearly horizontal limbs, implying that treated trees gain height more quickly than width. Results were consistent with previously reported responses (Looney and McKellar, 1987; Webster et al., 1986), except trees did not recover after 2 years nor were repeated applications necessary to restrict growth. Differences in treatment application, amounts of PBZ, and soil type probably accounted for differential effects from published reports.

Flower buds/cm shoot growth were increased by PBZ in 1986 and 1987 on all-year wood. However, no differences were found in 1988 (Fig. 1). These results suggest that flowering on a unit basis was increased by PBZ but that the effect was lost by 1988. Fruit count per flower bud, a measure of fruit set, was reduced by PBZ on most growth increments in 1987 and 1988 (Fig. 2). On wood present before treatment (1983), PBZ increased fruit count on the measured branch units in 2 out of the 3 years data were collected (1986 and 1988) (Fig. 3). Where terminal growth was restricted to a large extent (1985 and 1986 year-wood), PBZ treatment reduced fruit count. Fruit count/cm of shoot length was not altered on any wood in any year (data not shown). The interrelationships between growth, flowering, and fruit set indicate that fruiting per unit of growth was not changed. Since fruit count/cm of shoot was unaffected and growth and fruit count declined with PBZ treatment, yields per tree should decline as time passes. This, of course, would depend on whether the trees had filled their allotted spaces, subsequent pruning, tree spacing, and many other factors. In addition, during harvest, some spurs are inadvertently removed. Unless these spurs are replaced by new growth, cropping will decline. Reduced growth in the PBZ trees may make this replacement more difficult. We did not measure yields, but these data strongly suggest reduced yields occurred, since the growth years measured (1983-1986) cover the fruiting portion of the trees. No significant amount of fruit was borne on wood that grew before 1983 in any treatment. Wood that grew before 1983 constituted the structural part of

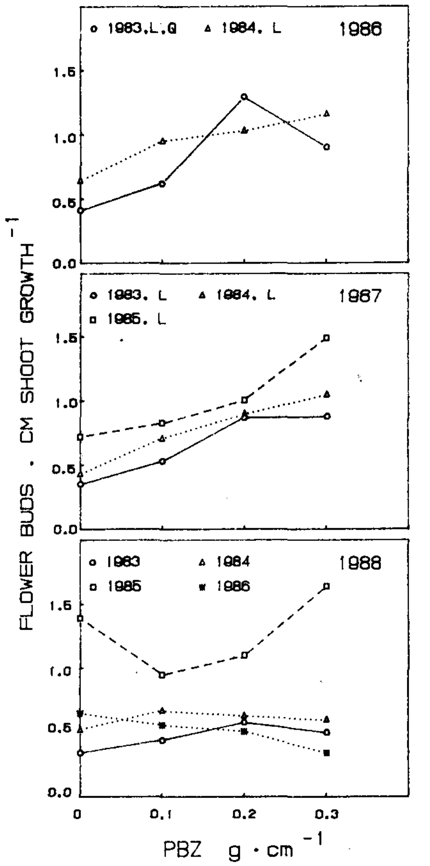
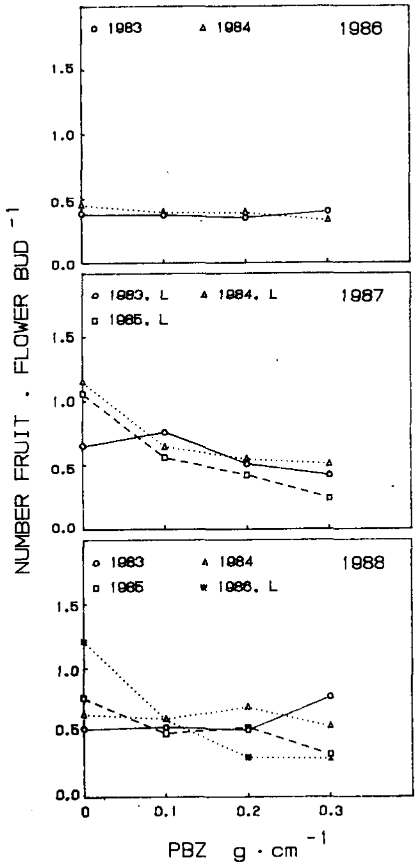


Fig. 1. Number of flower buds/cm of shoot growth for data years 1986-1988 from 5-year-old 'Napoleon' sweet cherry trees treated with basal drenches of PBZ on 11 Jan. 1984. Lines within each year are years in which that wood grew. The L and Q indicate statistical significance for linear and nonlinear models at $P \leq 0.05$.



2. Number of fruit per flower bud for data years 1986-1988 from 5-vear-old 'Napoleon' sweet cherry trees treated 'with basal drenches of PBZ on 11 Jan. 1984. Lines within each year are years in which that wood grew. The L and Q indicate statistical significance for linear and nonlinear models at $P \leq 0.05$.

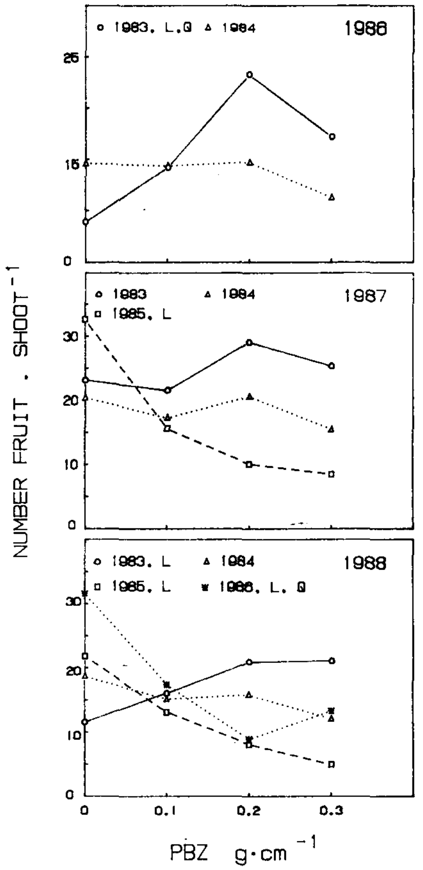


Fig. 3. Number of fruit per shoot for data years 1986-1988 from 5-year-old 'Napoleon' sweet cherry trees treated with basal drenches of PBZ on 11 Jan. 1984. Lines within each year are years in which that wood grew. The L and Q indicate statistical significance for linear and nonlinear models at $P \leq 0.05$.

those trees, The differential effects of PBZ on flowering and fruit set could be explained by the relationships of endogenous gibberellins to these physiological processes. Flowering is often inhibited by GAs, whereas fruit set can be enhanced (Westwood, 1978). PBZ has been shown to inhibit gibberellin biosynthesis (Hedden and Graebe, 1982).

Fruit count/cm of shoot length was reduced on older-year wood. Mean fruit/cm produced for nontreated trees for 1986, 1985, 1984, and 1983 year-wood in 1988 were 0.72, 1.01, 0.36, and 0.22, respectively. Thus, cropping ability declined. In addition, older wood generally produces fruit with lower SSC and color (Patten and Patterson, 1986), quality attributes especially important in fresh-market sweet cherries. The long-term effect of PBZ, as noted by Looney and McKellar (1987), will be that most fruit will be borne on spurs on older wood. Unless better light conditions caused by less growth alter normal patterns, fruit quality and production may decline on PBZ-treated trees, Shaded sweet cherry limbs have been shown to have reduced fruit set and fruit had lower levels of SSC and less color as compared with fruit from unshaded limbs (Patten and Proebsting, 1986).

No differences in fruit weight, SSC, or firmness were found in samples taken in 1985-1988 from either plot (data not shown). PBZ treatment has been shown to cause an increase in fruit size (Looney and McKellar, 1987; Webster et al., 1986). In this study, fruit were harvested at brine maturity and were less mature than fruit usually harvested for fresh market. Fruit size, along with firmness and SSC, might have been altered if harvest had been at a later maturity.

Results presented here show that reduction in terminal growth can be achieved using PBZ. The range of rates tested resulted in a 30% to 90% reduction in terminal growth of nearly horizontal and vertical limbs without altering quality characteristics at brine maturity. The higher concentrations tested caused almost a total suppression of annual extension with more effect on nonupright branches at all concentrations. While fruiting on a unit of length was not altered by PBZ, long-term yields may decline because of increased spur age and/or through loss of fruiting spurs.

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