Harvest Date and Size Distribution of Peach Fruit Are Altered with Fall-applied Ethephon

Edward F. Durner, Thomas J. Gianfagna, Francis X. Rooney, Gale S. Teiger, Martin J. Seiler, and Mark J. Cantarella

Rutgers Fruit Research Center, New Jersey Agricultural Experiment Station, Cook College, Rutgers University, RD 2 Box 38, Cream Ridge, NJ 08514

Additional index words. *Prunus persica*, bloom delay, bud hardiness, plant growth regulators

Abstract. Ethephon was applied at 100 mg-liter⁻¹ to peach [*Prunus persica* (L.) Batsch., cvs. Jerseydawn and Cresthaven] trees in Oct. 1987 and 1988 to increase flower bud hardiness and delay bloom the following spring. Flower bud survival after exposure to -26C in Jan. 1988 was enhanced with fall ethephon application in both cultivars. Ethephon delayed bloom by 7 (1988) and 3 (1989) days in 'Jerseydawn' and by 10 (1988) and 4 (1989) days in 'Cresthaven'. Total fruit production per tree for 'Jerseydawn' was not affected by ethephon treatment in 1988; however, yield was enhanced with ethephon treatment in 1989. For 'Cresthaven', yield was enhanced by ethephon treatment in both years. Most fruit from the untreated trees were harvested on the first harvest dates and were in the largest size categories, while most fruit from the treated trees were harvested on the last harvest dates and were in the smaller size categories both years in both cultivars. Smaller pistils and heavier prethinning crop loads lead to smaller fruit and a later harvest date. Chemical names used: 2-chloroethylphosphonic acid (ethephon).

Fall-applied ethephon consistently delays bloom in peach (Coston et al., 1985; Dennis, 1976; Durner, 1989; Durner and Gianfagna, 1988; Gianfagna et al., 1986), thereby reducing spring frost injury to open flowers. The delay in bloom can be partially attributed to an inhibition in flower bud growth immediately after application. Pistils from ethephon-treated trees are shorter and have a lower fresh weight during dormancy and through bloom (Durner, 1989; Herrera, 1987). Gianfagna et al. (1986) reported a trend toward slightly later harvest for fall ethephon-treated 'Cresthaven' trees, although ethephon treatment did not affect fruit size. We have, however, often observed that harvest is delayed by several days in trees treated the previous fall with ethephon for bloom delay, and that ethephon-treated fruit tend to be smaller compared with controls. If the market demand for a particular cultivar is saturated, delayed harvest could be beneficial, allowing a grower to market that same cultivar after the excess has passed. However, any benefit from using ethephon for bloom or harvest delay could be offset if fruit size is significantly and unacceptably reduced at harvest. This research was initiated to investigate and quantify the harvest date and fruit size distribution of two peach cultivars treated the previous fall with ethephon

for bloom delay.

Ethephon (100 mg-liter⁻¹) was applied to runoff on 4-year-old 'Jerseydawn' peach trees on Lovell rootstock and 9-year-old 'Cresthaven' peach on 15 Oct. 1987. Ethephon was applied to different trees in the same orchards on 21 Oct. 1988 for 'Jerseydawn' and 20 Oct. 1988 for 'Cresthaven'. Regulaid (0.1% by volume) was added to assist spreading and was also used as a control in both years. Both cultivars in both years were

≈ 50% to 75% defoliated at the time of application. There were 13 (1987) and six (1988) single tree replicates of each treatment for 'Jerseydawn', and six (1987) and five (1988) single tree replicates of each treatment for 'Cresthaven'. Each cultivar in each year was a separate experiment in a randomized complete block. Trees were blocked within experiment by orchard location at Rutgers Fruit Research Center, Cream Ridge, N.J.

Trees were dormant-pruned in March and fruit were hand-thinned to 15 to 20 cm apart in early June both years. Firm, well-colored 'Jerseydawn' fruit were hand-harvested on 18, 20, 22, 25, and 27 July 1988 and 14, 18, 21, and 25 July 1989. Fruit were graded into three sizes: 6.4 to 6.9, 7.0 to 7.5, and 7.6 to 8.3 cm in diameter. There were no fruit with diameters >8.3 cm, and all fruit <6.4 cm in diameter were discarded. 'Cresthaven' fruit were hand-harvested on 23 and 30 Aug., 2, 6, and 9 Sept. 1988, and 21, 25, and 29 Aug. 1989 and graded into six sizes: 6.4 to 6.9, 7.0 to 7.5, 7.6 to 8.2, 8.3 to 8.8, 8.9 to 9.5, and >9.5 cm diameter. Fruit <6.4 cm were discarded.

Weights and numbers of marketable fruit and percent of the total harvest on a per-tree basis were analyzed with an analysis of variance using a split-split block model (Steel and Torrie, 1980). Ethephon treatment was the main plot, harvest dates were the sub-blocks, and fruit sizes were the sub-sub-blocks. This analysis is a modification of the split-plot model that computes a greater number of error terms for hypothesis testing to compensate for the fact that harvest date and fruit size cannot be randomly assigned.

Flower bud survival before bud expansion was enhanced with fall ethephon application in 1987-88 in both cultivars. There was a 3-fold increase in survival of ethephon-treated buds compared to controls after exposure to -26C on 11 Jan. 1988: 0.19 (ethephon) and

Table 1. Mean yield per tree, percentage of total fruit harvested, and fruit number per tree on various dates for 'Jerseydawn' peach trees treated in the fall with ethephon for bloom delay.

Harvest date (July)		1988		1989	
1988	1989	Ethephon	Control	Ethephon	Control
<i>Mean yield per tree (kg)</i>					
18	14	0.4 b*	5.3 a	0.1 b	4.4 a
20	18	4.5 b	12.9 a	6.5 b	12.3 a
22	21	3.1 a	3.1 a	14.0 a	6.4 b
25	25	15.1 a	10.3 b	9.5 a	0.0 b
27	---	9.7 a	0.8 b	---	---
Total		32.9 a	32.5 a	30.1 a	23.1 b
<i>Percentage total crop harvested on dates indicated</i>					
18	14	1.3 b	16.5 a	0.6 b	21.9 a
20	18	13.8 b	39.8 a	22.6 b	51.9 a
22	21	9.4 a	9.5 a	47.8 a	26.2 b
25	25	45.8 a	31.7 b	29.0 a	0.0 b
27	---	29.7 a	2.6 b	---	---
<i>No. fruit per tree harvested on dates indicated</i>					
18	14	3 b	38 a	1 b	28 a
20	18	33 b	97 a	44 b	82 a
22	21	23 a	23 a	103 a	48 b
25	25	129 a	81 b	76 a	0 b
27	---	90 a	7 b	---	---
Total		278 a	246 a	155 a	158 a

*Mean separation of treatment effect within harvest date, year, and totals by LSD, alpha = 0.05. Data are means of 13 (1988) or five (1989) samples.

†Only four harvests in 1989.

Received for publication 27 July 1989. New Jersey Agricultural Experiment Station, Publication no. D-12111-11-89, supported by state funds. 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.

Table 2. Mean yield per tree, percentage of total fruit harvested, and fruit number per tree on various dates for 'Cresthaven' peach trees treated in the fall with ethephon for bloom delay.

Harvest date		1988		1989	
1988	1989	Ethephon	Control	Ethephon	Control
<i>Mean yield per tree (kg)</i>					
23 Aug.	21 Aug.	0.0 b ^z	5.1 a	7.5 a	19.5 a
30 Aug.	25 Aug.	0.2 b	8.8 a	47.3 a	56.6 a
2 Sept.	29 Aug.	7.6 b	12.8 a	49.6 a	11.5 b
6 Sept.	---	36.8 a	12.7 b	---	---
9 Sept.	---	56.9 a	2.4 b	---	---
12 Sept.	---	9.4 a	0.1 b	---	---
Total		110.9 a	41.8 b	104.3 a	87.5 b
<i>Percentage total crop harvested on dates indicated</i>					
23 Aug.	21 Aug.	0.0 b	12.3 a	7.1 b	22.3 a
30 Aug.	25 Aug.	0.0 b	21.0 a	45.3 b	64.7 a
2 Sept.	29 Aug.	6.9 b	30.5 a	47.6 a	13.1 b
6 Sept.	---	33.2 a	30.3 a	---	---
9 Sept.	---	51.3 a	5.8 b	---	---
12 Sept.	---	8.5 a	0.2 b	---	---
<i>No. fruit per tree harvested on dates indicated</i>					
23 Aug.	21 Aug.	0 b	26 a	41 b	113 a
30 Aug.	25 Aug.	0 b	35 a	231 a	254 a
2 Sept.	29 Aug.	45 a	48 a	96 a	23 b
6 Sept.	---	225 a	51 b	---	---
9 Sept.	---	388 a	12 b	---	---
12 Sept.	---	72 a	0 b	---	---
Total		730 a	172 b	368 a	390 a

^zMean separation of treatment effect within harvest date, year, and totals by LSD, alpha = 0.05. Data are means of six (1988) or five (1989) samples.

^yOnly three harvests in 1989.

Table 3. Mean yield per tree, percentage of total fruit harvested, and fruit number per tree in various size categories for 'Jerseydawn' peach trees treated in the fall with ethephon for bloom delay.

Size category (cm)	1988		1989	
	Ethephon	Control	Ethephon	Control
<i>Mean yield per tree (kg)</i>				
6.4-6.9	12.6 a ^z	7.0 b	4.9 a	2.3 b
7.0-7.5	18.6 b	21.3 a	19.0 a	14.1 b
7.6-8.3	1.7 b	4.1 a	6.2 a	6.6 a
<i>Percentage of fruit in a given size category</i>				
6.4-6.9	38.2 a	21.7 b	15.7 a	8.6 b
7.0-7.5	56.5 a	65.6 a	62.6 a	57.2 a
7.6-8.3	5.3 b	12.6 a	21.1 b	34.3 a
<i>No. fruit in a given size category</i>				
6.4-6.9	124 a	64 b	46 a	21 b
7.0-7.5	143 b	158 a	141 a	100 b
7.6-8.3	11 b	24 a	37 a	38 a

^zMean separation of treatment main effect within size category and year by LSD, alpha = 0.05. Data are means of 13 (1988) or five (1989) samples.

0.06 (control) live flower buds per centimeter of shoot on 'Cresthaven' trees and 0.48 (ethephon) and 0.13 (control) live flower buds per centimeter of shoot on 'Jerseydawn' trees. Ethephon had no effect on live flower buds for either cultivar in 1988-89. 'Cresthaven' had an average 0.45 live buds per centimeter of shoot and 'Jerseydawn' had an average 0.63.

Ethephon delayed flower bud development in both cultivars in both years (Fig. 1). For 'Jerseydawn' there was a 7-day delay in bloom (50% open flowers) in 1988 and a 2- to 3-day delay in 1989. In 'Cresthaven', bloom was delayed by 10 days in 1988 and 4 days in 1989. The decreased bloom delay in 1989 can be attributed to greater growing degree hour accumulation during bloom compared with 1988 (Fig. 1).

In 1988, minimum daily temperatures

during the period of bud expansion remained above 0C, so there was no loss of flower buds due to frosts or freezes in the spring. However, as a result of midwinter low-temperature injury, significantly more thinning was required for 'Jerseydawn' treated with ethephon than for the control. On average, 5.7 kg of fruit was removed from ethephon-treated 'Jerseydawn' trees, while 3.8 kg was removed from control trees. Three freezes during bloom 1989 [20 Apr. (-1.7C), 23 Apr. (-3.9C), and 24 Apr. (-4.4C)] occurred. More fruits were removed at thinning from treated trees than from the controls (86 and 61 fruit per tree for treated and control trees, respectively). Average fruit size at thinning was greater for control fruit (41 g) than for treated fruit (29 g), but the total weight of fruit removed at thinning was not affected by treatment (2.5 kg/tree). Since bud

Fig. 1. Flower bud development, expressed as percent bloom, for 'Jerseydawn' and 'Cresthaven' peach following fall ethephon application (top and middle) and growing degree hours (GDH) for the two test years (bottom). Open circles are controls, filled circles are ethephon-treated. All comparisons of ethephon vs. control within year, date, and cultivar are significantly different at $P = 0.05$.

survival before bloom was not affected by treatment in 1988-89, the enhanced fruit set on treated trees was likely due to an intrinsic enhancement of hardiness in the ethephon-treated flowers (Durner and Gianfagna, 1988) that allowed more flowers to survive the freezes during bloom. Ethephon-treated 'Cresthaven' trees required thinning, while control trees did not, due to poor flower bud survival in 1988. Both treated and control trees required similar thinning in 1989. Thinned fruit were not counted or weighed for 'Cresthaven' in either year.

Total fruit production per year for 'Jerseydawn' was not affected by ethephon treatment in 1988 (Table 1). A flower bud survival rate of 0.13 live buds per centimeter of shoot on control trees was adequate for a full crop (Spring 1988 data). Yield was enhanced with ethephon treatment in 1989 due to the loss of flowers on control trees to freezes during bloom. When no winter injury occurs and bloom delay is minimal, ethephon provides protection from late frosts due to its enhancement of the intrinsic hardiness of open flowers (Durner and Gianfagna, 1988). For the 'Cresthaven' trees, 1988 yield was enhanced by ethephon treatment due to greater flower bud survival during the winter (Table 2). In this cultivar, a flower bud density of

Table 4. Mean yield per tree, percentage of total fruit harvested, and fruit number per tree in various size categories for 'Cresthaven' peach trees treated in the fall with ethephon for bloom delay.

Size category (cm)	1988		1989	
	Ethephon	Control	Ethephon	Control
<i>Mean yield per tree (kg)</i>				
6.4-6.9	11.8 a ²	0.1 b	10.4 a	2.4 b
7.0-7.5	53.8 a	1.8 b	42.6 a	28.2 b
7.6-8.2	35.1 a	8.6 b	35.1 a	36.7 a
8.3-8.8	7.4 b	10.6 a	12.8 a	13.9 a
8.9-9.5	1.7 b	6.8 a	3.0 a	5.3 a
>9.5	1.0 b	13.9 a	0.4 a	1.1 a
<i>Percentage of fruit in a given size category</i>				
6.4-6.9	10.7 a	0.4 b	10.0 a	2.7 b
7.0-7.5	48.5 a	4.2 b	40.8 a	32.2 b
7.6-8.2	31.7 a	20.5 b	33.7 b	41.9 a
8.3-8.8	6.6 b	25.4 a	12.3 b	15.9 a
8.9-9.5	1.6 b	16.3 a	2.9 a	6.1 a
>9.5	0.9 b	33.3 a	0.0 a	1.3 a
<i>No. fruit in a given size category</i>				
6.4-6.9	109 a	1 b	71 a	16 b
7.0-7.5	385 a	12 b	153 a	140 a
7.6-8.2	193 a	43 b	95 b	170 a
8.3-8.8	32 a	45 a	37 a	43 a
8.9-9.5	7 b	26 a	9 a	17 a
<9.5	4 b	45 a	2 a	3 a

²Mean separation of treatment main effect within size category and year by LSD, alpha = 0.05. Data are means of 13 (1988) or five (1989) samples.

0.06 buds per centimeter of shoot on control trees resulted in substantially reduced crop yields. In 1989, ethephon treatment enhanced total yield per tree compared to controls (Table 2) due to greater flower survival of freezes during bloom.

Ethephon altered the harvest date and fruit size of both cultivars both years. More than 50% of the 'Jerseydawn' crop was harvested on the first two harvest dates for controls and on the last two harvest dates for treated trees in both years (Table 1). A similar effect was observed in 'Cresthaven' trees (Table 2). The effect of ethephon on harvest date was more pronounced in 1988 than in 1989.

More and a larger percentage of all ethephon-treated fruit were in the smaller sizes relative to control fruit (Tables 3, 4). The reduced pistil size observed in flower buds after a fall ethephon application (Herrera,

1987) is reflected in smaller fruit at harvest.

Fall ethephon treatment clearly delays harvest and reduces fruit size. Weinbaum et al. (1977) reported that ethephon application to immature peach fruit inhibited growth rate and final fruit size. Proebsting and Mills (1976) found a similar reduction in sweet cherry fruit size with ethephon, although there was no delay in the harvest date. Irving (1987) reported that fall-applied ethephon had no effect on harvest maturity of 'Fantasia' nectarine in New Zealand. It is difficult to ascertain whether the reduced fruit size and delayed harvest observed in our work is a direct effect of ethephon on cell number, cell size, or rate of fruit development or an effect of ethephon on prethinning crop load. Havis (1962) showed that earlier thinning induced earlier ripening and larger fruit. The lighter crop load on the control trees prior to thin-

ning could induce earlier ripening and larger fruit. We experienced either winter injury or frost injury in both years of this study; thus, fruit size and harvest date alterations induced by ethephon in both cultivars are confounded with prethinning crop load. Further work is required to separate these confounded effects.

Literature Cited

- Coston, D.C., G.W. Krewer, T.E. Elkner, J.G. Williamson, and E.T. Sims, Jr. 1985. Chemical treatments to delay bloom in peach. J. Amer. Soc. Hort. Sci. 110:874-877.
- Dennis, F.G., Jr. 1976. Trials of ethephon and other growth regulators for delaying bloom in tree fruits. J. Amer. Soc. Hort. Sci. 101:241-245.
- Durner, E.F. 1989. Cryoprotection of deacclimating peach flower buds by ethephon alteration of pistil carbohydrate content. Cryobiology 26:290-296.
- Durner, E.F. and T.J. Gianfagna. 1988. Fall ethephon application increases peach flower bud resistance to low-temperature stress. J. Amer. Soc. Hort. Sci. 113:404-406.
- Gianfagna, T.J., R. Marini, and S. Rachmiel. 1986. Effect of ethephon and GA, on time of flowering in peach. HortScience 21:69-70.
- Havis, A.L. 1962. Effects of time of fruit thinning of Redhaven peach. Proc. Amer. Soc. Hort. Sci. 80:172-176.
- Herrera, M. 1987. Effect of fall application of ethephon on peach floral bud growth and development. MS Thesis, Rutgers Univ., New Brunswick, N.J.
- Irving, D.E. 1987. 'Fantasia' nectarine: effects of autumn-applied ethephon on blossoming and cropping. New Zealand J. Expt. Agr. 15:67-72.
- Proebsting, E.L., Jr. and H.H. Mills. 1976. Ethephon increases cold hardiness of sweet cherry. J. Amer. Soc. Hort. Sci. 101:31-33.
- Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics. A biometrical approach. 2nd ed. McGraw Hill, New York.
- Weinbaum, S.A., C. Giulivo, and A. Ramina. 1977. Chemical thinning: ethylene and pre-treatment fruit size influence enlargement, auxin transport, and apparent sink strength of French prune and 'Andross' peach. J. Amer. Soc. Hort. Sci. 102:781-785.