requirement and did not respond to early cold storage treatment. 'Tioga' is intermediate, responding favorably to some treatments but not all.

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Peach Cultivar Responses to Fruit Thinning with CPA[1]

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Abstract. Chemical thinning of peaches was conducted under orchard conditions using CPA,[3] followed by standard hand thinning, on the cultivars 'Jerseyqueen,' 'Sunhigh,' 'Redhaven', 'Sunqueen' and 'Rio Oso Gem.' Timing of the 3 sprays at 150 ppm was based on the water volume displacement of 100 fruits selected at random from each plot: a) at 200 ml displacement, b) at 280 ml, and c) at 280 ml plus 4 days. The control was hand thinned only. Ovule length was measured at each spray timing and found to be 7–10 mm at the 280 ml water displacement; both ovule length and water displacement techniques were used to time CPA sprays in over 2000 acres of New Jersey orchards in 1968.

Timing of the CPA thinner for optimum effectiveness in this experiment varied with cultivar. Individual fruit weight was greater on CPA-thinned trees than on the controls for the cultivars 'Redhaven,' 'Rio Oso Gem,' 'Sunqueen' and 'Sunhigh' at harvest. Chemically thinned 'Jerseyqueen' did not show an increased mean fruit weight at harvest. Yield reductions occurred on 'Sunhigh' at the 280 ml timing and on 'Redhaven' at the 280 ml + 4 days timing, due apparently to subsequent over-thinning by hand. Shading increased the thinning effectiveness of CPA on all cultivars. 'Jerseyqueen' and 'Redhaven' were difficult to thin with CPA under the conditions of this experiment. 'Rio Oso Gem' was moderately difficult, while 'Sunhigh' and 'Sunqueen' were thinned readily.

FRUIT growers have been slow to accept chemical fruit thinning of peaches in frost-prone areas because of the lack of effective chemicals that can be applied after the danger of frost without adversely affecting fruit growth and quality (4, 9). The auxin 2–3 chlorophenoxy propionamide (CPA) has shown promise as a desirable chemical peach thinner, but cultivars have been found to respond differently under different conditions (3, 5). The objective of this work was to determine the best timing of CPA sprays for 5 commercial peach cultivars.

MATERIALS AND METHODS

The cultivars used in order of ripening and which matured over a period of 6 weeks were 'Redhaven.' 'Sunhigh,' 'Sunqueen,' 'Jerseyqueen,' and 'Rio Oso Gem.' Trees were planted 24 ft apart in rows 20 ft apart and selected for uniformity of vigor. Each treated tree was separated in a row by at least one buffer tree. A split plot design was used consisting of 4 trees per treatment replicated 2 times with a total of 180 trees in all treatments. The experiment was located on a sandy loam soil (Freehold series) at Larchmont Farms in Burlington County east of Camden, New Jersey. The data were subjected to analysis of variance and multiple comparisons performed according to the Tukey "t" test.

Full bloom for all cultivars was April 14, 1968. The commercially prepared form of CPA was used at 150 ppm. Timing of the sprays was based on water volume displacement by 100 fruits of a cultivar as described by White and Kepka.[4] The peaches were selected at random and placed in a 1000 ml graduated cylinder holding enough water so that the pubescent peaches could be submerged before the volume reading was taken. Volume readings at which the sprays were applied were: C, control, only hand thinned; T_1, 200 ml water displacement; T_2, 280 ml water displacement; T_3, 280 ml water displacement + 4 days. Ovule measurements were made on 25 fruits selected at random and used in the volume displacement technique. Each fruit was cut along the suture and the ovule length measured. Both methods are being used by researchers and growers to time CPA sprays. Before the fruit thinning sprays were applied, 100 fruits were tagged on single branches on 4 sides of a tree for a total of 400 tagged fruits per tree. Fruit counts were taken on tagged areas to determine the fruit thinned off on each side of the tree and also to evaluate any effects of shading on fruit thinning. Dates of spray application on the 5 cultivars are given in Table 1.

Temperature at the time of spray application was be-

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[3]Commercially known as Fruitone[R] 3-CPA (2–3 chlorophenoxy propionamide, 7.9% plus 2–3 chlorophenoxy proprionic acid—0.4%). The Amdal Co., Abbott Laboratories, North Chicago, Illinois.

[4]White, D. G., and Marion Kepka. 1964. Results from using 3-chlorophenoxy-proprionamide (3-CPA) for thinning peaches. Rutgers University, New Brunswick, N. J. (Unpublished.)

tween 52° and 64°F for the T_1 application, 52° and 66° for the T_2 application, and 72° to 75° for the T_3 application (Table 1). The May 1968 average temperature for Moorestown, New Jersey (3 miles from the experimental plots) was 58.0° or 3.7° below the long-term normal (1931–1960) for May. Spray timing was generally difficult since most days were overcast and it rained intermittently.

All sprays were applied to the drip stage using a hand gun and a high-pressure sprayer at 250–300 psi. Gallonage applied per tree varied with its size; 'Rio Oso Gem,' 'Sunqueen' and 'Redhaven' (5 yr) received 3.5 to 4 gal of spray while 'Sunhigh' and 'Jerseyqueen' (8–10 yr) received 5 gal. A record of the number of fruit on the trees after spray application was completed in 3 days from June 20 to June 22, within 27 days after the last spray application. All cultivars were hand thinned by grower help shortly after natural drop to an arbitrary distance of 4–6″ with no predisposition as to treatments. Records were kept of total number and weight of fruit removed by both chemical and hand thinning.

Fruits were harvested at a stage of development considered commercially acceptable. Harvest of the latest maturing cultivar, 'Rio Oso Gem,' was completed on September 12. Total fruit weight and number of fruits harvested per tree were recorded.

Results

'Redhaven'. All sprays of CPA significantly reduced the number of fruit on 'Redhaven' trees as compared with natural drop (Fig. 1). The controls required significantly more hand thinning than did sprayed trees. Spray timing at T_3 necessitated significantly less hand thinning than at T_1 and T_2.

Significant reductions in fruit yield were associated with the T_1 and T_3 timings (Fig. 2). Fruit from CPA-treated trees were larger than fruit harvested from the control trees (Table 2). However, there were no significant differences in individual fruit weight among timings.

'Sunhigh'. Application of CPA sprays to 'Sunhigh' trees at all timings resulted in a marked reduction in the amount of hand thinning subsequently required (Fig. 1) with no difference among timings. Yield reductions were associated with T_1 and T_2 timings of CPA (Fig. 2). Individual fruits of sprayed trees were larger than those of the controls (Table 2).

'Sunqueen'. The control trees of 'Sunqueen' required significantly more hand thinning than sprayed trees, but there were no differences among CPA-thinned trees and the controls. The individual chemically thinned fruit were heavier (Table 2). There were no differences in fruit weight among CPA treatments.

'Jerseyqueen'. CPA applied to 'Jerseyqueen' trees at the T_3 timing accomplished a significant amount of thinning, but not at T_1 or T_2 timings (Fig. 1). A small yield reduction resulted from the CPA-thinned trees at the T_3 timing (Fig. 2). There were no differences in harvest weight per fruit among any of the treatments (Table 2).

'Rio Oso Gem'. All treatments of CPA significantly increased thinning on 'Rio Oso Gem' (Fig. 1). However, there were no differences in the amount of hand thinning necessary among CPA timings. There were no significant differences in harvest yield between the sprayed and unsprayed trees (Fig. 2). Average weight per fruit of CPA-treated trees was heavier than for the controls (Table 2).

Ovule length. There were significant differences in the

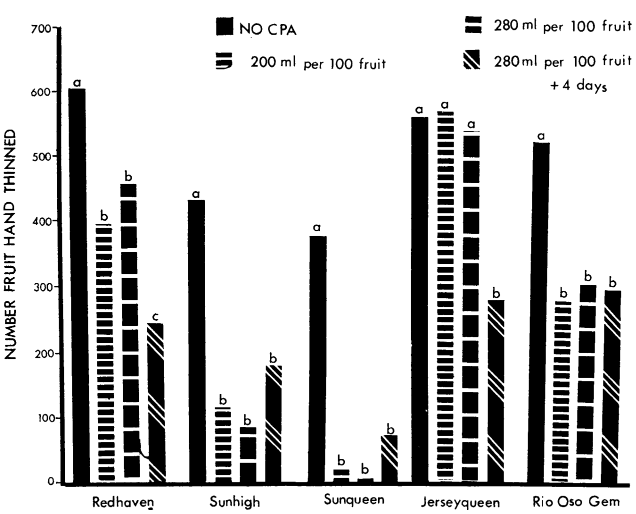

Fig. 1. Effect of CPA on the number of fruit subsequently hand-thinned per tree. HSD.05 = 105.35 and HSD.01 = 136.42.

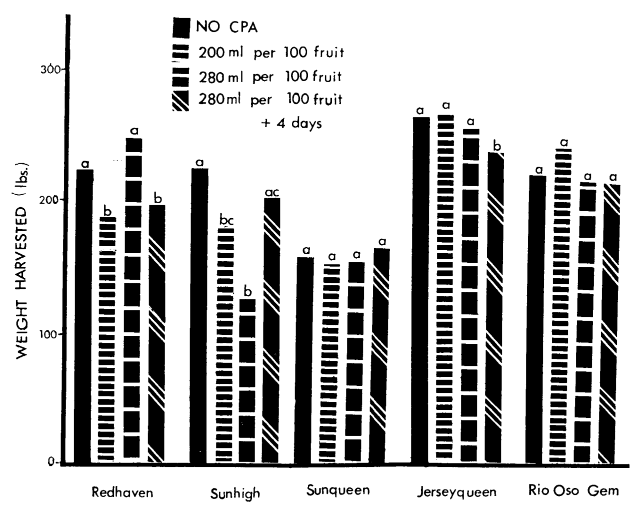

Fig. 2. Peach yield in pounds by cultivar and treatment as affected by CPA fruit thinning sprays. HSD.05 = 26.70 and HSD.01 = 33.02.

Table 1. Dates of CPA spray timings (T_1 to T_3) to 5 peach cultivars with respective temperature readings and fruit volume at T_3.

Cultivar	T_1	Temp.	DAFB[a]	T_2	Temp.	DAFB[a]	T_3	Temp.	DAFB[a]	Vol. in ml at T_3 time
Redhaven	May 18	58°	28	May 21	58°	35	May 25	72°	35	421
Sunhigh	May 20	54°	34	May 22	66°	36	May 26	72°	40	488
Sunqueen	May 18	61°	32	May 20	52°	34	May 25[b]	72°	39	460
Jerseyqueen	May 19	64°	33	May 20	52°	34	May 25[b]	75°	39	478
Rio Oso Gem	May 20	52°	34	May 21	64°	35	May 25	73°	39	350

[a]Days after full bloom.
[b]Due to inclement weather these treatments were applied at 280 ml + 5 days instead of 4 days.

Table 2. Effect of timing of CPA sprays on average weight at harvest of individual peaches by cultivar.

CPA timing	Redhaven	Sunhigh	Sunqueen Grams[x]	Jerseyqueen	Rio Oso Gem
No CPA........................	77.78 a	102.18 a	92.22 a	116.32 a	121.08 a
At 200 ml H_2O displ..............	98.98 b	126.52 b	128.50 b	118.82 a	133.71 b
At 280 ml H_2O displ..............	94.18 b	120.47 b	119.28 b	125.75 a	137.35 b
At 280 ml H_2O displ. + 4 days.....	102.76 b	119.61 b	111.77 b	120.17 a	133.59 b

[x]Means within a variety are not significantly different at the 5% level if they share the same letter. HSD .01 = 15.58 and HSD .05 = 12.51.

ovule length between the T_1 and T_2 spray timings for the 'Sunhigh,' 'Jerseyqueen' and 'Sunqueen' cultivars (Table 3). The ovule lengths were significantly different for the T_1 and T_3 timings for all cultivars. All cultivars except 'Redhaven' and 'Sunhigh' had significantly longer ovules at the T_3 timing than at the T_2 timing.

There were significant individual and group differences among cultivars within the 3 spray timings, as indicated in Table 3, but no particular reasoning for these differences can be given. Ovule length was between 8 and 9.8 mm for the 5 cultivars at the "average" water displacement timing (T_2) of 280 mm volume for a 100-fruit sample. *Shading effect*—shaded fruits were thinned by CPA to a greater extent than fruit with better exposure to sunshine (Fig. 3). *Phytotoxicity*—some leaf wilting occurred within a 24-hour period after CPA application. The leaves recovered within 2 days.

Discussion

CPA proved to be an effective chemical fruit thinner for the five peach cultivars 'Redhaven,' 'Sunhigh,' 'Sunqueen,' 'Jerseyqueen' and 'Rio Oso Gem.' There were differences, however, in the overall thinning action of CPA within cultivars and spray timings.

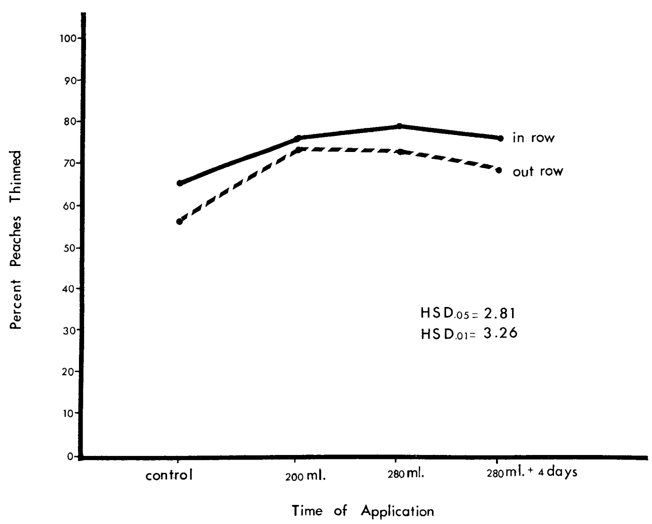

Fig. 3. Effect of CPA thinning of fruit in the shaded "within row" areas of the trees (solid line) and in sunny "between rows" areas (broken line). HSD.05 = 26.70 and HSD.01 = 33.02.

'Sunqueen' was most effectively thinned by CPA at 150 ppm under the conditions of this test. Little subsequent hand thinning was required for a commercial crop equal to that of the control. 'Sunhigh' also was thinned effectively by CPA although some over-thinning occurred at 2 of the spray timings as indicated by yield reductions.

CPA was somewhat less effective on 'Rio Oso Gem' and least effective on 'Redhaven' and 'Jerseyqueen.' Other workers also have found 'Redhaven' and 'Rio Oso Gem' somewhat difficult to thin chemically with CPA (5).

'Redhaven' and 'Jerseyqueen' were thinned best by the late T_3 timing of CPA. Generally speaking, 'Rio Oso Gem,' 'Sunqueen' and 'Sunhigh' were thinned satisfactorily with CPA at all 3 timings. This effective thinning period for these cultivars extended over 6 days. The cooler weather experienced before the spray period in 1968 may have retarded fruit growth and allowed a longer period of spray timing or the cultivars themselves may have a relatively slower physiological development.

The ovule length tentatively suggested for spraying with CPA has been 7–10 mm (5). Ovule lengths in this range were observed in 4 cultivars at the first spray timing, all 5 cultivars at the second timing, and 2 of the cultivars at the third timing (Table 3). Use of 7–10 mm ovule length range does not seem to be optimum for all 5 cultivars. 'Sunhigh,' 'Jerseyqueen' and 'Sunqueen' thinned at ovule lengths greater than the 7–10 mm ovule length. 'Jerseyqueen' was not thinned appreciably until the ovule length reached 10.5 mm.

The water volume displacement method for timing sprays compared favorably with the ovule length in the second timing (280 ml/100 fruits) for all cultivars. The volume-displacement method has proved simple and easy for New Jersey growers, most of whom used it to thin chemically over 2000 acres of peaches with CPA in 1968 (6).

In recent studies by Leuty and Bukovac (10), pericarp length was found to be less variable in determining spray timing than the number of days after full bloom and accumulated heat hours. These authors also proposed that during the critical growth period when the auxin content of seeds is at a maximum, and the auxin destruction factors like indolacetic oxidase are low, the appli-

Table 3. Ovule length by cultivar at the time of CPA application.

CPA spray timing	Cultivar				
	Redhaven	Sunhigh	Sunqueen	Jerseyqueen	Rio Oso Gem
			Ovule length, mm[x]		
T_1..............................	7.7 b	8.0 b	8.7 bc	6.6 a	8.2 bc
T_2..............................	8.7 bc	9.2 cd	9.8 d	8.0 b	8.6 bc
T_3..............................	9.5 c	10.6 de	11.6 e	10.5 cd	9.7 d

[x]All means within a column and within a row having the same letter are not significantly different at the 5% level. HSD.05 = 1.02 and HSD.01 = 1.32.

cation of an exogenous auxin like CPA may result in auxin changes which bring the onset of fruit abscission.

More fruit thinning by CPA occurred in shady areas of the trees, which indicates that light plays a role in the effectiveness of CPA thinning. This effect of shade may be caused by decarboxylation of the molecule when exposed to high light intensities as demonstrated by Edgerton (7) who used a similar thinner (2-3 chlorophenoxy proprionic acid or CP). Also, the stage of fruit development and fruit vigor may alter the resistance of the fruit to chemical thinners in shaded areas of the tree vs exposed areas. Over-thinning of fruit in shaded areas may prove to be a problem in orchards with trees densely planted in hedgerows, or insufficiently open-pruned.

Thinning with CPA increased individual fruit size over controls for all cultivars used in this experiment except 'Jerseyqueen,' which may require a different spray timing or concentration. Albrigo and Christ (2) found that CPA also increased fruit size over the controls for the cultivars 'Triogem' and 'Sunhaven.' They implied that the better fruit sizing resulted from thinning off the smaller, weaker fruit by CPA.

Phytotoxicity was not a problem under the conditions of this experiment. Some workers (5) have reported leaf drop with CPA and in one case in California suture reddening on 'Redhaven' at the 300 ppm level of CPA (8).

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Effects of Tomato Flesh Pigment Mutant Genes on Leaf Chlorophylls and Carotenoids[1]

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Abstract. Seven mutant strains of tomatoes, crimson *(og^c)*, high *beta*-carotene *(B)*, low total (yellow *r*), 'Snowball' (yellow *r*), apricot *(at)*, high pigment *(hp)*, 'Jubilee' (tangerine, *t*), and the check cultivar 'Rutgers' were surveyed to determine the effects of these fruit pigment mutants on leaf pigments. Chlorophylls *a* and *b*, *beta*-carotene, lutein, violaxanthin, lutein 5,6-epoxide, and neoxanthin were separated chromatographically and quantities were determined spectrophotometrically. Significant differences among strains were found in chlorophylls and *beta*-carotene levels. Xanthophyll differences were, generally, nonsignificant. A definite pattern of gene effects was suggested. The apricot strain produced the highest levels of chlorophylls and *beta*-carotene in the leaves; one of the *r* strains, 'Snowball', the lowest.

Parents, F_1 and F_2 generations involving apricot, yellow (low total), crimson, and normal were analyzed to determine whether these leaf pigment differences could be related to these particular genes. Apricot significantly increased chlorophyll and *beta*-carotene levels as suggested in the survey. Yellow in a variable background, however, did not lower these pigments significantly.

Pigment synthesis in tomato leaves and fruits was discussed in relation to the gene effects inferred in the survey and the specific gene effects demonstrated in the segregating populations.

Carotenoids accompany chlorophylls in all higher plants and in most other organisms. These two kinds of pigment have similarities functionally, structurally, and biosynthetically. The C-20 saturated phytol side chain of chlorophylls is similar structurally to C-40 carotenoids. And genes such as *ghost* (6), and *high pigment* (1), affect both pigment groups which suggests that the pigments are related biosynthetically.

Carotenoids can be divided into two classes, carotenes and xanthophylls. Carotenes are oxygenated to form xanthophylls (4), and some theorize that carotenes may be derived from xanthophylls (3).

The ghost and high pigment genes not only affect both chlorophylls and carotenoids but also their effects can be noted in the tomato fruit and leaf. This suggests that the

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