Prohexadione-calcium Inhibits Apple, but not Peach, Tree Growth, but Has Little Influence on Apple Fruit Thinning or Quality

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In northern Virginia, over 80% of the apple crop is grown for processing. Many trees are propagated on vigorous rootstocks and require much pruning, especially in the tops. To reduce costs and labor needs, many growers prune every second or third year. When trees are not pruned, shading caused by growth in the current season or in non-pruned years is detrimental to pest control, fruit quality, and yield.

Several plant growth regulators have been evaluated for their potential to reduce vegetative growth of tree fruits, thereby reducing pruning costs and improving fruit quality. Several reviews (Faust, 1984; Looney, 1983; Luckwill, 1970; Miller, 1988; Williams, 1984) dealing with many of these compounds indicate that most have several effects of greater commercial value than control of vegetative growth.

The objectives of the experiments reported here were to evaluate the effects of prohexadione-calcium (3-oxido-4-propionyl-5-oxo-3-cyclohexene-carboxylate), formulated as BAS-125 ("Apogee"®), on a) vegetative growth of apple and peach trees, b) fruit size and quality, and c) response to thinning chemicals.

MATERIALS AND METHODS

General. Randomized complete-block designs were used in all experiments. Trees were blocked by location within rows, by rootstock, and/or by flower density rating. All experiments had six blocks except for Expts. 1, 4, 5, and 6. Trees were sprayed with either a low pressure hand-wand sprayer or a Swanson three-point-hitch airblast sprayer with both fans adjusted to one side, which doubled air output and increased nozzle numbers.

In several experiments (Expts. 1–4), a 10-fruit sample was collected from each tree at harvest for quality evaluations, which included flesh firmness, soluble solids concentration, starch staining, percentage of red color, and incidence of water core. Flesh firmness of both peach and apple fruit was measured on two sides of each fruit with an Effegi penetrometer (model FT327; McCormick Fruit Tech, Yakima, Wash.) fitted with an 11.1-mm tip. Soluble solids concentration (SSC) was estimated with an Atago hand-held refractometer (model N1; McCormick Fruit Tech), utilizing a composite sample of juice resulting from penetrometer testing for each replicate of each treatment. Each apple fruit was cut in half transversely, and severity of water core was rated on a scale of 0 to 5 (0 = none, 5 = severe). Flesh starch was evaluated by dipping half of each apple in a solution of I₂/KI for ≈15 s. The degree of staining was rated on a scale of 0 to 5 where 1 = staining of the entire cut surface and 5 = absence of starch (Poapst et al., 1959).

In the dormant season (Expts. 1–4), average shoot length of the longest top two shoots, length of the five longest scaffold shoots, total length of shoots longer than 30 cm, weight and basal and terminal shoot diameters of these scaffold shoots, nodes/cm of the basal 40 cm, nodes/cm of the upper 30 cm of shoots, and time required to prune each tree, number of cuts/tree, and pruning weights/cm² trunk cross-sectional area (TCSA) per tree were recorded.

Prohexadione-calcium was formulated as BAS 125 10W in 1995–97. Regulaid® (a surfactant mixture, polyoxyethylenepolypropoxy-

propanol, alkyl 2-ethoxethanol, and dihydroxy propane) was used with all prohexadione-calcium treatments either at 0.125% (v/v) or as indicated.

Data were analyzed by ANOVA and GLM procedures using SAS software (SAS Institute, 1985). Means were compared by single-degree-of-freedom contrasts, or by linear and polynomial regressions, depending upon the experimental design.

Expt. 1. In 1994, sixteen 13-year-old 'Stayman'/seedling trees (four blocks) were used for four treatments. Four concentrations of prohexadione-calcium were applied (0, 125, 250, or 375 mg·L⁻¹) at 2805 L·ha⁻¹ 23 d after full bloom (AFB) (Table 1). In addition to fruit quality and dormant season shoot measurements previously described, five vegetative shoots selected at petal fall were measured on the periphery of each tree at intervals from 2 May to 7 Dec. For determining fruit cracking, three limbs having a total of ≈30 fruit per tree were examined at weekly intervals and cracked fruit were removed from 25 July to 13 Oct. On 13 Oct., the remaining noncracked fruit were counted and the percentage of fruit cracked was determined.

Expt. 2. In 1995, thirty-six 10-year-old 'Starkrimson'/MM.106 or 'Starkrimson'/MM.111 trees (6 blocks) were used for six treatments. Prohexadione-calcium was applied at 0, 125, 250, or 500 mg·L⁻¹ at 1870 L·ha⁻¹, at 250 mg·L⁻¹ at 935 L·ha⁻¹, at 500 mg·L⁻¹ at 468 L·ha⁻¹ 23 d AFB (Table 2). Fruit quality and dormant season shoot measurements were taken as previously described for evaluation of fruit characteristics. In addition, a 1-bushel (20 kg) sample was also passed over a Durand Wayland Omni Sort weight-sizer grader (Durand Wayland, LaGrange, Ga.) and the percentages of fruit in each weight category were determined.

Expt. 3. In 1996, thirty-six 10-year-old 'Starkrimson'/MM.106 or 'Starkrimson'/MM.111 trees (three blocks MM.106 and three blocks MM.111 for a total of six blocks) were used for six treatments. Prohexadione-calcium at 250 mg·L⁻¹ (1870 L·ha⁻¹) was applied on 1) 6 May; 2) 17 May; 3) 17 May + June 3; 4) 17 May, 3 June, and 3 July; or 5) 17 May, 3 June, 3 July, and 24 July (Table 3). Additional trees served as controls. Fruit quality and dormant season shoot measurements were taken as previously described. A 10-fruit sample was collected 1 Oct. and 15 Nov. from each tree for evaluation of fruit characteristics.

Expt. 4. Forty 10-year-old 'Ace Delicious'/MM.111 trees (eight blocks) were used for five treatments. Prohexadione-calcium treatments (Table 4) were applied with an airblast sprayer at 1870 L·ha⁻¹. Fruit quality and dormant season shoot measurements were taken as previously described. A 10-fruit sample was collected 1 Oct. from each tree for evaluation of fruit characteristics.

Expt. 5. In 1995, seventy 5-year-old 'Fuji'/M. 27 trees (seven blocks) were used for 10 treatments. Spray thinning chemical combinations (Table 5), included 1-naphthalenyl methylcarbamate (carbaryl), 6-benzyladenine + gibberellins A₄₊₇ (Accel®), 2-chloroethylphosphonic acid (ethephon), oil (Sun 6E, 70 second superior spray oil typically used as a delayed dormate oil), methyl N,N'-dimethyl-N[(methyl carbamoyloxy)-1-thiooxamimidate (Oxamyl®), and trisiloxane ethoxylate methyl ether (a silicon surfactant, Silwet L-77) were applied with or without prohexadione-calcium with a low-pressure hand wand sprayer on 15 May when fruit were ≈10 mm in diameter. The number of fruit on each tree was counted 15 d after treatment and expressed as number of fruit per cm² trunk cross-sectional area (TCSA). Ten fruit were harvested from each tree on 23 Oct. The fruit length (L) and diameter (D) were determined by aligning

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Table 1. Effects of prohexadione-calcium on 'Stayman' apple tree growth in 1994.^z

Prohexadione-calcium (mg·L ⁻¹)	Change in shoot length (cm)				Fruit/cm ²	Avg shoot ^y		Avg internode	Shoot base ^y	
	from 2 May until:				limb					
					CSA ^x	Length	Wt	length	Diam	CSA
	30 June	29 July	31 Aug.	7 Dec.	25 July	(cm)	(g)	(cm)	(mm)	(mm ²)
0	31.5	37.5	40.4	41.9	3.30	137.8	90.4	2.8	11.2	9.95
125	13.5	21.3	29.4	28.5	3.48	99.6	48.8	2.4	9.1	6.60
250	14.0	18.9	25.0	26.3	4.14	94.0	40.4	2.3	8.7	6.07
375	14.2	17.2	22.8	23.8	4.00	92.2	41.9	2.3	9.2	6.73
Regression										
L	**	**	**	**	NS	**	**	**	*	*
Q	***	**	*	***	NS	***	***	**	***	***

^zFull bloom occurred 22 Apr. 1994. Treatments were applied 2 May when fruit were 7.4 ± 0.60 mm in diameter. Airblast sprayer was calibrated for 2805 L·ha⁻¹. Tree spacing was 7.9 m between rows, 5.2 m tree width, and 4.9 m tree height, equivalent to 80% tree row volume (TRV).

^yMean for longest 10 shoots in top of tree, measured 7 Dec.

^xCSA = cross-sectional area.

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

Table 2. Effects of prohexadione-calcium applied in 1995 on dormant season measurements and pruning of 'Starkrimson'/MM.106 and 'Starkrimson'/MM.111 trees in Jan. 1996.^z

											Pruning		
Treatment	Prohexadione- calcium (mg·L ⁻¹)	Water applied (L·ha ⁻¹)	Shoot length (cm)			Shoot wt (g)		Basal diam (cm)	Nodes/m		Time (min/cm ² TCSA ^y)	Wt (g·cm ⁻² TCSA)	No cuts/ cm ² TCSA
			Top ^y	Scaffold ^x	>30 cm ^w	Top ^y	scaffold ^x		Basal 40 cm	Upper 30 cm			
1	0		130	116	457	193	368	1.41	45	63	3.48	97	1.45
2	125	1870	134	109	386	193	294	1.29	68	52	2.88	73	1.05
3	250	1870	123	103	360	165	259	1.24	74	52	3.12	84	1.28
4	500	1870	118	95	367	147	182	1.13	85	50	2.88	63	1.26
5	250	935	114	91	412	147	222	1.20	73	53	3.00	95	1.34
6	500	468	105	83	349	120	281	1.20	73	52	2.70	75	1.19
Comparisons:													
0 vs. 125			NS	NS	NS	NS	NS	*	***	***	*	**	**
0 vs. 250			NS	**	NS	NS	***	***	***	***	NS	NS	NS
0 vs. 500			NS	**	*	*	***	***	***	***	*	**	NS
125 vs. 500			NS	**	NS	NS	**	**	***	NS	NS	NS	NS
125(1870 water rate) vs. 500 (468 water rate)			*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chemical rate regression:													
(0, 125, 250, 500)													
L			NS	***	NS	NS	***	***	***	***	NS	*	NS
Q			NS	***	NS	NS	***	***	***	***	NS	NS	NS
Water rate regression													
(treatments 6, 5, 2)													
L			NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS
Q			NS	*	NS	NS	*	NS	NS	NS	NS	NS	NS

^zFull bloom occurred 22 Apr. 1995. Treatments were applied 12 May when fruit was 8.4 ± 0.60 mm in diameter. Tree spacing was 6.1 m between rows, 3.05 m tree width, and 4.3 m tree height, which was equivalent to 50% TRV.

^yTwo longest top shoots.

^xFive longest scaffold shoots.

^wShoots >30 cm only.

^vTCSA = trunk cross-sectional area.

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

all 10 fruit on a measuring tape, and the L : D ratio was calculated. Fruit russet was rated on the following scale : 0 = no lenticel development; 1 = small lenticel enlargement; 2 = lenticels rough and raised to touch; 3 = some russet between lenticels; 4 = considerable russetting other than lenticels; and 5 = severe russet. Color was visually estimated as percentage of the surface showing red.

Expt. 6. In 1996, fifty-five 5-year-old 'Gala'/M. 27 trees (5 blocks) were used for 11 treatments. Spray thinning treatments (Table 6) were applied with or without prohexadione-calcium with a low-pressure hand wand sprayer 10, 15, and 20 DAFB. As described for Expt. 5, crop load was recorded and ten fruit were harvested from each tree on 27 Aug. and evaluated.

Expt. 7. Thirty 6-year-old 'Redhaven' peach trees (six blocks) were used for five treatments. Prohexadione-calcium (375 mg·L⁻¹) was applied : 1) alone; 2) with 0.125% Silwet L-77; 3) with 0.5% 70° s oil; and 4) with 0.125% L-77+ 0.5% 70° s oil. Additional trees were left as controls. On 28 July, a sample of 10 fruit/tree were taken to determine

fruit diameter, color, firmness, soluble solids, and weight, and length of the five longest shoots in the periphery of the tree were measured.

RESULTS

Expt. 1. In 1994, airblast applications of prohexadione-calcium reduced shoot length of 'Stayman'/seedling apple trees during the growing season. In the dormant season (7 Dec. 1994), all parameters of shoot growth measured were reduced (Table 1), except the diameter of the most terminal part of shoot (data not shown). Pruning time, weight, and number of cuts appeared to be reduced by treatment (data not shown), but differences were nonsignificant at $P \leq 0.05$. The trees were rather variable in crop load and quite vigorous, which might account for lack of significance. The fruit L : D ratio, flesh firmness, soluble solids, starch, red color, and fruit cracking were not affected by prohexadione-calcium.

Expt. 2. In 1995, prohexadione-calcium again reduced shoot length

Table 3. Effects of prohexadione-calcium applied in 1996 on dormant season measurements and pruning of 'Starkrimson'/MM.106 and 'Starkrimson'/MM.111 trees in Jan. 1997.²

										Pruning		
Prohexadione-calcium (mg·L ⁻¹)	Application date	Shoot length (cm)			Shoot wt (g)		Basal diam (cm)	Nodes/m		Time		
		Top ^y	Scaffold ^x	>30 cm ^w	Top ^y	Scaffold ^x		Basal 40 cm	Upper 30 cm	(min/cm ² TCSA ^y)	Wt/tree (kg)	Cuts/ tree
0		118	115	985	148	304	12.2	54	84	6.0	2.52	106
250	6 May	65	74	462	53	145	10.2	86	128	3.3	0.84	55
250	17 May	96	85	627	91	155	9.8	75	97	5.2	1.52	83
250, 250	17 May, 3 June	98	83	633	110	174	10.4	85	108	4.8	1.55	81
250, 250, 250	17 May, 3 June, 3 July	75	70	555	72	160	11.0	95	112	4.3	1.32	78
250, 250, 250, 250	17 May, 3 June, 3 July, 24 July	48	46	265	36	86	9.2	110	78	2.4	0.50	39
Contrasts												
0 vs. May 6 250		***	***	***	***	***	***	***	NS	**	***	**
0 vs. 250, 250, 250, 250		***	***	***	***	***	***	***	***	***	***	***
250 6 May vs. 250 17 May		**	NS	*	NS	NS	NS	*	NS	*	*	NS
250 6 May vs. 250, 250		**	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
250 6 May vs. 250, 250, 250		NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS
250 6 May vs. 250, 250, 250, 250		NS	NS	***	NS	*	*	***	***	NS	NS	NS
Regression												
L		***	***	***	***	***	***	***	***	NS	***	***
Q		***	***	***	***	***	***	***	***	NS	**	***

²Full bloom occurred 28 Apr. 1996. Airblast sprayer was calibrated for 1870 L·ha⁻¹. Tree spacing was 6.1 m between rows, 3.0 m tree width, and 4.3 m tree height, which was equivalent to 50% TRV.

³Two longest top shoots.

⁴Five longest scaffold shoots.

⁵Shoots >30 cm only.

⁶TCSA = trunk cross-sectional area.

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

Table 4. Effects of prohexadione-calcium applied in 1997 on dormant season measurements and pruning of 'Ace Delicious'/MM111 trees in Dec. 1997.²

										Pruning		
Prohexadione-calcium (mg·L ⁻¹)	Application date	Shoot length (cm)			Wt (g)		Basal diam (cm)	Nodes/m		Time/ tree (min)	Wt/tree (kg)	Cuts/ tree
		Top ^y	Scaffold ^x	>30 cm ^w	Top ^y	Scaffold ^x		Basal 40 cm	Upper 30 cm			
0		74.6	67.5	2416	75.8	211	1.33	53	86	4.59	2.75	105.4
63, 63, 125	25 Apr., 2 May, 9 May	71.2	65.0	1826	70.8	202	1.29	61	84	3.55	2.08	78.9
125, 125	25 Apr., 2 May	58.8	61.2	1280	63.8	175	1.16	65	84	2.28	1.38	52.0
250	25 Apr.	64.4	71.0	1644	66.3	227	1.35	59	85	3.30	1.97	78.6
125	25 Apr.	58.3	60.7	1665	54.8	170	1.24	57	103	2.90	1.47	66.1
Comparisons												
0 vs. 63, 63, 125		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
0 vs. 125, 125,		NS	NS	**	NS	NS	**	*	NS	***	**	***
0 vs. 250		NS	NS	*	NS	NS	NS	NS	NS	*	NS	NS
0 vs. 125		NS	NS	*	NS	NS	NS	NS	NS	*	NS	NS
63, 63, 125 vs. 125, 125		NS	NS	NS	NS	NS	*	NS	NS	*	NS	NS
63, 63, 125 vs. 250		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
63, 63, 125 vs. 125		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

²Full bloom occurred 15 Apr. 1997. Data taken on treatments Dec. 1997.

³Airblast sprayer was calibrated for 1870 L·ha⁻¹. Tree spacing was 6.1 m between rows, 3.0-m tree width and 4.3-m tree height, which was equivalent to 50% TRV.

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

(Table 2). The most effective treatments, 500 mg·L⁻¹ at either 1870 or 468 L·ha⁻¹, reduced pruning weight and pruning time, but not number of cuts. The trees were again rather variable in crop load and tree vigor which may have accounted for the lack of significance in some cases. Fruit L : D ratio, soluble solids, and starch content were not affected by prohexadione-calcium, but fruit firmness and red color were slightly increased (data not shown). Neither weight per fruit nor yield per tree was affected by the chemical (data not shown).

Expt. 3. In 1996, multiple applications generally controlled tree growth better than did a single application (Table 3). Regrowth of the strongest shoots was observed as new light green leaves developing on the most vigorous shoots just before the second, third, or fourth applications. No differences were found in fruit diameter, red color, number of fruit per tree, fruit weight, or crop load (data not shown).

Expt. 4. In 1997, rates for multiple applications were greatly reduced from the 1996 rates, but were applied sooner after bloom. Growth and crop load were rather variable among trees, which resulted

in fewer statistical differences than expected (Table 4). The crop load on these trees was very light because of a prebloom freeze; this further increased variability. For this reason fruit quality measurements were not taken. Control trees required more time to prune than did prohexadione-calcium-treated trees. Two applications at 125 mg·L⁻¹ gave better growth control than did three treatments of 63, 63, and 125 mg·L⁻¹. These data further reinforce the need for adequate amounts of chemical, and possibly multiple applications, being applied soon after bloom (see also Expt. 3, Table 3) to achieve the optimum vegetative growth control.

Expt. 5. In 1995, prohexadione-calcium significantly increased thinning response to ethephon (treatments 8 vs. 9), but not to the combinations of carbaryl + Accel® (treatments 2, 4 vs. 5, 7) or Vydate + Accel®, (treatments 3 vs. 6) (Table 5). No differences in fruit diameter, L : D ratio, russet, or color were found (data not shown).

Expt. 6. In 1996, NAA thinned significantly at 10 and 15 DAFB, but not at 20 DAFB, but neither Accel®, nor carbaryl was effective.

Table 5. Effect of prohexadione-calcium on response of 'Fuji'/M.27 to chemical thinning agents (1995).^z

Treatment	Thinning agent ^y	Added chemicals			Fruit/cm ² limb cross-sectional area (30 May)
		Prohexadione-calcium	Silwet	Oil	
1.	Control	—	—	—	8.30
2.	Carbaryl + Accel	—	—	+	0.34
3.	Carbaryl + Accel	+	—	+	1.08
4.	Carbaryl + Accel	—	+	—	3.10
5.	Carbaryl + Accel	+	+	—	2.47
6.	Vydate + Accel	—	—	—	2.71
7.	Vydate + Accel	+	—	—	1.76
8.	Ethephon	—	—	—	4.87
9.	Ethephon	+	—	—	1.99
10.	Hand thinned	—	—	—	4.74
Contrasts: prohexadione-calcium vs. none					
2 vs. 3					NS
4 vs. 5					NS
6 vs. 7					NS
8 vs. 9					**
2, 4, 6 vs. 3, 5, 7					NS
2, 4, 6, 8 vs. 3, 5, 7, 9					*

^zFull bloom = 22 Apr. 95; petal fall = 3 May. Treatments were applied on 15 May at 10 mm fruit diameter.^yConcentrations (mg·L⁻¹): carbaryl-1800 ; Accel-50; Vydate-300; ethephon-500.NS, *, **, *** Nonsignificant or significant at $P < 0.05$, 0.01, or 0.001, respectively.

Table 6. Effects of prohexadione-calcium on response of 'Gala'/M.27 to chemical thinning agents (1996).

Treatment ^y	Thinning agent	Prohexadione-calcium ^y	Spray timing (DAFB) ^z	Fruit/cm ² limb cross-sectional area (7 June)	Fruit diam (cm) (8 Aug)
1.	Control			12.8	6.94
2.	NAA	—	+ 10	8.7	7.23
3.	NAA	+	+ 10	3.9	7.12
4.	NAA	—	+ 15	6.6	7.21
5.	NAA	+	+ 15	8.2	7.26
6.	NAA	—	+ 20	11.4	6.85
7.	NAA	+	+ 20	11.9	6.98
8.	Carbaryl	—	+ 20	10.0	6.67
9.	Carbaryl	+	+ 20	14.3	6.95
10.	Accel	—	+ 20	12.8	6.94
11.	Accel	+	+ 20	14.9	6.79
Contrasts: Comparisons					
2, 3 vs. 4, 5				NS	NS
2, 3 vs. 6, 7				NS	NS
4, 5 vs. 6, 7				***	**
6, 7 vs. 8, 9				NS	NS
6, 7 vs. 10, 11				NS ₁	NS
8, 9 vs. 10, 11				NS	NS
2 vs. 3					
Prohexadione-calcium vs. none (10 DAFB)				NS	NS
4 vs. 5 (15 DAFB)				NS	NS
6 vs. 7 (20 DAFB)				NS	NS
2, 4, 6 vs. 3, 5, 7					
NAA vs NAA+ prohexadione-calcium (10, 15, 20, DAFB)				NS	NS
2, 4, 6, 8, 10 vs. 3, 5, 7, 9, 11					
All thinners vs. all thinners + prohexadione-calcium				NS	NS

^zFull bloom occurred 30 Apr. 1996; DAFB = days after full bloom.^yConcentrations (mg·L⁻¹) used: NAA-15; carbaryl-600 ; Accel-50 ; prohexadione-calcium-250.NS, *, **, *** Nonsignificant or significant at $P < 0.05$, 0.01, or 0.001, respectively.

Prohexadione-calcium had no effect on fruit set in response to NAA, Accel®, or carbaryl (Table 6), or on fruit characteristics or subsequent season flowering.

Expt. 7. One application of prohexadione-calcium applied 2 May on 'Redhaven' peach trees did not affect shoot length of the five longest shoots on the tree, or fruit diameter, weight, color, firmness, or soluble solids (data not shown). Adjuvants L-77, oil, or oil + L-77 did not affect the efficacy of the chemical (data not shown).

DISCUSSION

Since ≈75% of apple tree shoot growth occurs in the first 30 days after bloom (Expt. 1), maximum suppression of tree growth can only be achieved if the first flush of growth is controlled. Other growth retardants also suppress shoot growth of apple trees more when

applied early in the growing season (Miller, 1988). Adequate prohexadione-calcium (125 mg·L⁻¹) was required in the first and subsequent applications to maximize shoot growth control (Expt. 3). Prohexadione-calcium suppression of shoot growth was short lived, and shoots with the greatest vigor began growing again within a few of weeks of application (Expts. 3 and 4). Trees in highest vigor (due to a partial crop load, vigorous rootstocks, good soil moisture, etc.) may require weekly monitoring to determine the number and timing of additional applications to prevent regrowth. Even though the most vigorous shoots on the trees were used for most of the shoot growth measurements reported in this paper (Expts. 1–4), the number of cuts required to prune the tree may be more reflective of the degree of or shoot growth suppression, since less vigorous shoot are less likely to regrow. Prohexadione-calcium did not promote enlargement of terminal buds or basal shoot diameter as did daminozide [butanedioic acid

mono(2,2-dimethylhydrazide)] (Emerson, unpublished). The enlarged terminal buds and shoot diameters of daminozide-treated trees may explain why daminozide sprays did not control shoot growth in subsequent seasons. Additional studies are needed to determine if any subsequent season carry-over effects are noticed in prohexadione-calcium-treated trees; the reduced terminal bud size and shoot diameters of such trees suggest a reduction in tree vigor.

Very little if any direct effect on fruit firmness, soluble solids, starch content, shape (Expts. 1–4), or fruit cracking (Expt. 1) was observed with the rates of prohexadione-calcium used in these studies. The small increase in red color probably resulted from better light penetration because of vegetative growth suppression rather than being a direct effect on fruit coloring. Thinning activity of NAA, carbaryl, or Accel was not affected by tank mixing prohexadione-calcium with chemical thinning sprays applied to ‘Gala’/M.27 trees 20 DAFB (Expt. 6). Tank mixing prohexadione-calcium with combinations of NAA, Vydate + Accel, or carbaryl + Accel + oil also did not alter fruit thinning of ‘Fuji’/M.27 when applied at 10-mm fruit diameter (Expt. 5). In one experiment, prohexadione-calcium potentiated thinning by ethephon when applied to ‘Fuji’/M.27 (Expt. 5). Interference of prohexadione-calcium with chemical thinning or natural fruit set was found to be minimal, if any, in these experiments (Expts. 5 and 6). Several years of commercial experience will be

required to determine if this growth regulator can eliminate or reduce the need to annually prune apple trees, while maintaining fruit quality and production.

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