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The Influence of Prohexadione-Calcium Sprays on Apple Tree Growth, Chemical Fruit Thinning, and Return Bloom

R. E. Byers[1], D. H. Carbaugh[2], and L.D. Combs[2]

Abstract

P-Ca [formulated as BAS-125 (10% P-Ca) or Apogee™, (27.5% P-Ca + 56.1% $(NH_4)_2SO_4$ + 16.4% other proprietary additives)] applied to 'Fuji'/M.9 trees in 3 applications at 250 mg•L^{-1} (a.i. P-Ca), increased fruit set compared with the unsprayed control. Chemical thinning sprays reduced crop load and promoted tree growth in both P-Ca and non-P-Ca sprayed trees. P-Ca did not affect chemical fruit thinning when chemical thinners were applied between the first and second of three P-Ca applications. Carbaryl + oil, carbaryl + Accel + oil, oxamyl + Accel caused fruit thinning, but ethephon or shading trees for 3 days did not. Shading + P-Ca sprays caused additional shoot growth suppression, which suggested that P-Ca may be light labile. In a second experiment, three sprays of P-Ca [BAS 125: 10% P-Ca; 90% $(NH_4)_2SO_4$] at a low rate of 63 mg•L^{-1} or ethephon at 135 mg•L^{-1} applied to 'Fuji'/M.9 did not affect shoot growth; however, the combination of P-Ca + ethephon at these rates gave good control of tree growth without influencing flowering, fruit set, or fruit abscission. In a third experiment, GA_3 alone did not promote shoot growth when compared with the unsprayed control, but GA_3 sprays partially counteracted the shoot growth suppression of P-Ca + $(NH_4)_2SO_4$ + Regulaid. Flower bud formation was inhibited by GA_3 in the next season, but P-Ca had no effect on return bloom or return fruit set.

Chemicals used: Prohexadione-calcium (P-Ca) formulated as BAS-125 (10% P-Ca + 90% $(NH_4)_2SO_4$) or Apogee™, (27.5% P-Ca + 56.1% $(NH_4)_2SO_4$ + 16.4% other proprietary additives), Regulaid® (a surfactant mixture, polyoxyethylenepolypropoxypropanol, alkyl 2-ethoxethanol, and dihydroxy propane; Silwet L-77 (polyalkyleneoxide modified heptametyltrisiloxane, silicon surfactant), oxamyl (Vydate; methyl N',N' dimethyl-N[methylcarbamoyl] (oxy)]-1-thiooxamimidate); superior oil (Drexel Damoil 70 sec delayed dormant spray oil), ethephon (Ethrel, 2-chloroethyl phosphonic acid), $(NH_4)_2SO_4$; carbaryl (Sevin XLR, 1-naphthy N-methylcarbamate); Accel (mixture of 6-benzyladenine and gibberellin A_{4+7}), and gibberellin A_3.

Introduction

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 shoot growth in the current season is detrimental to pest control, fruit quality, and yield. Several plant growth regulators have been used to reduce vegetative growth of fruit trees, thereby reducing pruning costs and improving fruit quality (5,7,8,9,12). Foliar sprays of P-Ca (a gibberellin biosynthesis inhibitor) registered for inhibiting shoot growth of apple trees, reduced pruning time, tree canopy size and density, and reduced the severity of fireblight (4, 10, 13).

Since P-Ca is applied soon after bloom and during the same period that several other plant growth regulators may be used, it is important to determine if P-Ca sprays may modify the expected effects of other growth regulators used for fruit thinning, increased or decreased return bloom, control of fruit cracking, and russet. Previously, Greene (6) reported that P-Ca sprays increased fruit set and chemical thinning difficulty. Miller

[1] Professor Emeritus of Horticulture and [2]Research Specialists, Virginia Polytechnic Institute and State University, Alson H. Smith, Jr. Agricultural Research and Extension Center, 595 Laurel Grove Road, Winchester, VA 22602. Appreciation to Seth Combs, Heath Combs, Jean Engleman, Tim Stern, Maurice Keeler, and Harriet Keeler for data collection, analysis, and technical assistance.

(unpublished) determined that P-Ca interfered with the control of fruit cracking and fruit russet. Multiple low-dose applications of ethephon inhibited tree growth and increased following season flowering and fruit set without causing current season fruit abscission (1). Logically, combinations of P-Ca + ethephon could provide additional shoot growth control at a lower cost.

The objectives of the experiments reported here were to: 1) determine the influence of P-Ca on fruit set and chemical thinning, 2) evaluate the combination of ethephon and P-Ca for suppression of tree growth, and subsequent season flowering and fruit set, and 3) determine if GA_3 applications used to reduce flowering would interfere with growth inhibition by P-Ca.

Materials and Methods

General. Randomized complete block designs were used in all experiments. Trees were blocked by location within rows or by trunk cross sectional area (TCSA). Trees were sprayed dilute with a low pressure, hand-wand sprayer. Two formulations were used in these experiments: BAS-125 (10% P-Ca + 90% $(NH_4)_2SO_4$) and Apogee™, (27.5% P-Ca + 56.1% $(NH_4)_2SO_4$ + 16.4% other proprietary additives). Even though both formulations contained $(NH_4)_2SO_4$, additional $(NH_4)_2SO_4$ tank mixed with either P-Ca formulation was required for maximum efficacy (2). Several experiments have shown that $(NH_4)_2SO_4$ has improved P-Ca efficacy if well water high in calcium and/or additional $CaCl_2$ is used in spray water for calcium disorders. Even when deionized water is used, $(NH_4)_2SO_4$ has also improved efficacy of the technical P-Ca (Byers, unpublished). In the 1998 experiment, no additional $(NH_4)_2SO_4$ was used to improve efficacy, since it was not known at that time that Ca ions in well water could interfere with efficacy.

Even though daminozide retarded shoot growth soon after application, it caused an increased shoot diameter and the shoots grew longer than on non-sprayed trees the following season. Therefore in our study, considerable data were collected in the summer and/or dormant season on average shoot length of the longest top two shoots, length and weight of the 4 or 10 longest scaffold shoots, total length of all shoots longer than 30 cm or 40 cm, and time required to prune each tree, number of cuts per tree, and pruning weights per cm^2 TCSA per tree.

Data were analyzed by ANOVA and GLM procedures using SAS software (11). Means were compared by single-degree-of-freedom contrasts, by linear and polynomial regressions, or Duncan's new multiple range test depending upon the experimental design.

Expt. 1. In 1998, forty-eight 4-year-old 'Fuji'/M.9 trees were blocked by row and terrain into 6 blocks of 8 treatments (Table 1). Treatments consisted of 1) untreated control; 2&3) P-Ca (BAS 125) applied at 63 $mg \bullet L^{-1}$ to drip in 3 applications to the same trees at petal fall (PF), PF+14, and PF+28 days or PF+28, PF+42, and PF+56 days; 4&5) ethephon applied alone at 135 $mg \bullet L^{-1}$ at PF, PF+14, and PF+28 days or PF+28, PF+42, and PF+56 days; 6) combination of ethephon applied at PF, PF+14, and PF+28 days plus P-Ca applied PF, PF+14, and PF+28 days, 7) a combination of BAS 125 applied at PF, PF+14, and PF+28 days plus ethephon applied PF+28, PF+42, and PF+56 days, 8) a combination of BAS 125 applied at PF+28, PF+42, and PF+56 days plus ethephon applied PF, PF+14, and PF+28. In the dormant season, we recorded 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 shoot diameters of these terminal scaffold shoots, and time required to prune each tree, number of cuts/tree, and pruning weights/ cm^2 TCSA per tree.

Expt. 2. In 1999, seventy-two 5-year-old 'Fuji'/M.9 trees were blocked by row and terrain into 6 blocks of 12 treatments (Table 2). P-Ca (Apogee) at 250 $mg \bullet L^{-1}$ P-Ca + 0.909 $g \bullet L^{-1}$ $(NH_4)_2SO_4$ was applied at PF, PF+24 days, and PF+45 days. Seven days after the first P-Ca application, the thinning chemicals ethephon, carbaryl, Accel, oxamyl and shading (92% for 3 days) were applied in various combinations at approximately 10 mm fruit diameter (PF+ 7 days) (Table 2). Shading was used to determine if P-Ca

Table 1. Effect of P-Ca (BAS 125) on 'Fuji'/M.9 apple tree growth applied in 1998 and return bloom in 1999.[z]

Treatment[y]	Added chemicals: P-CA (BAS 125)	Added chemicals: ethephon	Application time	Scaffold shoot[x]: length (cm)	Scaffold shoot[x]: weight (g)	Basal diam (mm	Change in cm^2 TCSA[w]	Pruning: Cuts/ tree	Pruning: Wt/tree (kg)	Return bloom (1999): % Spurs flowering (visual)	Return bloom (1999): Clusters/ cm^2 LCSA[v]
1.	-	-	—	89 a[u]	205 a	12.5 a	13.8 a	86 ab	1.76 a	62 ab	5.18 a
2.	+	-	PF, +14, +28	83 abc	182 ab	12.1 ab	12.4 ab	86 ab	1.77 a	48 bc	5.80 a
3.	+	-	+28, +42, +56	86 ab	191 a	11.5 bc	12.1 ab	91 a	1.81 a	47 c	6.01 a
4.	-	+	PF, +14, +28,	81 abc	165 abc	11.4 bcd	11.7 ab	82 abc	1.63 ab	52 abc	5.83 a
5.	-	+	PF+28, +42, +56	81 abc	177 ab	11.6 abc	11.3 ab	79 abc	1.60 ab	43 c	5.75 a
6.	+		PF, +14, +28	71 bc	136 bc	10.9 cd	10.5 b	68 c	1.27 bc	63 a	6.63 a
		+	PF, +14, +28								
7.	+		PF, +14, +28	78 abc	159 abc	11.5 abc	9.8 b	68 c	1.18 c	52 abc	6.44 a
		+	+28, +42, +56								
8.	+		+28, +42, +56	70 c	123 c	10.5 d	10.6 ab	72 bc	1.02 c	65 a	8.75 a.
		+	PF, +14, +28								
Contrasts:	Comparisons:			Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2,3 vs 4,5	BAS 125 vs ethephon			ns	ns	ns	ns	ns	ns	ns	ns
2,3 vs 6,7,8	BAS 125 vs BAS 125+ethephon			*	**	**	*	***	***	**	ns
4,5 vs 6,7,8	ethephon vs BAS 125+ethephon			ns	ns	ns	ns	*	***	**	ns

z Full bloom occurred 15 April 1998. Pruning and growth data taken on treatments Dec 2,1998, except for return bloom data taken Apr 12 and Apr 27, 1999 respectively.
Treatments were applied with a low pressure handwand sprayer. Fruit size on spray dates May 6, May 20, June 3, June 17 were 7.9, 22.5, 36.0, 46.4 mm .

y Concentrations: P-Ca (BAS 125)=63 mg/L^{-1}; ethephon=135 mg/L^{-1}.

x Five longest scaffold shoots.

w TCSA=trunk cross sectional area.

v LCSA=limb cross sectional area.

u Mean separation within columns by Duncan's new multiple range test; (ns,*,**,***Nonsignificant or significant at P < 0.05, 0.01, 0.001, respectively).

influenced natural fruit drop which may be initiated by cloudy weather (3).

Expt. 3. In 2000, thirty-two 6-year-old 'Fuji'/ M.9 trees were blocked by row and terrain into 8 blocks of 4 treatments (Table 3). P-Ca (Apogee) was applied at 125 mg•L^{-1} + 0.909g•L^{-1} $(NH_4)_2SO_4$ + Regulaid to the same trees at PF, PF+21, and PF+53 days. In addition, since GA_3 (Pro-Gibb formulation, Abbott Labs, Inc.) is used for control of fruit cracking, fruit russet and to inhibit return bloom, GA_3 was tank mixed at 213 mg•L^{-1} in combination with P-Ca + $(NH_4)_2SO_4$ + Regulaid or alone (Table 3). On June 26, ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were recorded. During dormancy, on Nov. 28, the ten previously tagged scaffold shoots were pruned and the basal diameters and lengths of the terminal shoots were recorded. In addition, trees were pruned and the total length of the shoots longer than 30 cm, their weight, number of cuts, and the time required to prune, and the pruning weights per cm^2 TCSA per tree were recorded.

Results and Discussion

Expt. 1. At these low rates, three applications of BAS 125W (63 mg•L^{-1}) or ethephon (135 mg•L^{-1}) did not suppress shoot growth of 'Fuji/M.9 trees (Table 1). Combinations of P-Ca and ethephon (trts 6, 7, and 8) gave better control of shoot growth, basal shoot diameter, TCSA, number of pruning cuts and weight/tree without fruit thinning by ethephon and/or increased fruit set by P-Ca. Although not statistically significant, ethephon tended to cause a slightly greater return bloom, which may not be desirable if the trees are in the 'off year' of the biennial bearing cycle (Table 1, trts 2,3 vs 6,7,8). The added growth suppression of ethephon plus P-Ca at reduced rates avoided fruit thinning by ethephon and the increased fruit set of P-Ca. Ethephon applications at PF, PF +14, and PF + 28 days combined with P-Ca at PF + 28, PF + 42 and PF + 56 provided the best control of tree growth.

Expt. 2. When applied in 3 applications at 250 mg•L^{-1}, P-Ca (Apogee) significantly increased fruit set on Fuji/M.9 trees compared to the control (Table 2, trt 1 vs trt 2). P-Ca did not interfere with chemical thinners applied between the first and second P-Ca application, as indicated by a comparison of all thinning treatments, with or without P-Ca (Table 2, trts 3,4,5,6,7 vs 8,9,10,11,12). The thinners carbaryl+oil, carbaryl +Accel+oil, and oxamyl+Accel caused fruit thinning, but ethephon or shading trees for 3 days did not. Overall, P-Ca + thinning appeared to reduce return bloom when compared to thinning alone (Table 2, trts 3,4,5,6,7 vs 8,9,10,11,12).

In this experiment, P-Ca treated trees were as responsive to chemical thinning as non-P-Ca treated trees. When a single P-Ca was applied seven days prior to thinning with carbaryl+NAA, Greene (6) found inadequate thinning and a decreased return bloom which may have been related to additional cropping of P-Ca treated trees.

Ethephon suppressed shoot growth, decreased pruning weight and cuts per tree, and promoted flowering in the subsequent season (Table 2, trt 1 vs 10). Carbaryl+Accel+oil over-thinned trees causing increased shoot growth and promoting return bloom in the subsequent season (Table 2, trt 1 vs 9).

Length of the longest scaffold shoots of Fuji/ M.9 was inhibited by P-Ca + $(NH_4)_2S0_4$. Ethephon alone was the only chemical thinner that suppressed shoot growth (trt 10). Chemically thinned trees did not grow any stronger than the control trees, but P-Ca controlled tree growth even though cropping was reduced substantially by some of the thinners (Table 2, trts 1 vs 8; 1 vs 9; 1 vs 11; 1 vs 12). The average shoot weight, shoot basal diameter, number of pruning cuts, and pruning weight was reduced by P-Ca (Table 2). Observations of the daminozide sprayed trees were that shoot length in the year of application was suppressed, the basal diameter appeared to be increased and shoots grew longer the year after application; shoot weights in the year of application were not known (Emerson and Byers unpublished observations). The suppression of growth by P-Ca visually appeared to be different than daminozide in that P-Ca shoots were less vigorous in the subsequent season, and shoot diameter and

Table 2. Effect of P-Ca (Apogee) and chemical thinners on fruit set, thinning, tree growth, and return bloom of 'Fuji'/M.9 in 1999-2000.[z]

Treatment[y]	Applied chemicals: P-Ca + $(NH_4)_2SO_4$ + Silwet L-77	Thinning agent (PF+7)	Fruit/cm² limb cross sectional area (30 Jun)	Shoot length (cm)[x] Scaffold[w]	Shoot wt (g)[x] Scaffold[w]	Basal diam (mm)	Pruning[x] Cuts/tree	Pruning[x] Wt/tree (kg)	Return bloom rating (2000) (%)[v]
1.	-		5.1 b[u]	54 a	54 bcd	6.6 abcd	67 a	4.5 a	7 fg
2.	+		7.3 a	36 bc	39 de	6.7 abcd	59 abcd	2.9 bc	6 fg
3.	+	carbaryl + Oil	4.1 bc	32 cd	32 e	6.0 bcde	48 d	2.7 c	24 def
4.	+	carbaryl + Accel + Oil	1.4 e	35 bc	40 cde	6.1 abcde	59 a	4.1 ab	61 ab
5.	+	ethephon	6.7 a	28 de	28 e	5.9 cde	46 d	3.2 bc	4 g
6.	+	oxamyl + Accel	4.3 bc	35 bc	37 de	6.0 bcde	52 bcd	3.2 bc	19 efg
7.	+	Shade 3 days	3.6 bc	26 e	25 e	5.4 e	49 cd	2.5 c	4 g
8.	-	carbaryl + Oil	3.0 cd	53 a	59 abc	6.7 abcd	65 a	3.6 abc	40 cd
9.	-	carbaryl + Accel + Oil	1.7 de	54 a	74 a	7.2 a	65 ab	4.5 a	71 a
10.	-	ethephon	6.7 a	40 b	34 e	5.7 de	49 d	2.8 bc	29 de
11.	-	oxamyl + Accel	3.3 c	53 a	62 ab	7.0 ab	62 abc	4.1 ab	47 bc
12.	-	Shade 3 days	3.6 bc	50 a	58 abc	6.9 abc	58 abcd	3.2 bc	27 de
Contrasts:	Comparisons:		Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2 vs 3,4,5,6,7	P-Ca vs P-Ca + thinners		***	*	ns	*	ns	ns	*
3,4,5,6,7 vs 8,9,10,11,12	P-Ca + thinners vs thinners alone		ns	***	***	***	***	*	***

z Full bloom occurred Apr 30, 1999. Petal fall occurred May 7, 1999. All trees used in experiment were visually bloom rated 90-100%.
y P-Ca + $(NH_4)_2SO_4$ + Silwet L-77 was applied at PF, PF+24, PF+45 days with a low pressure hand-wand sprayer. Thinning agents were applied at PF+7 days. Chemical rates were as follows: P-Ca=250 mg/L^{-1} (P-Ca); $(NH_4)_2SO_4$ =0.909 g/L^{-1}; Silwet L-77=1.257 ml/L^{-1}; ethephon=135 mg/L^{-1}; carbaryl XLR=1.257 ml/L^{-1}; Accel=2.75 ml/L^{-1}; oxamyl=1.257 ml/L^{-1}; oil=5.00 ml/L^{-1}.
x Data taken 12 Dec 1999.
w Five longest scaffold shoots.
v Return bloom rating taken 11 Apr 2000.
u Mean separation within columns by Duncan's new multiple range test; (ns,*,**,***Nonsignificant or significant at P $\leq$ 0.05, 0.01, 0.001, respectively).

Table 3. Effect of P-Ca (Apogee) (3 applications of 125 mg/L^{-1}; PF, 21 days AFB, 53 days AFB), gibberellin A_3 (3 applications), and adjuvants on 'Fuji'/M.9 on apple tree growth applied in 2000 and return bloom and fruit set in 2001.

Treatment[y]	P-Ca	$(NH_4)_2SO_4$	Regulaid	GA_3	pH of mix	Scaffold shoots[x] length (cm) (26 Jun 00)	Scaffold shoots[w] (28 Nov. 00) Length (cm)	Scaffold shoots[w] (28 Nov. 00) Weight (g)	Basil diam (mm)[w]	Pruning[v] Cuts/ tree	Pruning[v] Wt/tree (kg)	Flowering (2001)[t] Clusters/ cm^2 (LCSA[u])	Flowering (2001)[t] % Spurs flowering (visual)[r]	Fruit cm^2 limb cross sectional area (2001)[s]
1.	-	-	-	-	7.4	67 a[q]	101 a	65 a	13.9 a	102 a	3.8 a	4.4 b	81 b	3.7 ab
2.	+	+	+	-	7.8	32 c	70 b	33 b	11.5 b	59 b	1.5 b	6.6 a	92 a	4.3 a
3.	+	+	+	+	7.4	51 b	74 b	42 b	12.2 b	85 a	2.3 ab	1.8 c	54 c	2.2 ab
4.	-	-	-	+	7.3	69 a	85 ab	48 ab	12.5 ab	103 a	3.5 a	1.4 c	37 d	1.3 b

[z] Full bloom occurred April 14, 2000. Treatments were applied at April 24, May 7 and June 9 respectively with a low pressure hand-wand sprayer.
[y] Concentrations: P-Ca=125 mg/L^{-1}; $(NH_4)_2SO_4$=0.454 g/L^{-1}; Regulaid=0.125 %; GA_3=213 mg/L^{-1} (3 applications=total 640 mg/L^{-1}).
[x] 10 shoots per tree. Data taken 26 Jun 2000.
[w] 10 shoots per tree. Data taken 28 Nov 2000.
[v] Data taken 8 Dec 2000.
[u] LCSA =limb cross sectional area.
[t] Data taken 26 Apr 2001.
[s] Data taken 18 Jun, 2001.
[r] Percentage data was transformed to arscin before analysis.
[q] Mean separation within columns by Duncan's New Multiple Range Test ($P< 0.05$).

weight appeared to be equivalent to the untreated control (4); thus, shoot growth suppression from one season's applications of P-Ca suppressed tree vigor over two growing seasons. Treatment differences were more easily detected by shoot length suppression than by shoot weight, basal diameter, pruning cuts, or pruning weight; however, these data were of interest since they may reflect more accurately the reduced pruning and brush removal by P-Ca.

Unexpectedly, P-Ca suppressed shoot growth more when trees were shaded (Table 2, trts 2 vs 7). Priority information from BASF suggests that P-Ca is rather sensitive to photooxidation and that high light intensity soon after the application may reduce P-Ca efficacy (Rademacher, personal communication). However, the seven day period separating the shade application and the P-Ca application probably was too long to account for the increased effect of P-Ca when shaded in this experiment.

Expt. 3. P-Ca applied in April to June 2000 reduced shoot growth of the longest scaffold shoots, reduced their basal diameter, decreased the number of pruning cuts and weight per tree, and may have slightly increased the number of spurs flowering in 2001 but did not increase fruit set in 2001. GA_3 (Table 3, trt 4) did not promote shoot growth, but GA_3 (3 applications at 213 mg•L^{-1}) reduced the shoot growth suppression of P-Ca + $(NH_4)_2SO_4$ + Regulaid (trt 3). Application of GA_3 (trts 3,4) in 2000 inhibited bloom in 2001, but it did not influence fruit set. Visual ratings of flowering were difficult to make due to differences between treatment shoot lengths and the spatial density of flowers. For this reason, the flower cluster counts based on cm^2 limb cross-sectional area appeared to be more reliable than visual ratings, but visual ratings may reflect flower density/m^3. GA_3 inhibited return bloom in trees sprayed with or without P-Ca (trt 3, 4); but GA_3 reduced the suppression of scaffold shoot growth caused by P-Ca (trt 3).

Since P-Ca is rather expensive, its interaction with other plant growth regulators may produce additional responses that may be of value. These experiments suggest that even though P-Ca may increase fruit set of non-spray thinned trees, the selection of a chemical thinner was more important than the influence of P-Ca on thinning. In addition, the P-Ca + ethephon combination provided better control of shoot growth than P-Ca, and P-Ca was rather neutral for return bloom. GA_{4+7} counteracted the P-Ca shoot growth suppression by stimulating shoot growth, but flower bud inhibition caused by GA_{4+7} was not influenced by P-Ca. Since Miller (unpublished) determined that P-Ca interfered with the GA_{4+7} control of fruit cracking and fruit russet, careful consideration should be made when P-Ca and GA_{4+7} are used in the same period.

Literature Cited

1. Byers, R. E. 1993. Controlling growth of bearing apple trees with ethephon. HortScience 28:1103-1105.
2. Byers, R. E. 2004. Prohexadione-calcium suppression of apple tree shoot growth affected by spray additives. HortScience 39: (In press).
3. Byers, R. E., D. H. Carbaugh, C. N. Presley, and T. K. Wolf. 1991 The influence of low light levels on apple fruit abscission. J. Hort. Sci. 66:1-17.
4. Byers, R. E. and K. S. Yoder. 1999. Prohexadion-calcium inhibits apple, but not peach, tree growth, but has little influence on apple fruit thinning or quality. HortScience 34:1205-1209.
5. Faust, M. (ed.). 1984. International workshop on controlling vigor in fruit trees. Acta Hort. 146.
6. Greene, D. W. 1999. Tree growth management and fruit quality of apple trees treated with prohexadione-calcium (BAS 125). HortScience 34:1209-1212.
7. Looney, N. E. 1983. Growth regulator usage in apple and pear production, p. 27-40 In: L. G. Nickell (ed.). Plant growth regulating chemicals, Vol. I. CRC Press, Boca Raton, Fla.
8. Luckwill, L. C. 1970. The control of growth and fruitfulness of apple trees. p. 237-254 In: L. C. Luckwill and C. V. Cutting (eds.). Physiology of tree crops. Academic Press, London.
9. Miller, S. S. 1988. Plant bioregulators in apple and pear culture. Hort. Rev. 10:309-401.
10. Rademacher, W. 2000. Growth retardants: Effects on gibberellin biosynthesis and other metabolic pathways. Annu. Rev. Plant Physiol. Plant Mol. Biol. 51:501-31.
11. SAS Institute, Inc. 1985. SAS user's guide:Statistics. SAS Inst., Cary, N. C.
12. Williams, M. W. 1984. Use of bioregulators to control vegetative growth of fruit trees and improve fruit efficiency, p.93-99. In: R. L. Orydn and F. R. Rittig (eds.). Bioregulators: Chemistry and Uses. Amer. Chem. Soc. Wash. D. C.
13. Yoder, K. S., S. S. Miller, and R. E. Byers. 1999. Suppression of fireblight in apple shoots by prohexadione-calicum (BAS125W) following experimental and natural inoculation. HortScience 34:1202-1204.

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Shepard Award Winner for 2003

At the Annual Meeting in Providence, RI on October 5, 2003 the following paper was announced as the winner of the Shepard Award for 2003:

Barden, J.A. 2003. The Influence of Cultivar and Orchard System on Pruning Time per Tree, per Hectare, and per Unit of Field. J. Amer. Pomol. Soc. 56:202-206.