Effects of Accel and Carbaryl on Apple Tree Nutrition and Fruit Yield

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ABSTRACT

Experiments were carried out in 1995 and 1996 to investigate the effect of accel (N-(Phenylmethy)-(H-purine 6-amine (6-BA) and carbaryl (1-Naphthyl methyl carbamate) sprayed two weeks postbloom on fruit set yield and plant nutrition of three apple *(Malus pumila* Mill.) cultivars; Empire; 'Jon-A-Red' and 'Braeburn'. The treatments consisted of accel (25, 50 and 75ppm), carbaryl (0.05, 0.1 and 0.2%) and unsprayed controls.

Thinning trials conducted over two years indicated that accel and carbaryl consistently thinned the apple cultivars and significantly (P< 0.05) increased the yields. The leaf mineral concentrations were increased, decreased or not affected by the treatments. In 1995 the treatments significantly (P< 0.05) affected the leaf contents of N, Ca and Mg while in 1996 the treatments affected the leaf contents of N, P, K, Ca, Mg, Fe, Mn and Zn but not Cu. The treatments increased the fruit-flesh K, P and Mg contents in 1996. These results indicate that depending on apple cultivar, N content was reduced by the treatments while Ca and Mg were generally increased. Similarly the fruit-flesh contents of P, K and Mg were also increased. Carbaryl and Accel therefore thin apples, increase yields and affect the fruit quality.

1.0 INTRODUCTION

The practice of fruit thinning has been known for a very long time (Ryugo, 1988) cited by Valenzuela, 1992. Thinning refers to the removal of either certain flowers, cluster of flowers or individual fruits after fruit set and natural droppmg has occurred (Valenzuela, 1992). Under optimum conditions most trees will set more fruits than needed for a full crop. Fruit thinning is done to reduce limb breakage, increase fruit size, improve color and quality and stimulate floral initiation for next year's crop (Westwood, 1993). Increasing the leaf to fruit ratio by removing some of the fruits causes the remaining fruits to be larger, but not in direct proportion to the increase in the number of leaves, leading to some yield reduction (Westwood, 1993). Three methods are used for fruit thinning namely: chemical hand and mechanical. The advantages of chemical thinning over hand or mechanical thinning are: reduced thinning costs, better fruit size and quality and better return bloom on biennial varieties (Westwood, 1993). Chemical thinners are classified as plant growth regulators e.g. synthetic auxins such as cytokinins, carbaryl NAA and Gibberellins (Knight 1980). Other chemicals with thinning properties are Ethephon (Jones *et al,* 1983, 1989; Knight 1980; Knight *et al.* 1987, Koen *et al.* 1988, benzyladenine (BA) and N-(2-chloro-4 pyridyl) - N,-l-phenyl urea (Cppu) which are cytokinins (Bound *et al,* 1991; Byers and Carbaugh, 1989, Elfving and Cline, 1993; Greene, 1989; 1989; Greene *et al,* 1990); and Accel (Hull *et al,* 1995 and Stiles (1995).

Thinning can be done at bloom time and during the early postbloom period. Apple cultivars which are strongly biennial may require both a bloom and a postbloom spray programme for adequate thinning (Williams, 1979).

In the Mississippi State of U. S. A, good apple orchard management practices have usually led to the setting of more, fruits than needed for a full crop. Many thinning trials have been conducted in the United States but few have been done under Mississippi conditions using Accel and Carbaryl on 'Empire' "Jon-A-Red' and 'Braeburn'. Still Accel is a new chemical thinner which needs more years and sites for experimentation. Few studies have also been conducted previously to establish the effect of different chemical thinners on Apple nutrition. The present study was undertaken to investigate the effects of carbaryl and Accel on Apple nutrition with respect to fruit set and fruit yield, leaf nutrition and fruit nutrition.

2.0 MATERIALS AND METHODS

Two similar experiments were carried out using mature apple trees at the Mississippi State University Agricultural and Forestry Experimental station (MAFES) at Pontotoc Experimental Station which is located about 7 Miles South of Pontotoc Country. The station consists of soils classified as alfisol Ultisol, Inceptisol and entisol orders with soil ranging from deep red and high in silt to gray-having silt loam and finer textured subsoils containing expansive montmorillonite clay.

The first experiment was initiated on April 21st, 1995 and terminated on July 19th, 1995. The second experiment was started on May 15th 1996 and terminated on August 30th 1996. The spray chemicals were prepared by determining their amounts in each of the treatments by calculating in terms of the active ingredients they contained. Since the volume of the sprayer was known the amount of the spray chemicals to be added as per the treatments was calculated and added to water in the sprayer and thoroughly mixed with it before spraying. Spraying of the chemical thinners for both experiments was done on calm, clear and dry days from 1 1:00 a.m. to 4.00 p.m. The trees were sprayed with accel (N-(phenyl methyl) - (H-purine 6-amine (BA) and carbaryl (Naphthyl methyl carbamate) at concentrations of 25ppm, 50pprm and 75ppm and 0.05%, 0.1% and 0.2% respectively. The control trees were not sprayed. These treatments were replicated three times in a completely randomised design with a factorial arrangement. Each treatment was applied with a hand sprayer (FMC 252,, Food Machinery Corp; Jonesboro, Ark).

The surfactant 'Tween' 20 at 0. 1 % was mixed with the chemical thinners to act as a wetting agent. The trees were sprayed to dripping point. 'Empire', 'Braeburn and 'Jon-A-Red' were the main apple cultivars grown in the orchard at the Pontotoc Experimental Station and by Mississippi farmers hence were chosen for the study. Recommended cultural practices for commercial apple production i.e. fertilization, weeding pest and disease control were applied. Fruit harvesting started at the beginning of August each year. We determined fruit set yield and mineral composition of the leaves and fruits.

2.1 Fruit set:

Before bloom, four representative limbs 12 to 15cm in circumference were tagged on each tree for use in fruit set counts (Forshey and Elfving, 1979a; 1979b, Lombard *et al,* 1988). The number of fruits were counted after June drop (one month after application of chemicals) and expressed as the number of fruits per unit limb cross-sectional area.

2.2 Yield:

A sample of 20 fruits per tree was taken and weighed using a Mettler PE 160 electronic scale and the weight per tree was calculated from the total weight of all fruits on the tree.

2.3 Leaf and fruit mineral composition:

Four weeks after the application of the chemicals, leaf samples were collected for the determination of N, P, K, Ca, Mg, Fe, Mn, Zn and Cu. The samples were cleaned by dipping in detergent solution and tap water and rinsed with distilled water. Leaf samples were dried at 60°C and ground to pass through a I-mm screen in a steel mill. Samples weighing 1.5g were combusted at 500°C in a muffle furnace for 4 hours and allowed to cool. The resulting ash was dissolved in 1OmI IMHOCI and distilled water added to make a 50 ml solution. P, K, Ca, Mg, Mn, Cu, and Zn were determined by an inductively coupled plasma emission spectrophotometer (Dahliquist and Knoll, 1978). N was determined by the Kjeldahl procedure (Nelson and Sommers, 1972). Fruit samples were also collected for the determination of N, P, K Ca, Mg, Fe, Mn, Zn and Cu. Samples of 15 fruits were used for these determinations. Fruit samples were freeze-dried and ground to pass through a I-mm screen. The samples were analysed for the nine mineral elements using the methods described above for leaf samples.

2.4 Statistical analysis

All statistical analysis were carried out using the General Linear Models (GLM) procedure of the statistical system (SAS Institute, N. C, 1988) program-package. Mean separation was done on the treatment means using the least significant difference (L.S.D) at P<0.05. Analysis of variance was also done.

3.0 RESULTS

3.1 Effects of accel and carbaryl on fruit set and yield:

Fruit set which was expressed as the number of fruits per square centimetre limb cross sectional area was significantly (P<0.05) reduced by all treatments in 1995 (Table 1).

Table 1: Effects of accel and carbaryl on the number of fruit per square centimetre limb cross sectional area of three cultivars grown at the Pontotoc Research and Extension Centre, 1995 Experiment

Treatment	Empire	Jon-A-Red	Braeburn	Average
Carbaryl 0.05%	8.33	7.40	8.37	8.03 ab
Carbaryl 0.1%	5.40	4.43	6.07	4.38 c
Carbaryl 0.2%	3.13	3.03	4.43	3.53 c
Accel 25ppm	6.10	0.37	4.00	3.49 c
Accel 50ppm	4.23	2.07	5.87	4.06 c
Accel 75ppm	1.67	0.23	1.43	1.11 d
Control	11.67	12.68	12.80	12.38 a
Variety average	5.79 a	4.31 b	6.13 a	

L.S.D (0.05) for variety averages = 0.91, S.E = 0.46; L.S.D (0.05) chemical treatment averages = 1.41. Means with the same letter(s) are not significantly different at P= 0.05. Mean separation within row and column by least significant difference test (P=0.05). No cultivars and chemical thinners interactions.

There were no significant (P< 0.05) differences between carbaryl at 0.1% and 0.2% and accel at 25 ppm and 50ppm. The interaction between the chemical thinners and cultivars was not significant in 1995. In 1996 carbaryl and accel at 25 ppm significantly reduced the fruit set in

'Empire', (Table 2) and similar results were observed in 'Jon-A-Red' while the fruit set in 'Braeburn' was significantly (P< 0.05) reduced by all treatments.

Table 2: Effect of accel and carbaryl on fruit number per limb cross sectional area of three apple cultivars 1996 Experiment

Treatment	Empire	Jon-A-Red	Braeburn
Carbaryl 0.05%	9.47 b	4.43 cd	7.67 bc
Carbaryl 0.1%	4.63 c	1.80 cd	5.60 bc
Carbaryl 0.2%	0.23 cd	1.63 cd	1.37 d
Accel 25ppm	13.97 a	7.40 b	6.73 bc
Accel 50ppm	7.73 bc	2.43 cd	4.97 bc
Accel 75ppm	3.57 d	0.83 d	0.73 d
Control	14.60 a	8.20 bc	12.33 a

L.S.D. (0.05%) = 4.03, S.E. = 1.20. Means with the same letter(s) are not significantly different at P=0.05 using the least significant difference test, chemical thinners interaction is significant.

In 1995 the yield of 'Empire, was not significantly (P< 0. 05) affected by accel or carbaryl. Accel at 50ppm significantly (p<0.05) increased the yield of 'Jon-A-Red'. The yield of 'Braeburn' was significantly increased by carbaryl at 0.2% and accel at 50ppm. The rest of the treatments had no significant effect on yield (Table 3).

Table 3: Effects of accel and carbaryl on yield (kg/tree) of three apple cultivars grown at the Pontotoc Research and Extension Centre, 1995 experiment

Treatment	Empire	Jon-A-Red	Braeburn
Carbaryl 0.05%	5.60 b	0.80 c	5.90 b
Carbaryl 0.1%	8.40 b	1.30 bc	10.50 ab
Carbaryl 0.2%	9.60 b	4.20 bc	17.80 a
Accel 25ppm	6.40 b	0.80 c	11.20 b
Accel 50ppm	5.60 b	8.50 b	17.20 a
Accel 75ppm	8.00 b	7.70 bc	8.80 b
Control	4.60 b	0.80 c	4.90 bc

L.S.D. (0.05%) = 7.80, S.E. = 0.90. Means with the same letter(s) are not significantly different at P= 0.05 using the least significant difference test. Cultivar and chemical thinners interaction is significant.

Accel at 25ppm and carbaryl at 0.1% caused significantly higher yields than the rest of the treatments in 'Braeburn', while carbaryl at 0. 1 % and accel at 50pprn significantly (P< 0.05) increased the yields in, 'Empire' in 1996. All other treatments had no significant effects on yield (Table 4).

Table 4: Effects of accel and carbaryl on yield (kg/tree) of three apple cultivars grown at the Pontotoc and Research and Extension Centre, 1996 experiment.

Treatment	Empire	Jon-A-Red	Braeburn	Average
Carbaryl 0.05%	4.57	23.43	17.30	15.10 b
Carbaryl 0.1%	21.27	21.77	22.30	21.78 a
Carbaryl 0.2%	5.43	23.47	18.87	15.92 b
Accel 25ppm	9.37	9.73	21.33	13.48 b
Accel 50ppm	23.87	27.57	21.47	24.30 a
Accel 75ppm	13.10	37.10	29.03	26.41 a
Control	3.63	2.97	6.00	4.20 c
Variety average	11.60 a	20.86 ba	19.47 b	

L.S.D (0.05) for cultivar averages = 4.38; S.E 0.76; L.S.D (0.05) for chemical treatment averages = 6.70. Means with the same letter(s) are not significantly different at (P= 0.05). Mean separation within row and column by least significant difference test (P 0.05). No cultivar and chemical thinners interactions.

3.2 Effects of accel and carbaryl on leaf mineral nutrition

No treatment had any significant ($P < 0.05$) effect on the percent N in 'Empire' or 'Jon-A-Red' in 1995 (Table 5). The N content in 'Braeburn' was also not significantly affected by carbaryl. All concentrations of accel generally significantly ($P < 0.05$) reduced the N content in 'Braeburn' (Table 5). Conversely, in 1996 percent N was significantly reduced in 'Empire' by accel at 50ppm and 75pprn. The rest of the treatments had no significant effect. Percent N of 'Jon-A-Red' was significantly reduced by all treatments except carbaryl at 0.05% and accel at 25ppm. Percent N in 'Braeburn' was significantly ($P<0.05$) reduced by all concentrations of accel and carbaryl at 0.05% while all the other treatments had no effect (Table 6).

Percent Ca was significantly ($P<0.05$) reduced by all concentrations of the chemicals in 1995 except for carbaryl at 0.2% in 'Empire'. It had no significant effect on 'Jon-A-Red'. Carbaryl did not significantly affect the Ca content in 'Braeburn' whereas, all concentrations of accel significantly ($P<0.05$) increased it (Table 5). Only carbaryl at 0.2% significantly ($P<0.05$) increased percent Mg in 'Empire' in 1995. The rest of the treatments had no significant effect (Table 5). The percent Mg of 'Jon-A-Red' and 'Braeburn' was not significantly affected, by carbaryl and accel (Table 5). In 1996 percent Mg was significantly increased by accel at 75ppm in 'Empire'. Similarly, percent P was significantly ($P<0.05$) increased by carbaryl at 0.2% and similarly, percent P was significantly ($P< 0.05$) increased by carbaryl at 0.2% and accel at 75pprn in 'Jon-A-Red'. The rest of the treatments had no significant effect. Percent P in 'Braeburn' was significantly increased by carbaryl at 0. 2% and significantly reduced by accel at 25ppm and 50ppm (Table 5).

Table 5: Effects of accel and carbaryl on leaf mineral composition of three apple cultivars grown at the Pontotoc Research Extension Centre, 1995 experiment.

Treatment	Cultivar	N%	Ca%	Mg%
	Empire			
Carbaryl 0.05%		2.32 bc	1.19 bc	0.30 c
Carbaryl 0.1%		2.25 b	1.40 b	0.35 c
Carbaryl 0.2%		2.42 bc	1.59 ba	0.63 a
Accel 25ppm		2.34 bc	1.09 bc	0.29 bc
Accel 50ppm		2.13 bc	1.17 bc	0.23 cd
Accel 75ppm		2.08 c	1.10 c	0.26 bc
Control		2.21 bc	1.74 a	0.31 bc
	Jon-A-Red			
Carbaryl 0.05%		2.35 b	1.27 bc	0.24 d
Carbaryl 0.1%		1.96 c	1.10 c	0.24 d
Carbaryl 0.2%		2.45 b	1.35 bc	0.23 d
Accel 25ppm		2.25 c	1.01 cd	0.22 d
Accel 50ppm		2.10 c	1.15 cd	0.26 cd
Accel 75ppm		2.07 c	1.14 cd	0.23 d
Control		2.24 bc	1.03 cd	0.28 c
	Braeburn			
Carbaryl 0.05%		2.56 a	0.02 cd	0.27 cd
Carbaryl 0.1%		2.70 a	0.91 d	0.36 c
Carbaryl 0.2%		2.82 a	1.12 cd	0.45 b
Accel 25ppm		2.21 bc	1.20 c	0.35 c
Accel 50ppm		2.11 bc	1.18 c	0.31 cd
Accel 75ppm		2.25 bc	1.33 c	0.30 cd
Control		2.59 a	0.83 d	0.44 bc
L.S.D. (0.05)		0.35	0.20	0.10
S.E.		0.30		

Means with the same letter(s) are not significantly different at P= 0.05 using the least significant difference test. Cultivar and chemical thinners interaction is significant.

In 1996 percent Ca was only significantly increased by accel at 25ppm in 'Empire' and significantly increased by accel at 75ppm in 'Jon-A-Red' and by accel at 25ppm in 'Braeburn' (Table 6). In 1996 percent K in 'Empire' was significantly (P<0. 05) increased by accel at 75ppm. The rest of the treatments had no significant effect. Conversely, percent K was significantly increased only by carbaryl at 0.2% in 'Jon-A-Red'. All other treatments had no significant effect on the percent K in 'Braeburn (Table 6). Carbaryl at 0.1% significantly (P<0.05) increased the Fe content in 'Empire' in 1996 while accel at 25 and 50ppm significantly reduced it. All treatments had no significant effect on Fe content in 'Jon-A-Red' and 'Braeburn' (Table 6). Percent Zn in 'Empire' was significantly (P< 0.05) increased by accel at 25ppm and carbaryl at 0.1% while the treatments had no effect on percent Zn in 'Jon-A-Red' and 'Braeburn' (Table 6).

Table 6: Effects of accel and carbaryl on leaf mineral concentration of three apple cultivars grown at the Pontotoc Research and Extension Centre, 1996 experiment

Treatment	Cultivar	K%	P%	Fe	Mn%	Zn%	Mg%
	Empire						
Carbaryl 0.05%		1.19 c	0.15 cd	43.6 cd	86.7 bc	9.0 c	0.52 a
Carbaryl 0.1%		1.56 b	0.15 cd	57.0 ab	111.7 a	11.3 b	0.31 c
Carbaryl 0.2%		1.56 b	0.13 cd	46.7 c	63.0 bc	10.3 b	0.18 c
Accel 25ppm		1.13 c	0.13 cd	40.0 d	153 a	12.3 a	0.30 c
Accel 50ppm		1.45 c	0.14 cd	41.0 d	90.0 bc	10.3 b	0.23 c
Accel 75ppm		1.85 a	0.21 b	48.7 c	80.0 bc	9.7 b	0.18 c
Control		1.43 bc	0.14 cd	45.3 c	97.7 bc	11.0 b	0.25 c
	Jon-A-Red						
Carbaryl 0.05%		1.31 c	0.16 cd	55.6b	110.7 a	10.7 b	0.30 c
Carbaryl 0.1%		1.61 b	0.19 bc	60.7 ab	98.3 b	11.7	0.29 c
Carbaryl 0.2%		1.73 b	0.27 a	53.06 b	69.9 bc	11.0 b	0.28 c
Accel 25ppm		1.15 bc	0.18 b	58.0 ab	92.0 b	13.3 a	0.49 a
Accel 50ppm		1.41 bc	0.16 cd	58.7 ab	126.3 a	10.7 b	0.32 c
Accel 75ppm		1.53 bc	0.12 cd	60.3 ab	131.0 a	12.0 a	0.32 c
Control		1.42 bc	0.16 cd	56.7 ab	97.7 bc	12.4 a	0.23 d
	Braeburn						
Carbaryl 0.05%		1.78 ab	0.19 bc	57.3 ab	79.7 b	8.3 c	0.36 b
Carbaryl 0.1%		1.74 ab	0.16 c	59.7 a	117.3 ab	9.0 c	0.30 c
Carbaryl 0.2%		1.98 a	0.22 b	56.7 ab	60.7 bc	9.7 bc	0.20 c
Accel 25ppm		1.50 b	0.11 d	55.0 ab	79.7 bc	8.7 c	0.32 d
Accel 50ppm		1.50 b	0.09 d	51.3 b	49.3 c	8.0 c	0.28 b
Accel 75ppm		1.56 b	0.12 c	58.7 a	80.3 bc	8.0 c	0.27 b
Control		1.68 b	0.14 c	59.0 ab	110. 0 a	9.0 c	0.32 d
L.S.D. (0.05)		0.29	0.05	4.5	47.6	2.23	0.14
S.E.		0.08					

Means with the same letter(s) are not significantly different at P=0.05 using the least significantly difference test. Cultivar and chemical thinners interaction significant.

Percent Mn in 'Empire" in 1996 was significantly (P<0.05) increased by accel at 25 ppm and carbaryl at 0.1% while it was unaffected by any treatment in 'Jon-A-Red'.

Percent Mn in 'Braeburn' was significantly (P<0.05) reduced by accel at 50ppm and carbaryl at 0.2% (Table 6).

3.3 Effects of accel and carbaryl on fruit nutrition

Fruit flesh mineral composition was determined in 1996. Only P. K and Mg levels were significantly (P< 0.05) affected by the treatments. The level of K, in significantly reduced by carbaryl at 0.05% and 0.2% in 'Jon-A-Red'. Conversely all treatments had no significant effect on the K levels in 'Braeburn' (Table 7). In 'Empire' P levels were significantly (P<0.05) increased by carbaryl at 0.1% and 0.2% and accel at 75ppm while only carbaryl at 0.2% significantly increased the P levels in 'Jon-A-Red' (Table 7). At levels in 'Empire were significantly increased by accel at 50ppm and 75ppm while the rest of treatments had no significant effect on Mg levels in 'Empire', 'Jon-A-Red' and 'Braeburn'.

4.0 DISCUSSION

4.1 Effects of accel and carbaryl on fruit set and yield

The reductions of fruit set by all concentrations of accel and carbaryl is attributable to their thinning effects. Several workers have reported thinning effect of accel and carbaryl. Comparing carbaryl with Naphthalene acetic acid (NAA) as a petal fall spray, William (1993) reported reduced fruit set by carbaryl to one fruit per cluster with no adverse effects on foliage. He observed that carbaryl applied at petal-fall or at petal-fall plus 7 days effectively reduced fruit set in 'Fuji' and 'Delicious' apples. Other similar findings on carbaryl have been reported by Stiles (1995), Elfving and Cline and Wismer and Elfving (1995). Reports of thinning effect of accel have been obtained from Hull *et al* (1995) who used concentrations of 25 to 150ppm in 'Delicious', 'Empire' and 'Gala' apples; Black *et al* (1993) on 'Delicious' apples at concentrations of 15ppm to 75ppm and Stiles (1995) on 'Empire' apples at concentrations of 50ppm to 100ppm. Thinning effects of carbaryl and accel is believed to be due to increased competition in the partitioning of metabolites to fruit tissues which causes reduction in growth and eventual activation of abscission mechanisms (Knight 1983b).

Fruit yield was generally increased by the chemical thinners. Fruit thinning is done to reduce fruit set which increases fruit size (Westwood, 1993). Increasing the leaf to fruit ratio by removing some of the fruits causes the remaining fruits to be larger, but not in direct proportion to the increase in the number of leaves per fruit. This means some yield reduction (Westwood, 1993).

Table 7: Effects of accel and carbaryl on fruit mineral concentration of three apple cultivars grown at the Pontotoc Research and Extension Centre, 1996 Experiment.

Treatment	Cultivar	P%	K%	Mg%
	Empire			
Carbaryl 0.05%		0.30 d	0.73 c	0.11 b
Carbaryl 0.1%		0.09 c	0.75 ab	0.05 bc
Carbaryl 0.2%		0.09 c	0.76 ab	0.06 bc
Accel 25ppm		0.05 cd	0.84 ab	0.12 b
Accel 50ppm		0.04 d	0.80 ab	0.41 a
Accel 75ppm		0.86 a	0.78 ab	0.58 a
Control		0.05 d	0.72 ab	0.12 b
	Jon-A-Red			
Carbaryl 0.05%		0.05 d	0.60 c	0.03 c
Carbaryl 0.1%		0.05 d	0.82 ab	0.04 c
Carbaryl 0.2%		0.03 d	0.69 c	0.05 bc
Accel 25ppm		0.05 d	0.70 b	0.04 c
Accel 50ppm		0.05 d	0.77 ab	0.04 c
Accel 75ppm		0.06 d	0.64 c	0.04 c
Control		0.06 d	0.70 c	0.04 c
	Braeburn			
Carbaryl 0.05%		0.05 d	0.67 c	0.09 bc
Carbaryl 0.1%		0.08 d	0.71 b	0.10 b
Carbaryl 0.2%		0.10 b	0.81 ab	0.07 bc
Accel 25ppm		0.07 c	0.74 b	0.14 b
Accel 50ppm		0.08 c	0.79 b	0.12 b
Accel 75ppm		0.80 cd	0.64 c	0.07 bc
Control		0.06 cd	0.72 b	0.07 bc
L.S.D. (0.05)		0.04	0.10	0.10
S.E.		0.02	0.08	

Means followed by the same letter(s) are not significantly different at P= 0.05 using the least significant difference test. Cultivar and chemical thinners interaction significant.

Davis (1986) has reported that the yield of a blueberry plant is a function of factors such as flower bud-number, flower number per buds, fruit number and fruit size. The assumption has been that these factors contribute equally to yield. Nevertheless, the effects of thinning on yield has been contradictory (Forshey and Elfving, 1977). The results of the present study support the work done by Kaps and Cahoon (1989), Stiles (1995) and Wismer and Elfvingg (1995) who reported increased yields from thinning but differ with Valenzuela (1992), Blanco, 1987, Gambrelli *et al* 1983, Nielsen and Dennis, 1993; and Hull *et al,* 1995 who reported decreased yields from fruit thinning which could have been due to the different experimental conditions under which they carried out their experiments.

4.2 Effects of accel and carbaryl on leaf mineral composition

The effects of all chemical thinners on foliar nutrient concentrations may either be attributable to crop load-induced changes in foliar levels of N, Ca, Mg, K, Mn, Zn and Fe where increase in one mineral element from reduced fruit load may have induced lower levels of Ca and Mg and other mineral elements in the leaves (Elfving and Cline, 1993) or increased shoot growth resulting from their application (Elfving and Cline, 1993) which alters foliar mineral composition. Benzyladenine has been reported to increase shoot growth which induced changes in foliar K, Ca, and Mg concentrations (Elfving and Cline, 1993).

4.3 Effects of accel and carbaryl on fruit nutrition

As a result of leaf nutrient analysis for the 1995 experiment it was decided that fruit-flesh mineral composition be determined in 1996. From the results presented above (Table 7) only P, K and Mg levels in the fruit were affected. Plant growth regulators are classified as having direct and indirect effects on fruit mineral contents. The direct effects of plant growth regulators operate through decreasing the basipetal movement of auxin which in turn decreases the acropetal movement of mineral nutrients (Faust and Miller, 1989). As a result mineral content decreases. The indirect effects are associated with: a change in fruit size, elimination of shoot-fruit composition for nutrients, increase in root mass and elimination of mycorrhizae (Faust and Miller, 1989).

According to the direct effect of mineral nutrient transport there is evidence that acropetal transport depends on basipetal auxin transport (Bannelos *et al,* 1987). When auxin inhibitor is sprayed on apple trees as early as two weeks after bloom, Ca accumulation in the fruit is decreased (Stahly and Benson, 1982). Pac lobutrazol treatment decreased Ca content of 'Jonathan' apples on appear fruit basis by 28% one month after antithesis. The difference was reduced to 11% at maturity (Kallai *et al,* 1987). The direct effect of most plant growth regulators, therefore is to reduce Ca and other elements in the fruit. Indirectly, plant growth regulators often increase fruit mineral contents by reducing fruit size, eliminating sinks in the shoot and increasing root mass. Since these parameters were not determined in the present study it may be appropriate to attribute the effects of accel and carbaryl on fruit-flesh composition to either their direct or indirect effects on mineral nutrient transport.

5.0 CONCLUSIONS

Experiments were conducted to evaluate the Effluence of carbaryl and accel on fruit set yield and leaf and fruit mineral concentration. Since both accel and carbaryl effectively reduced fruit set of all cultivars in both years, we conclude that these chemicals can be used for g at the concentrations tested. Fruit yield was increased by carbaryl and accel in both of the years but this depended on the apple cultivar used and chemical concentration. It can therefore be concluded that carbaryl and accel at the concentrations used can increase yield of 'Empire', 'Jon-A-Red' and 'Braeburn'.

There were also inconsistencies in the effect of the treatments on the leaf mineral levels from year to year, but it can be concluded that depending on apple cultivar N content was reduced by the treatments while Ca and Mg generally increased. We therefore, conclude that the treatments only affected the levels of N, Ca and Mg consistently for the two years and increased fruit-flesh contents of K, P and Mg.

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