Comparison of New Blossom Thinners for Apples under Conditions of Intermountain West of the United States

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Abstract

Blossom thinners are caustic and reduce fruit set by damaging different flower parts, including anthers, stigma, style, and pollen tubes, and thus prevent fertilization. Elgetol (sodium dinitro-ortho-cresol (Elgetol, 19% a.i.) was previously used for blossom thinning in pome fruit. It was removed from the market in 1989 because of the high cost of re-registration. Elgetol's loss renewed research efforts to find blossom thinners with similar modes of action. Effects of various rates and/or timings of Dormex, ammonium thiosulfate (ATS), Endothal, and Wilthin on blossom thinning (fruit set), fruit quality, and yield of 'Delicious', 'Law Rome', 'Fuji' and 'Jonathan' apples (*Malus domestica* Bork.) were studied. All of these chemicals reduced the fruit set, with higher concentrations being more effective. Double application of these chemicals often resulted in more blossom thinning than a single application. Double application of ATS at a rate of 15 mL L^{-1} or a single application of this chemical at a rate of 25 mL L^{-1} resulted in satisfactory levels of thinning in 'Fuji' apple. Double application of ATS at a rate of 25 mL L^{-1} resulted in excess thinning and is not recommended for apples. A single application of Dormex at rate of 3.12 mL L^{-1} significantly reduced the fruit set of 'Law Rome'. Double application of Endothal caused fruit marking.

INTRODUCTION

Flower and fruit thinning of apples (*Malus domestica* Borkh.) is an important cultural practice since it increases fruit size the year of application and aids flower bud initiation for the following year. For several decades, growers have been spraying chemical thinners to reduce the labor costs. Several fruit thinners have been used for apple trees, such as 1-naphthyl-N-methylcarbamate (carbaryl), naphthaleneacetic acid (NAA), gibberellin (GA_{4+7}) and 6-benzylamino purine (Byers and Carbaugh, 1991; Ferree, 1996; Greene, 1984; Williams, 1993). Ammonium thiosulfate (ATS), hydrogen cyanamide (Dormex), endothalic acid (Endothal), perlargonic acid (Thinex), and sulfcarbamide (Wilthin) have been tested as possible replacements for Elgetol (Fallahi et al., 1997; Fallahi et al., 1998).

Even though these chemical bloom thinners effectively reduced fruit sets of certain apple cultivars, others have been ineffective (Byers, 1997; Fallahi, 1997; Williams, 1994). Also, some of these thinners possibly caused fruit marking (russeting) when sprayed at certain rates. Therefore, the objective of this study was to compare the effects various rates and timing of new bloom thinners on fruit set and fruit quality of 'Red Delicious', 'Law Rome', 'Fuji', and 'Jonathan' apple in the Intermountain West of the United States.

MATERIALS AND METHODS

A 'Delicious'/M.7 apple orchard (10 years old) was selected at the University of Idaho Parma Research and Extension Center near Parma, Idaho, USA. 'Fuji'/M.26 (6

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years old), ‘Jonathan’/M.7 (12 years old), and ‘Law Rome’/M.7 (12 years old) apple trees were located in commercial orchards of Canyon and Washington Counties, near Parma Idaho, USA.

Dormex and ATS were sprayed as blossom thinners to ‘Delicious’ and ‘Law Rome’ apple in 1998. A different set of ‘Law Rome’ apple trees were treated with ATS, Dormex, and Endothal in 1999. ATS was applied to ‘Fuji’ and ‘Jonathan’ apples in 2000. Additionally, a ‘Jonathan’ apple orchard was treated with Wilthin in 2000. Treatments for each study and the rates of each bloom thinner are described in each table. Modified phthalic glycerol alkyd resin (Latron B-1956, a.i. 77%) at the rate of 1.25 mL L^{-1} was used as surfactant with all Dormex treatments. Polyoxyethylenepolypropoxypropanol (Regulaid, a.i. 90.6%) at the rate of 1.25 mL L^{-1} was mixed with Wilthin and postbloom thinners. ATS and Endothal treatments did not receive any surfactant.

In 1998, a combination of Sevin WP50 at 0.6 g per L of water and NAA-800 at 0.0156 mL L^{-1} plus Regulaid at 5 mL L^{-1} was applied as postbloom thinner to ‘Delicious’ apple in certain treatments as shown in Table 1. A liquid formulation of Sevin (Sevin 4 F) at the rate of 1.25 mL L^{-1} mixed with NAA-800 at 0.023 ml L^{-1} plus Regulaid at 1.25 mL L^{-1} was applied as a postbloom thinner to certain treatments in ‘Rome’ in 1998 and ‘Fuji’ apples in 2000, as shown in Tables 2 and 4. Hand thinning (when applied) was performed after June drop to create a 12 to 15-cm spacing between fruits.

In single-applications, bloom thinners were sprayed when all king blooms plus one side bloom were open. In double application treatments, the first spray was performed when all king blooms were open and the second spray was applied when two side blooms were open. All blossom thinners were applied using an air-blast sprayer with 1871 L per hectare liquid delivery.

Three 1- to 2-m branches on each tree were selected, and number of blossom clusters before bloom and number of fruits after June drop were counted. Percentage of fruit set was calculated as number of fruit divided by number of blossom clusters x 100, and/or number of fruit divided by branch cross-sectional area. Thirty fruits were randomly sampled from each tree at normal harvest time of each year and average fruit weight was calculated. Fruit russeting (marking) status was assessed, and the percentage of fruit russeting was calculated in apples. The amount of apple fruit surface covered with pink or red was rated visually on a scale of 1 to 5, with 1 = 20% red progressively to 5 = 100% red. Yield per tree was recorded on the harvest day of each year.

The experimental design for all experiments was a completely randomized design with six replications.

RESULTS AND DISCUSSION

ATS and Dormex significantly reduced fruit set of ‘Red Delicious’ apple (Table 1). Average fruit weight of ‘Delicious’ apple was increased with sprays of bloom thinners and/or hand thinning or postbloom treatment. Most of treatments improved ‘Delicious’ fruit red color in 1998, but the values were not always statistically different. Fruit set of ‘Law Rome’ apple was significantly reduced by 3.12 mL of Dormex and both ATS treatments in 1998 (Table 2). The postbloom thinner (Sevin and NAA) plus hand thinning treatment significantly increased average fruit weight of ‘Law Rome’ apples in 1998 (Table 2). Both ATS at 24 mL and postbloom treatments significantly increased russeting rates of ‘Law Rome’ apple in 1998. Sevin 4F liquid formulation was used as a postbloom thinner and this formulation could have increased russetting in ‘Law Rome’ fruit in 1998. The postbloom treatment reduced ‘Law Rome’ fruit red color in 1998. Yield of ‘Law Rome’ apple trees was not affected by any thinning treatments in 1998 (Table 2).

In 1999, ATS, Dormex, and Endothal significantly reduced fruit set of ‘Law Rome’ apple (Table 3). Average fruit weights and fruit color of ‘Law Rome’ apple were not affected by any bloom thinners treatments in 1999, because yield was drastically reduced by frost injury, eliminating fruit-to-fruit competition. Double application of Endothal induced the highest rate of fruit russeting in ‘Law Rome’ apple, and yield was significantly decreased with this treatment (Table 3).

Most ATS treatments on 'Fuji' apples, except the 15 mL L^{-1} rate and the postbloom treatment, had significantly lower fruit sets than control (Table 4). Compared with control, average fruit weight of 'Fuji' apples was not significantly affected by ATS treatments.

Single or double application of ATS at rate of 25 mL L^{-1} significantly reduced fruit set of 'Jonathan' apple in 2000 (data not shown). 'Jonathan' trees receiving a single or double application of 15 or 25 ml of ATS per liter had higher average fruit weights and lower russeting rates than those receiving only postbloom fruit thinners in 2000. Lower russeting in the fruits that received ATS could be due to suppression of powdery mildew by the sulphur in the chemical. However, Wilthin had no significant effects on fruit set, average of fruit weight, or russeting rates of 'Jonathan' apple in 2000. Fruit color of 'Jonathan' apple was not affected by any ATS or Wilthin thinner treatments (data not shown).

The results of our studies showed that ATS, Dormex, and Endothal effectively reduced the fruit set of 'Red Delicious', 'Law Rome', 'Fuji', and 'Jonathan' apple trees. These results confirm previous studies (Fallahi et al., 1997; Fallahi et al., 1998; Taylor, 1998; Williams, 1994; Williams, 1998). In most of cases, higher concentrations and double applications of bloom thinners caused more thinning than lower concentrations and single applications. Double application of ATS at a rate of 15 mL per liter of water or a single application of this chemical at a rate of 25 mL in a liter of water caused satisfactory thinning of 'Fuji' apple. Double application of ATS at a rate of 25 mL in a liter resulted in excess thinning and is not recommended for 'Fuji' apple (Table 4).

It should be kept in mind that effectiveness of blossom thinners is influenced by several factors, including, rate of flower fertilization, concentrations of the blossom thinners, temperature, and frequency and time of application.

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Tables

Table 1. Effect of ATS and Dormex on fruit set, fruit quality, and yield of 'Delicious' Apples in 1998 [z].

Treatment [y]	Fruit set [x]	Avg. fruit wt (g)	Fruit color (1-5)
Control	8.83 a	99.91 e	2.70 cd
1.56 mL Dormex/L	6.54 b	128.05 d	3.00 bcd
2.34 mL Dormex/L	5.92 b	140.48 abcd	3.00 bcd
16 mL ATS/L	5.67 b	128.52 cd	3.06 bcd
24 mL ATS/L	5.78 b	136.28 bcd	3.31 abc
1.56 mL Dormex/L+Sevin&NAA	-	140.58 abcd	2.63 d
2.34 mL Dormex/L+Sevin&NAA	-	138.27 abcd	3.00 bcd
1.56 mL Dormex/L+Hand	-	140.44 abcd	3.63 ab
2.34 mL Dormex/L+Hand	-	145.69 abcd	3.50 ab
1.56 mL Dormex/L Sevin&NAA+Hand	-	140.77 abcd	3.25 abcd
2.34 mL Dormex/L Sevin&NAA+Hand	-	155.34 a	3.25 abcd
16 mL ATS/L+Sevin&NAA	-	151.28 ab	3.63 ab
24 mL ATS/L+Sevin&NAA	-	146.60 abc	3.13 abcd
16 mL ATS/L+Hand	-	142.15 abcd	3.19 abcd
24 mL ATS/L+Hand	-	141.39 abcd	3.44 ab
16 mL ATS/L+Sevin&NAA+Hand	-	154.17 ab	3.25 abcd
24 mL ATS/L+Sevin&NAA+Hand	-	150.32 ab	3.50 ab
Hand	-	128.37 d	3.75 a
Sevin&NAA+Hand	-	133.89 abcd	3.35 abc

[z] Mean separation within columns of each year by LSD at $\alpha \leq 0.05$.

[y] Dormex treatments were sprayed with Latron B-1959, as a surfactant (1.25 mL L^{-1}). Sevin&NAA treatment consisted of 0.6 g of Sevin (carbaryl) WP50 plus 0.0156 mL of NAA-800 plus 1.25 mL of Regulaid per liter of water, sprayed at 1871 L per hectar as a postbloom thinner in some treatments as shown in the table. Hand thinning (when applied) was done after June drop.

[x] Fruit set = Number of fruit/Branch cross-sectional area (cm^2).

Table 2. Effect of ATS and Dormex on fruit set, fruit quality, and yield of 'Law Rome' apple in 1998 [z].

Treatment [y]	Fruit set [x] (%)	Avg. fruit wt (g)	Russeting rates (%)	Fruit color (1-5)	Yield (kg/tree)
Control (Handthinng only)	105.50 a	173.78 b	0.00 c	4.54 ab	108.68 a
2.50 mL Dormex/L+Hand	85.28 ab	173.68 b	0.00 c	4.54 ab	109.63 a
3.12 mL Dormex/L+Hand	82.06 bc	172.92 b	9.67 bc	4.38 bc	103.91 a
16 mL ATS/L+Hand	75.80 c	165.73 b	0.00 c	4.29 c	109.63 a
24 mL ATS/L+Hand	82.06 bc	177.94 b	21.33 ab	4.68 a	103.91 a
Sevin&NAA-800 +regulaid+Hand	-	218.47 a	31.83 a	3.67 d	112.49 a

[z and y] Dormex treatments were sprayed with Latron B-1959, as a surfactant (1.25 mL L^{-1}). ATS treatments did not receive any surfactant. Sevin& NAA-800 consisted of Sevin 4 F (carbaryl) at 1.25 mL L^{-1} plus 0.023 mL NAA-800 per L plus 1.25 mL of Regulaid per L. Mean separation within columns by LSD at $\alpha \leq 0.05$.

[x] Fruit set = Number of fruit/100 clusters.

Table 3. Effect of ATS, Dormex and Endothal on fruit set, fruit quality, and yield of 'Law Rome' apple in 1999[z].

Treatment[y]	Fruit set[x] (%)	Avg. fruit wt (g)	Russeting rates (%)	Fruit color (1-5)	Yield (kg/tree)
Control (No thinning)+Hand	106.27 a	248.76 a	28.68 abc	3.79 a	23.83 a
16 mL ATS/L+Hand	62.59 b	236.19 a	35.40 ab	3.79 a	21.28 abc
24 mL ATS/L+Hand	40.61 b	237.58 a	22.30 c	3.58 a	16.51 abc
3.12 mL Dormex/L+Hand	56.65 b	240.47 a	34.38 ab	3.75 a	17.16 abc
3.75 mL Dormex/L+Hand	30.00 b	233.38 a	26.59 bc	3.58 a	11.92 bc
1.25 mL Endothal/Ltwice+ Hand	48.28 b	232.13 a	40.92 a	3.58 a	9.95 c
1.88 mL Endothal/Lonce+ Hand	57.14 b	233.44 a	33.20 abc	3.83 a	22.88 ab

[z and y] Dormex treatments were sprayed with Latron B-1959 at 1.25 mL L^{-1} as a surfactant. ATS and Endothal treatments did not receive any surfactant. Mean separation within columns by LSD at $\alpha \leq 0.05$.

[x] Fruit set = Number of fruit/100 clusters.

Table 4. Effect of chemical thinning on 'Fuji' apple fruit in 2000[z].

Treatment[y]	Fruit set[x] (%)	Avg. fruit wt (g)	Russeting rates (%)	Fruit color (1-5)
Control	133.2 a	205.99 ab	23.3 a	3.39 a
15 mL ATS/L once+PB	114.4 ab	228.96 a	8.3 b	2.91 ab
15 mL ATS/L twice+PB	95.3 bc	198.37 ab	15.0 ab	2.42 b
25 mL ATS/L once+PB	77.0 cd	215.18 ab	18.3 ab	3.08 ab
25 mL ATS/L twice+PB	56.3 d	191.11 b	18.3 ab	2.58 b
30 mL ATS/L once+PB	97.0 bc	220.60 ab	12.9 ab	2.59 b
PB	122.2 ab	203.95 ab	15.0 ab	2.78 ab

[z] Mean separation within columns of each year by LSD at $\alpha \leq 0.05$.

[y] No surfactant was used with ATS treatments. PB = Post Bloom thinner which consisted of a mixture of Sevin 4 F (carbaryl) at 1.25 mL L^{-1} plus 0.023 mL NAA-800 per liter plus 1.25 mL of Regulaid per L. Mean separation within columns by LSD at $\alpha \leq 0.05$.

[x] Fruit set = Number of fruit/100 clusters.