Agricultural Research & Technology
Open Access Journal
ISSN: 2471-6774

Juniper Publishers
key to the Researchers

Research Article
Volume 25 Issue 2 - December 2020
DOI: 10.19080/ARTOAJ.2020.25.556304

Agri Res & Tech: Open Access J

Potential and Challenges of Branched Secondary Alcohol Ethoxylate and Fish Oil Applications as Blossom Thinners in Apples

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Submission: November 27, 2020; **Published:** December 08, 2020

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Abstract

Thinning excessive fruit in apples is an essential but expensive cultural practice and the use of blossom thinners can facilitate this practice. To assess the potential and challenges of branched secondary alcohol ethoxylate (Tergitol TMN-6) and Crocker Fish Oil (CFO) as blossom thinners, their impacts on fruit set, yield, and fruit quality of "Delicious", 'Top Export Fuji' and 'Early Spur Rome' apples (*Malus domestica Borkh*)were studied. Application of Tergitol TMN-6 at all rates reduced fruit set, yield per tree, and fruit weight in 'Top Export Fuji'. Applications of Tergitol TMN-6 at all rates in "Delicious" and at the rate of 3.12 mL.L-1 in "Top Export Fuji" apples were challenging and caused phytotoxicity, induced fruit russeting in both cultivars and resulted in smaller fruit and lower yield in "Top Export Fuji". The exent of russeting was diercetly proporotional to the Tergitol TMN-6 rate. The use of CFO at 30 mL.L-1 alone did not have any significant effects on yield per tree, fruit weight, or fruit color, while significantly reduced fruit sunburn and increased fruit russeting in 'Top Export Fuji'. In 'Early Spur Rome' apple, application of Tergitol TMN-6 at or higher than 1.87 mL.L-1reduced fruit set. Despite fruit set reduction, application of Tergitol TMN-6 at the rate of 1.87 mL.L-1 did not reduce total yield per tree, fruit weight, fruit color, or fruit russeting when compared to Un-treated Control and thus, this rate can be recommended for blossom thinning in 'Early Spur Rome' apple.

Crop Regulation; Fruit thinning; PomeFruit Blossom Thinning; Malus domestica; Regular Cropping

Introduction

Apple crops often need to be thinned to create a balance between leaf/fruit to reduce biennial bearing habit and to produce marketable fruit, with optimum size and quality attributes [1-5]. Blossom thinners are usually caustic and reduce fruit set by damaging different flower parts, including anthers, stigmas, styles, and pollen tubes, and thus prevent fertilization [3,4]. Hydrogen cyanamide (Dormex, 50% a.i.) is an effective blossom thinner for peaches and plums [6,7]. In commercial trials in Idaho, USA, Dormex was found to be a consistent and effective blossom thinner for apples when applied at about 80% bloom [8]. Monocarbamide dihydrogensulfate (Within) has been used for blossom thinning in apples [2] and stone fruit [5-10]. In a comparison of ammonium thiosulfate (ATS), Wilthin, and Endothall, ATS was the best blossom thinner under Washington conditions [5]. In California, a full-bloom application of the surfactant N, N-bis2-(omegahydroxypolyoxyethylenepoly-oxypropylene) ethyl alkylamine (Armothin) at 30 $mL.L^{-1}$ or 5 $mL.L^{-1}$ reduced fruit set in 'Loadel' peach [11]. Miller and Tworkoski reported that application of eugenol at 8% and 10% caused major caustic effects but application of this compound at 1% or 2% showed promising results on peach blossom thinning. Surfactant 2,6,8-trimethyl-4-nonyloxypolyethyleneoxyethanol (Tergitol) TMN-6 (90% aq.) was at least one of the putative active ingredients of Surfactant WK, a surfactant that was labeled by DOW Chemical Company. Surfactant WK had a different mode of action than most other caustic thinners that are only toxic to pistils and/or stamens [12]. This chemical killed peach flowers by killing peduncles and pistils [12]. Wilkins et al. [13] reported that Tergitol-TMN-6 effectively reduced fruit set in 'Fireprince' peach under climatic conditions of Clanton, Alabama, USA. In that report, there was no difference in thinning response at full bloom or petal fall, suggesting a wide window of efficacy for this chemical. Fallahi et al. [14] reported that Terittol-TMN-6 at 5 $mL.L^{-1}$ rates, applied at 75% to 85% bloom, reduced fruit set in peaches.

Rex lime sulfur (29% calcium polysulfide) at 3% plus 2% JMS stylet oil causes significant russeting and reduced pack out, whereas low rates (e.g. 1% lime sulfur and 1% JMS stylet oil) had no significant thinning effect in apples under conditions of West Virginia [15]. Blossom thinning using 1.5-2% Rex lime sulfur and 2% oil showed acceptable thinning results and less fruit russeting in apples [16]. Choosing a risk-free and a reliable blossom thinner for apples is an extremely difficult task as most fruit-producing regions face with the risk of frost damage during bloom. Apple growers spend between $1200-2400 per ha for hand thinning of apples (personal knowledge). The increasing cost of fruit production and labor issues in the globally competitive fruit market mandates discovery of a reliable blossom thinner for pome fruits. Thus, the goal of this study was to determine potential and challenges associated with the use of Tergitol TMN-6 and Crocker Fish Oil (CFO) as blossom thinners, by studying their effects on fruit set, yield, fruit size, fruit color, and fruit russeting. Any blossom thinner and favorable spray conditions that would lead to a fruit set reduction with an optimum yield, fruit size, and acceptable "fruit finish" is considered desirable. However, any blossom thinner that result in an excessive fruit russeting, is considered a challenge for apple fresh market, and thus for that blossom thinner.

Materials and Methods

Apple Experiments

General Description of Experiments

Three experimental apple orchards were used in this study. For 'Top Export Fuji' apple, the experimental orchard was a 5- or 6-year-old 'Top Export Fuji' on RN-29 rootstock with a 1.52 x 4.27-m tree spacing in both Years 1 and 2. For 'Early Spur Rome' in Year 1, the experimental orchard was a 7-year-old 'Early Spur Rome' on M.7 EMLA rootstock with a 2.13 x 4.27-m tree spacing. For 'Delicious' apple in Year 1, trees in a 15-year-old orchard on M.7 EMLA rootstock with a 2 x 5-m tree spacing was used. All experimental orchards were established at the University of Idaho Parma Research and Extension Center, near Parma, Idaho, USA. Soil in the orchard was sandy loam with pH of approximately 7.3. Other than blossom and post-bloom thinning treatments, all cultural practices were performed according to the commercial orchard standards [17]. In addition to the blossom thinning treatments, 'Top Export Fuji' and 'Early Spur Rome' apples were sprayed with a mixture of post-bloom thinner (PB) consisted of Sevin 4 F at 1.25 mL.L^{-1}, Ethrel at 1.25 mL.L^{-1}, Amid Thin at 375 mg.L^{-1}, plus Regulaid at 1.25 mL.L^{-1} and was sprayed at petal fall (about May 6, when temperature was about 20°C, reaching to maximum of about 26°C. each year). After June drop, fruits in all treatment were counted for fruit set calculation and then hand thinned to maintain 13 to 15 cm spacing between fruits. Fruit set in apples was calculated as the number of fruits after June drop divided by number of mixed buds x 100. Air blast sprayers were used to deliver 1871 L.ha^{-1} in all experiments throughout this study.

After June drop in each year, fruits in all treatment and cultivars were counted for fruit set calculation and then hand thinned to maintain 14 to 16 cm spacing between fruits. Apple yield was recoded and thirty fruits per tree were randomly sampled from each apple cultivar at harvest (around October 20 in 'Top Export Fuji' and 'Early Spur Rome' and September 20 in 'Delicious'), and average fruit weight was calculated. Fruit russeting (marking) status was visually assessed, and the percentage of russeting was calculated. The amount of fruit surface covered with red was rated visually on a scale of 1 (least red color) to 5 (most red color).

Blossom Thinning Treatments

Blossom thinning treatments on 'Top Export Fuji', 'Early Spur Rome', and 'Delicious' apple trees in Year 1 were as follows:

i. Control + Hand, where trees received no thinning treatments, but received only a hand thinning.

ii. Terg 1.875 mL.L^{-1} + PB +Hand, where trees received Tergital TMN-6 at the rate of 1.875 mL.L^{-1} once plus a PB plus hand thinning.

iii. Terg2.5 mL.L^{-1} + PB +Hand, where trees received Tergital TMN-6 at the rate of 2.5 mL.L^{-1} once plus a PB plus hand thinning.

iv. Terg3.12 mL.L^{-1} + PB +Hand, where trees received Tergital TMN-6 at the rate of 3.12 mL.L^{-1} once plus a PB plus hand thinning.

In Year 1, both 'Top Export Fuji' and 'Early Spur Rome' trees were sprayed with each blossom thinner treatment on April 28, when about 85% of blooms (king bloom plus 1 or 2 side blooms; Figures 1 and 2) were open, and temperature during thinning applications was about 21°C, reaching a maximum of 25°C. 'Delicious' apples were sprayed at 85% bloom on April 23 in Year1, when temperatures were about 20 to 23°C during applications.

Blossom thinning treatments on 'Top Export Fuji' trees in Year 2 were as follows:

i. Control + Hand, where trees received no thinning treatments, but received only a hand thinning.

ii. FO 30 ml.L^{-1} + Hand, where trees received Crocker Fish Oil (CFO) at the rate of 30 mL.L^{-1} once plus a post-bloom thinner (PB) plus hand thinning.

iii. Terg 1.875 mL.L^{-1} + FO 30 ml.L^{-1} + PB + Hand, where trees received Tergital TMN-6 at the rate of 1.875 mL.L^{-1} once plus CFO at the rate of 30 mL.L^{-1} once plus a PB plus hand thinning.

iv. Terg 3.75 mL.L^{-1} + FO 30 ml.L^{-1} + PB + Hand, where trees received Tergital TMN-6 at the rate of 3.75 mL.L^{-1} once plus CFO at the rate of 30 mL.L^{-1} once plus a PB plus hand thinning.

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In Year 2, 'Top Export Fuji' trees were sprayed with each blossom thinner treatment on April 28, when about 85% of blooms (king bloom plus 1 or 2 side blooms); (Figure 1) were open, and temperature during thinning applications was about 22.2°C, reaching a maximum of 24.4°C.

Figure 1: Fuji' apples in 85% bloom stage, when all king blooms and one or two side blooms were open.

Experimental Design

Each experiment in this study was arranged according to a randomized complete block design with three blocks. Each block consisted of two adjacent rows with five trees per treatment and thus a total of 30 data trees per experiment with three buffer rows between adjacent blocks and four guard trees between different plots of treatments within each block were used to prevent any cross contamination from the sprays.

Results and Discussion

'Top Export Fuji' Apple Experiment in Year 1

Application of Tergitol TMN-6 at 3.12 mL.L^{-1} significantly reduced fruit set and yield per tree in 'Top Export Fuji' (Figure 3). Total yield per tree usually has an inverse relationship with fruit weight. However, in our study, application of Tergitol TMN-6 at the rate of 3.12 mL. L^{-1} reduced fruit set and yield per tree, while did not increase fruit size (Table 1). Also, fruit color in the Un-treated Control trees were similar to those receiving Tergitol TMN-6 at the rate of 3.12 mL.L-1 and fruit from both treatments had lower red color than those receiving 1.87 mL. L^{-1} or 2.5 mL. L^{-1} in Year 1 (Table 1). The results in fruit set, fruit size, yield, and fruit color clearly indicate that application of Tergitol TMN-6 at 3.12 mL. L^{-1} was an excessive rate and caused some phytotoxicity, leading to less carbohydrate formation and transport from the leaf into the fruit tissue, causing smaller size and lower yield.

Application of Tergitol TMN-6 at all rates significantly increased fruit russeting as compared to Un-treated Control in Year 1 (Table 1). The extent of russeting increased with each incremental increase in the rate of Teritol TMN-6 application (Figure 4).

'Top Export Fuji' Apple Experiment in Year 2

Application of CFO at 30 mL× L^{-1} alone did not have any significant effects on yield per tree, fruit weight, or fruit color, while significantly reduced fruit sunburn and increased fruit russeting in 'Top Export Fuji' in Year 2 (Table 2). Reduction of sunburn after application of CFO in 'Fuji' apple had not been reported previously. Application of CFO could have created reflective layer on the fruit surface, preventing fruit from sunburn, and this area deserves further investigation.

Adding Tergitol TMN-6 at 1.87 mL× L^{-1} or 2.5 mL. L^{-1} to CFO at 30 mL× L^{-1} reduced yield per tree but increased fruit russeting in 'Top Export Fuji' apple in Year 2 (Table 2). Fruit weight and color were not affected by either CFO or CFO plus Tergitol TMN-6 applications at any concentrations (Table 2).

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Figure 2: 'Early Spur Rome' apple, before Tergitol TMN-6 application in Year 1.

Figure 3: 'Top Export Fuji' apples, 7 hours after Tergitol TMN-6 application.

'Early Spur Rome' Apple Experiment in Year 1

Application of Tergitol TMN-6 at all rates significantly reduced fruit set, as expressed on a number of fruit/branch cross sectional area or number of fruit set in 100 cluster mixed bud bases. Despite fruit set reduction, application of Tergitol TMN-6 at the rate of 1.87 mL. L^{-1} did not reduced total yield per tree, fruit weight, fruit color, or fruit russeting when compared to Un-treated Control in

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'Early Spur Rome' in Year 1. Thus, application of Tergitol at 1.87 mL.L^{-1} seemed to be an optimum rate for fruit thinning in 'Early Spur Rome' in Year 1 (Table 3). Lack of fruit size difference among treatments was because fruits of all treatments were hand thinned in June, providing enough leaf/fruit ratio in most treatments.

Figure 4: High rates of Tergitol TMN-6 caused severe russeting in 'Delicious' (left) and 'Top Export Fuji' apple fruits.

Table 1: Effect of blossom thinners on fruit set, fruit quality attributes, and yield in 'Top Export Fuji' apple in Year1.

Blossom Thinner & Bloom Stage	Fruit set (No/BCSA)[y]	Yield(kg/tree)	Avg. Fruit weight (g)	Fruit color (1-5)[z]	Fruit russet (%)
Un-treated Control	5.16 aX	13.04 a	284.6 b	2.84 a	49.6 b
Terg1.87mL.L^{-1}@ 85%Bl	5.39 a	10.46 ab	310.0 a	3.41 a	74.2 a
Terg2.5mL.L^{-1}@85%Bl	6.18 a	8.04 bc	298.2 a	3.43 a	82.6 a
Terg3.12mL.L^{-1}@85%Bl	2.08 b	5.47 c	284.2 b	2.68 a	85.0 a

[z]Fruit color ranking: 1= green, progressively to 5= uniform red.
[Y]BCSA = Branch Cross Sectional Area in cm^{-2}.
[X]Mean separation within each column by LSD at 5% level.

Table 2: Effect of blossom thinners on fruit set, fruit quality attributes, and yield in 'Top Export Fuji' apple in Year 2.

Blossom Thinner & Bloom Stage	Yield(kg/tree)	Avg. Fruit weight (g)	Fruit color (1-5)[z]	Fruit sun-burn (%)	Fruit russet (%)
Un-treated Control	22.4 ab Y	296.8 a	3.31 a	10.8 a	1.39 c
FO30 mL.L^{-1}80%Bl	24.0 a	305.2 a	3.28 a	3.3 b	18.75 b
Terg1.87 mL.L^{-1} Plus FO30 mL.L^{-1}80%Bl	18.4 b	297.5 a	3.59 a	4.3 ab	35.3 b
Terg3.75 mL.L^{-1} Plus FO30 mL.L^{-1}@80%Bl	18.7 b	292.5 a	3.04 a	7.5 ab	77.90 a

[z]Fruit color ranking: 1= green, progressively to 5= uniform red.
[y]Mean separation within each column by LSD at 5% level.

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Table 3: Effect of blossom thinners on fruit set, quality attributes, and yield in 'Early Spur Rome' apple in Year1.

Blossom Thinner & Bloom Stagez	Fruit set (No/BCSA) Y	Fruit set (fruit/100 buds)	Yield(kg/tree)	Fruit weight (g)	Fruit color (1- 5)Z	Fruit russet (%)
Un-treated Control	16.17 aX	92.7 a	64.3 a	258.5 a	4.67 b	14.36 c
Terg1.87mL.L^{-1}@ 85%Bl	12.28 b	67.9 b	60.4 a	258.6 a	4.69 b	15.15 c
Terg2.5mL.L^{-1}@85%Bl	9.99 b	63.8 bc	47.4 b	262.0 a	4.75 ab	26.56 b
Terg3.12mL.L^{-1}@85%Bl	10.26 b	53.7 c	41.6 b	271.4 a	4.80 a	37.29 a

[z]Fruit color ranking: 1= green, progressively to 5= uniform red.
[y]BCSA = Branch Cross Sectional Area in cm^{-2}.
[x]Mean separation within each column by LSD at 5% level.

'Delicious' Apple Experiment in Year 1

Tergitol TMN-6 treatments at all rates reduced fruit set (data not reported) but caused severe and unacceptable levels of fruit russeting (Figure 4). Therefore, we don't recommend application of Tergitol TMN-6 at the tested levels for this cultivar.

Conclusions and General Remarks

An assessment of results in Years 1 and 2 revealed that application of Tergitol TMN-6 at 1.87 mL. L^{-1} can be beneficial, particularly in 'Early Spur Rome'. At this rate, yield per tree was similar to those Un-treated Control while fruit size was slightly or significantly larger than those in the Untreated control (Tables 1-3). Also, fruit russeting in the trees receiving 1.87 mL. L^{-1} were as low as those in the Un-treaded Control in 'Early Spur Rome' (Table 3) and lower than trees with higher than that 1.87 mL. L^{-1} Tergitol TMN-6 sprays in 'Top Export Fuji' apples. Tergitol TMN-6 at the rates used in this study is a suitable blossom thinner for 'Delicious' due to induction of severe fruit russeting. Application of CFO had very limited effects on fruit set and quality attributes. However, reduction of sunburn as a result of CFO application is extremely important, with a huge impact on apple growers and thus deserves further study.

Acknowledgements

The author wishes to express his gratitude to the Idaho Apple Commission and the Idaho Agricultural Experiment Station for their financial support of this project. Technical assistance of Ms. Bahar Fallahi throughout this project is gratefully appreciated.

References

1. Fallahi E (1997) Application of endothallic acid, pelargonic acid, and hydrogen cyanamide for blossom thinning in apple and peach. Hort Technology 7(4): 395-399.
2. Fallahi E, Williams MW, Colt WM (1997) Blossom thinning of 'Law Rome Beauty' apple with hydrogen cyanamide and monocarbamide dihydrogen sulfate. J Tree Fruit Prod 2(1): 33-44.
3. Fallahi E, Willemsen K (2002) Blossom thinning of pome and stone fruit. Hort Science 37(3): 474-476.
4. Hildebrand EM (1944) The mode of action of the pollenicide, Elgetol. Proc. Amer. Soc. Hort. Sci. 45:53-58.
5. Warner G (1998) Consistent tonnage needed for profitability. Good Fruit Grower 49(7): 9-10.
6. Fallahi E, Kilby M, Moon JW (1990) Effects of various chemicals on dormancy, maturity and thinning of peaches. Deciduous Fruit and Nut. University of Arizona, College of Agri. Rpt. Ser. 83: 121-128.
7. Fallahi E, Simons BR, Fellman JK, Colt WM (1992) Use of hydrogen cyanamide for apple and plum thinning. Plant Growth Regular 11: 435-439.
8. Fallahi E, Lee RR, Lee GA (1998) Commercial-scale use of hydrogen cyanamide for blossom thinning of apple and peach. HortTechnology 8(4): 556-560.
9. Fallahi E (1998) The use of blossom thinners for regular cropping deciduous fruit trees. Proc. Plant Growth Regulation Society of America. p. 27-33.
10. Greene D, Hauschild WKI, Krupa J (2001) Effect of blossom thinners on fruit set and fruit size of peaches. Hort Technology 11(2): 179-183.
11. Southwick SM, Weis KG, Yeager JT, Rupert ME (1998) Blossom thinning of 'Loadel' cling peach with a surfactant: Effects of concentration, carrier volume, and differential applications within the ccanopy. HortTechnology 8(1): 55-58.
12. Byers RE, Lyons Jr CG (1985) Peach flower thinning and possible sites of action of desiccating chemicals. J. Amer. Soc. Hort. Sci. 110(5): 662-667.
13. Wilkins BS, Ebel RC, Dozier WA, Pitts J, Boozer R (2004) Tergitol-TMN-6 for thinning peach blossoms. HortScience 39(7): 1611-1613.
14. Fallahi E, Fallahi B, McFerson JR, Byers RE, Ebel RC, et al. (2006) Tergitol-TMN-6 surfactant Is an effective blossom thinner for stone fruits. HortScience 41(5): 1243-1248.
15. Miller SS, Tworkoski T (2010) Blossom thinning in apple and peach with essential oil. HortScience 45(8):1218-1225.
16. Sherif S (2020) Apple blossom thinning: general overview and updates.
17. Wenatchee (2020) Tree Fruit Research and Extension Center, Washington State University.

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