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Thinning Scab-resistant Apples with Liquid Lime Sulfur Sprays during Bloom

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Abstract
Growing scab-resistant apple cultivars on fully dwarfing rootstocks increases the feasibility for producing organically grown apples in the Midwest. However, in an organic orchard, fruit thinning to optimize crop load must be done by hand at a very high labor expense. The alternative is biennial bearing and inconsistent supply to meet consumer demands. Recently, sprays containing organicapproved materials such as liquid lime sulfur, fish, and various vegetable oils, salts, and kaolin have been tried alone or in combination for thinning apples with some degree of success. Lime sulfur alone or in combination with spray oil was recently labeled for use in Washington state orchards. This study was undertaken to evaluate the effectiveness of liquid lime sulfur alone and in combination with spray oil applied at various times during bloom on thinning three scab-resistant apple cultivars under Iowa conditions.

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Introduction

Growing scab-resistant apple cultivars on fully dwarfing rootstocks increases the feasibility for producing organically grown apples in the Midwest. However, in an organic orchard, fruit thinning to optimize crop load must be done by hand at a very high labor expense. The alternative is biennial bearing and inconsistent supply to meet consumer demands. Recently, sprays containing organic-approved materials such as liquid lime sulfur, fish, and various vegetable oils, salts, and kaolin have been tried alone or in combination for thinning apples with some degree of success. Lime sulfur alone or in combination with spray oil was recently labeled for use in Washington state orchards. This study was undertaken to evaluate the effectiveness of liquid lime sulfur alone and in combination with spray oil applied at various times during bloom on thinning three scab-resistant apple cultivars under Iowa conditions.

Materials and Methods

A portion of an 8-year-old scab-resistant apple orchard located at the ISU Horticulture Research Station containing Redfree, Liberty, and GoldRush apple trees on M.9 rootstock and trained to a vertical axis was used for the study. Because the mode of action of lime sulfur is to kill the vital floral parts with some "kick-back" action, multiple applications were evaluated. Spray oil has been shown to increase the effectiveness of lime sulfur and the original plans were to use organically-approved JMS Style-Oil, however, it was not registered for use in Iowa. On short notice, dormant oil (BioCover MLT) was substituted for JMS Style-Oil. Treatments included: 4 percent liquid lime sulfur (LS) applied 2 or 3 times (2x, 3x), 2 percent liquid lime sulfur plus 1 percent dormant oil (LS+O) applied 2x or 3x, and a water only control (Table 1). Treatments were applied to run-off with a hydraulic spray gun on single-tree plots replicated nine times in a randomized complete block design.

At about 7 to 10 days after the last treatment, when fruit set could be determined, fruits remaining on the trees were counted, and any fruit in excess of a pre-determined number of 6 fruit per cm^2 trunk cross-sectional area (TCA) were removed by hand and the time required to remove the fruit was recorded. At harvest, the number and weight of fruit per tree were recorded. Data was analyzed in a split-plot design with cultivar whole plots and thinning treatment sub plots. Often there was a significant cultivar by thinning treatment interaction, and then the data were re-analyzed and presented by cultivar.

Results & Discussion

All LS and LS+O treatments induced phyto-toxicity symptoms on the leaves and killed some spur blossom clusters and axillary blossom clusters (Figures 1, 2 and Table 2). Symptoms were more severe on Redfree and Liberty than on GoldRush, and for each cultivar, three applications of LS or LS+O caused more injury than two applications. Spur and axillary blossom cluster mortality was greatest on Redfree with 3x LS+O causing the most injury. No dead spur

blossom cluster and very few dead axillary blossom clusters were evident on GoldRush trees.

Based on the number of fruit harvested per tree and the target of six fruit per cm^2 of the spring trunk cross sectional area, 3x LS+O over-thinned Redfree and Liberty, and insufficient hand thinning was performed on controls and some other trees (Table 2). For GoldRush, LS applications seemed to be somewhat more effective than LS+O. Fruit yield per tree and yield efficiency reflected these trends. Although 3x LS+O over thinned Redfree and Liberty, the average fruit weight was lower than on the controls, with the other treatments being intermediate and not different from either. For GoldRush, which exhibited somewhat less severe phytotoxic symptoms and the least spur and axillary shoot injury, fruit weight seemed to be inversely related to the crop load.

Based on the recorded time to thin the trees and number of harvested fruit over the target of 6 per cm^2 of the spring TCA, we were able to predict the time required to properly thin the trees (Table 2). For Redfree, 3x LS and both 2x and 3x LS+O significantly reduced the thinning time when compared with the water only control. For Liberty and GoldRush, all LS and LS+O treatments reduced the thinning time compared with the controls.

In conclusion, LS and LS+O sprays can thin scab-resistant apples and reduce the hand labor required for thinning an organic orchard. Two applications of LS or LS+O cause less injury to the foliage than three applications of either, did not over thin, and generally reduced the hand thinning labor requirement when compared with the controls. A reduction in fruit size on lime sulfur-sensitive cultivars such as Redfree and Liberty is a concern.

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Table 1. Liquid lime sulfur thinning treatments and time of applications by cultivar.

Code	Treatment	80-100% full bloom	Full bloom axillary buds	Petal fall + 3 days
2x LS	4 % (v/v) lime sulfur applied 2 times:	X		X
3x LS	4 % (v/v) lime sulfur applied 3 times:	X	X	X
2x LS+O	2 % (v/v) lime sulfur + 1% (v/v) oil applied 2 times:	X		X
3x LS+O	2 % (v/v) lime sulfur + 1% (v/v) oil applied 3 times:	X	X	X
Control	Water only	X	X	X
Date of application				
	Redfree	May 16 (FB)	May 23	May 27
	Liberty	May 11 (FB)	May 16	May 23
	GoldRush	May 11 (80%)	May 16	May 23

Table 2. Effects of lime sulfur sprays applied during the bloom period on thinning dwarf Redfree, Liberty, and GoldRush apple trees in 2011.[z]

Treatment	Phyto-toxicity rating[x]	Dead spur clusters /tree	Dead axillary clusters /tree	No. of fruit /tree	No. of fruit/cm^2 TCA Spring	Fruit yield /tree (lb)	Yield eff. kg/cm^2 TCA Fall	Average fruit wt. (g)	Predicted thinning time (min.)
Redfree									
Control	1.0 c	.0 b	.0 c	179 a	7.9 a	50.5 a	.88 a	129 a	5.7 a
2x LS	3.0 b	1.8 ab	10.0 bc	169 ab	7.6 ab	44.6 a	.78 ab	119 ab	5.8 a
3x LS	4.3 a	1.8 ab	17.6 b	132 bc	6.0 bc	36.3 ab	.64 bc	125 ab	2.5 b
2x LS+O	2.8 b	1.8 ab	10.8 bc	129 bc	5.4 cd	34.7 ab	.54 cd	121 ab	0.6 b
3x LS+O	4.5 a	5.4 a	34.9 a	89 c	3.8 d	22.9 b	.36 d	116 b	0.0 b
Liberty									
Control	1.0 c	.0 a	.0 b	212 a	8.4 a	66.7 a	.96 a	145 a	6.8 a
2x LS	3.2 b	.3 a	2.1 b	131 bc	6.2 b	38.9 b	.68 b	141 a	2.2 b
3x LS	4.3 a	.2 a	2.4 b	132 bc	6.0 b	38.9 b	.63 b	139 ab	1.9 b
2x LS+O	3.0 b	.6 a	2.8 b	135 b	5.7 b	39.1 b	.58 b	137 ab	1.0 b
3x LS+O	4.8 a	1.1 a	8.1 a	82 c	3.7 c	22.2 c	.35 c	126 b	0.0 b
GoldRush									
Control	1.0 c	.0 a	.0 a	380 a	10.5 a	115.0 a	1.24 a	140 c	16.9 a
2x LS	2.9 b	.0 a	.5 a	244 b	6.5 bc	84.4 b	.80 b	162 ab	5.5 b
3x LS	4.0 a	.0 a	1.0 a	161 b	4.9 c	60.3 b	.69 b	175 a	3.5 b
2x LS+O	2.8 b	.0 a	.4 a	224 b	7.5 b	74.8 b	.90 b	154 bc	6.7 b
3x LS+O	3.6 a	.0 a	.5 a	192 b	6.0 bc	66.4 b	.76 b	163 ab	2.7 b

[z]Mean separation by Tukey's HSD (P=0.05), means followed by the same letter within a cultivar are not significantly different.

[x]Phytotoxicity rating (scale of 1 to 5): 1 = no symptoms; 2 = slight; 3 = moderate; 4 = severe; and 5 = very severe.

Figure 1. Phytotoxcity symptom on Redfree treated three times with lime sulfur.

Figure 2. Axillary blossom clusters on Redfree killed by three applications of lime sulfur plus dormant oil.