ORGANIC FARMING RESEARCH FOUNDATION

Project report submitted to the Organic Farming Research Foundation:

Project Title:

Organic Apple Thinning Strategies

FINAL PROJECT REPORT

Principal investigator:
Curt Rom
Department of Horticulture
University of Arkansas
Arkansas Ag. Experiment Station
Fayetteville, AR 72701

Collaborator:
Steve Ela, Silver Spruce Orchard, Hotchkiss, CO

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Organic Apple Thinning Strategies,
Funded by the Organic Farming Research Foundation
Research by:

C. R. Rom, Department of Horticulture, University of Arkansas
S. Ela, Silver Spruce Orchard, Hotchkiss, CO

Summary:

A proposal was funded in 2001 and renewed in 2002 by OFRF to study methods and begin the development of technologies for organic apple crop thinning. The work was coordinated by C. R. Rom at the University of Arkansas in conjunction with the Colorado Organic Crop Management Association (COCMA), organic fruit growers in Colorado, and research scientists at Colorado State University. Additional funding for the project were received from COCMA and Gerber Products. Subsequent related projects for laboratory and additional field testing in Washington was funded in part by the Washington Tree Fruit Research Commission. Overhead and additional project expenses were contributed by the University of Arkansas and Colorado State University.

The objectives of the funded proposed project research were:

1. To survey and evaluate current methods for fruit thinning and crop load regulation used by certified organic apple growers.

2. To test various crop load regulating treatments to thin fruit, encourage fruit size development and return bloom in apple.

Of the proposed objectives, both were achieved within the time-span of this project. The original Objective 2 proposed methods proposed in the initial project were modified based upon direction and funding from OFRF and were achieved with field studies in Colorado in 2001 and 2002. Results and progress of the project follow in this report.

Executive Summary of Findings:

Objective 1 Survey of Organic Apple Growers for Current and Best Practices

- A 25% response rate was achieved of a mailed survey of organic apple growers in 15 US states, Canada, and New Zealand.
- The survey represented approximately 7,000 acres of orchards and growers with conventional, transitional, and certified organic acreage.
- 40-45% of respondents indicated their organic acreage was steady to increasing while only 10% indicated a decrease in organic production
- The majority of respondents were using traditional apple cultivars on M.9 or M.26 rootstock and with tree densities in the 200-500 tree range.
- Motivation for organic apple production included economic, environmental and ethical reasons; growers were deemed to be “capitalists with conscience”
- A vast majority of respondents indicated fruit thinning as very important to their production systems.
- The most common fruit thinning strategy used by organic growers was post-bloom hand thinning.
- Approximately 17% used lime-sulfur sprays during bloom to regulate cropping but rated the success of the treatments as being less than acceptable.
- The survey indicated alternative thinning strategies are desperately needed and appropriate technologies limit their production systems.

Objective 2. Development and Testing of Thinning Techniques for Organic Apples

- Field tests were conducted in 2001 in Colorado and Arkansas to test current best practices indicated in the survey (Obj. 1).
- Field tests were conducted in 2002 in Colorado to retest best treatments of 2001 field studies and additional treatments reported in other regions.
- In 2001, 2% lime-sulfur plus 2% Crocker fish oil applied at full bloom resulted in the greatest reductions in fruit set, the most blank or resting spurs, and the greatest percentage of single fruits per spur, in most cases.
  - There was variation in attenuation of treatment results among the two cultivars tested
  - Concentrations of lime-sulfur above 2% did not appear to have significantly different affects
- In 2002, due to management and springs frosts, three of four trials had to be abandoned after treatments were established. However, one orchard trial was successful. Bloom was very heavy but fruit set relatively light due to heavy June-drop in 2002 on ‘Smoothee Golden Delicious’.
  - Treatments did not significantly reduce fruit set (fruits/100 flower clusters) but did result in reductions in fruits per limb, and reduced fruits set per flower cluster, especially the percentage of clusters with four fruits.
  - The percentage of flower clusters with only one fruit was increased by all treatments.
  - The most effect thinning treatments were 4% lime-sulfur plus fish oil applied at full bloom and petal fall, 4% vegetable oil emulsion applied at full bloom plus 4% lime sulfur at petal fall, 2% NaCl applied at first bloom and full bloom, and 2% NaCl applied at 30% bloom plus 2% lime-sulfur at full bloom plus 4% vegetable oil emulsion applied at 80% bloom.
  - High concentrations (10%) of lime-sulfur alone did not affect fruit set.
  - When all treatments are considered, it appears that multiple treatments or multiple applications of treatments throughout the bloom period were more affective than single treatments.

Following is a more detailed presentation of methods and findings.

Methods

Objective 1. Survey of Organic Apple Fruit Thinning Strategies used by Growers

A survey of thinning methods used by certified organic and transitional apple orchardists was conducted by both surface mail and an internet form (HTML) formats. A list of approximately 400 potential organic growers was compiled from lists or state and private certification agencies and from cooperator scientist and extension workers in key apple production states. Surveys were mailed surveys to 330 potential organic apple producers in 15 primary apple producing states. Distribution of surveys to the states were approximately proportional to the number of certified growers identifiable in each state and the approximate acreage of apples produced in the state according to USDA Statistical Services data. Survey respondents had 30 days to complete the survey. All surveys were to be completed anonymously and were confidential; there were no returned addresses or grower-identifiable indicators on the survey. On the internet survey form, responses were checked for IP addresses to eliminate potential duplicate or multiple entries from a single site (there were none).

Prior to distributing the survey, a test group was given the survey to evaluate the simplicity and ease of form completion, identify confounding questions and to assess an approximate time to complete the survey. The test group had an average completion time of less than 20 minutes.

Data of the returned surveys were compiled for frequency and distribution of the responses. When numerical responses were requested, data were summarized as means.

Objectives 1 and 2. Evaluation of Organic Apple Fruit Thinning Strategies.

The objectives and methods of the original project submitted in 2001 and for renewal in 2002 were modified based upon suggestion and funding from OFRF. As a result of reduced funding and direction from OFRF, laboratory studies of potential thinning agents (proposed in original and renewal proposals) were not tested as part of this project. Additionally, field tests in AR were discontinued and only field trials on certified acreage in Colorado were tested in 2002.

Field Studies - 2001:

Two field studies in Colorado and one smaller-scale study established in Arkansas in 2001 (Table 1). In Colorado, the orchards studied were certified organic producers. In the first orchard (Alvey), 'Empire'/M26, planted at 1.75m x 5m, 6-years-old and trained to a supported vertical axis and maintained at approximately 3m height was studied. The second orchard (Silver Spruce) was 'Smoothee Gold Delicious'/M26, 8-years-old, planted 3 x 6m, and trained to a vertical axis. Both orchards received grower-dependent management care and were irrigated.

Treatments were applied to three single trees of which the center of the triplet was used as a data tree and the two outside trees of a triplet were nondata buffers between treatments. Studies in both orchards were established as random complete block designs with eight replications and blocked for orchard location. Treatments were applied in the Alvey orchard with a motorized backpack sprayer at an approximate rate of 100 gals/acre (on a per tree basis). Treatments at Silver Spruce were applied with a "miniblast" tractor-mounted sprayer at an application rate of approximately 200gal/acre. Treatments in both orchards were begun when approximately 80% of the flower clusters on the tree were showing at least one flower open (first bloom), or the majority of the flower clusters on the tree had 3 or more flowers open (full bloom).

The following treatments were applied to whole trees: 1) Soybean oil (SO) at 4% applied twice - full pink flower stage (first flower open) and again at full bloom (50-70% blooms open); 2) 4% SO applied at full pink flower stage followed by lime-sulfur (LS) at 2% plus Crocker's fish oil

(CFO) at 2% at full bloom; 3) 2% LS plus 2% CFO applied at full bloom; 4) 4% LS plus 2% CFO full bloom, 5) 5% LS plus 2% CFO applied at petal fall, 6) an unsprayed check.

Prior to application 1-3 limbs per tree had flower clusters counted and were tagged. After treatments were completed petal and foliage burn were subjectively rated (not statistically analyzed) and photographed. After treatment, initial set was evaluated 30-45 days after petal fall by counting the number of fruits on the tagged limbs and calculating fruit set as fruit/100 flower clusters. Additionally, the number of clusters with 0, 1, 2, 3, or 4 or more fruit were counted to evaluated the distribution of fruitlets after thinning treatments. Trees in the Alvey orchard had some light handing-thinning touch-up at approximate 60 days after petal fall. Fruit were harvested at perceived maturity as determined by the grower. The total weight of fruit per tree was measured and the weight of a 25-fruit subsample was measured to calculate average fruit size and to have russet rated.

In the AR trial, individual spurs on 150 'Gala' trees on a range of rootstocks were used as the experimental study units. The following treatments were applied at full bloom by spraying individual spurs with liquid solution from hand-spray bottles until drip: 1) a water spray control, 2) 2% LS plus 2% CFO; 3) 2% LS plus 5% CFO; 4) 5% LS plus 2% CFO; 5) 5% LS plus 5% CFO; 6) 2% LS plus microthiol sulfur at 2%; 7) seaweed extract at 20%; 8) fish emulsion at 10%; 9) 6.5% K-fatty acid lipid (organic herbicide). For each treatment 100-125 spur flower clusters were used. Four weeks after treatment, the number of fruitlets and fruits per cluster were counted. Unfortunately, a severe fireblight infection occurred in this block which destroyed approximately 30% of the spurs studied.

Field Studies - 2002:

Four field trials in Colorado on were planned for the 2002 season. Three trials using certified organic grower-cooperator orchards, as requested by OFRF, and one was on the Western Colorado Research Center (WFRC) organic orchard were established.

At the time of trial establishment, one grower denied access to the orchards citing the risk of crop damage without any compensation as being too high. So, only the three other trials were established. After a bloom-time freeze and a hail storm, one grower orchard and the WFRC orchard were deemed as lost to the study as no fruit were set or were maintained until harvest. Thus, only one trial was continued until harvest. The completed trial was the Silver Spruce orchard using trees similar to those described above in the 2001 studies. Bloom in these trees was very heavy in this orchard indicating biennialism and fruit set was moderate compared to previous years due to a heavy June-drop. As a result, although yields per tree were high, fruit size was very small.

In 2002, the goal of treatments was to achieve greater thinning response than observed in 2001. Treatments used were based upon studies by others or work outside this project in New Zealand and Washington, and preliminary studies in Arkansas. The following treatments were used: 1) an unsprayed control, 2) 4% LS + 2% CFO applied twice - at full bloom and again at petal fall; 3) 4% LS + 2% Stylet oil applied twice - at full bloom and again at petal fall; 4) 4% Vegetable oil emulsion (VOE) applied at full bloom followed by 4% LS applied at petal fall; 5) 10% LS applied at full bloom; 6) 10% LS applied twice - at full bloom and again at petal fall; 7) 2% NaCl applied twice - at first/king bloom and again at full bloom; 8) 2% NaCl applied at 30% full bloom plus 2% LS and 4% VOE at 80% full bloom. Treatments were applied with a tractor-mounted miniblast sprayer at a rate of approximately 200 gal/acre. Experimental design of this study and data collection were identical to the previous season.

RESULTS AND DISCUSSION

Objective 1 - Survey of Organic Fruit Growers

A complete report of this project objective was previously submitted in July 2001 and again in January 2001. The report included a color, PowerPoint ™ presentation report of survey results which had presented at the First National Symposium on Organic Tree Fruit Production, Grand Junction, CO, May, 2001. . Summary findings follow.

Of the 330 mailed surveys 82 were returned completed (24.8% response rate); returned but incomplete surveys were not tallied. An additional 24 responses were returned completed from the internet site for a total of 106 completed responses from 15 states in the US, 1 province in Canada, and from New Zealand. The responses represented a reported 2548 ha (6,297 acres; some acreage not reported) comprised of 1007 ha (2489 acres) of certified organic production, 219 ha (542 acres) of transitional production, and 1576 ha (3896 acres) of conventional orchard (Figure 1). For organic orchards, the average size was 6.2 ha (15.4 acres; range of 1-489 acres) (Figure 2). The cultivars comprising the largest percentage of the acreage were Gala, Braeburn, and Fuji with 23 other cultivars being reported, and 55% of the acreage reported did not list a cultivar produced. Less than 1% of the reported acreage produced scab resistant and spring disease resistant cultivars. Of the respondents, 45% intended to increase production, 42% reported no change in organic production, and 12% reported decreasing production (Figure 3). Of the respondents, 76% indicated the basis for organic production was economics and crop value, 69% and 47% reported that organic production was practiced for environmental and ethical reasons, respectively (Figure 4).

The great majority of the respondents indicated that thinning was important or very important to their production system (Figure 5). When asked why growers desire to thin the fruit crop, respondents indicated the primary and most important reasons were to increase fruit size, increase return bloom, and reduce biennial bearing (Figure 6).

Survey respondents were given choices of treatments that they utilize for organic thinning. The greatest percentage of respondents indicated that post bloom hand removal (30% of responses) was used for crop regulation with the highest level of perceived success. Full bloom lime-sulfur application was used by 16% of the respondents with low to acceptable success rating (Figure 7). An additional 8% of the respondents used one or more of the following thinning treatments: petal fall lime-sulfur application, pre-bloom hand removal, or full-bloom hand removal of blossoms. Of the respondents, 10% did not provide any information about their thinning practices. Approximately 20% of the respondents indicated using multiple methods of thinning. The highest level or reported success of fruit thinning in organic orchards was post bloom and full bloom hand-removal (Figure 8). However, no thinning method was regarded as achieving acceptable success or satisfaction.

Objective 2 Field Testing of Reported Methods

The focus of 2001 and 2002 field trials were bloom thinning treatments.

2001

In the AR trial, individual spurs on 150 ‘Gala’ trees on a range of rootstocks were used as the experimental unit. The following treatments were applied at full bloom: 1) a water spray control, 2) lime-sulfur at 2% plus fish oil at 2%; 3) lime-sulfur at 2% plus fish oil at 5%; 4) lime-sulfur at 5% plus fish oil at 2%; 5) lime-sulfur at 5% plus fish oil at 5%; 6) lime-sulfur at 2% plus microthiol sulfur at 2%; 7) seaweed extract at 20%; 8) fish emulsion at 10%; 9) 6.5% K-fatty acid lipid (organic herbicide). For each treatment 100-125 spur flower clusters were used. Four weeks after treatment, the number of fruitlets and fruits per cluster were counted. Unfortunately, a severe fireblight infection occurred in this block which destroyed approximately 20% of the

spurs studied. Lime-sulfur plus fish oil applied at full bloom reduced fruit set but there was no significant concentration affect compared to the control. The fatty acid organic herbicide killed spurs at that concentration. There was no thinning effect of fish emulsion. Spurs treated with the 20% seaweed extraction were killed indicating the concentration was excessive. Because of only moderate fruit set and severe fireblight in whole trees, there was not a treatment effect on fruit size.

In the Colorado trials in certified organic apple orchards, treatment effects varied between the two orchards and cultivars (Table 1). For 'Empire' all treatments reduced fruit set. The 2% and 4% LS plus fish oil applied at full bloom resulted in the greatest percentage of spurs with single fruits and least with 4 fruitlets. There was not statistical difference among the LS concentrations tested or full bloom versus petal fall application for fruit set.

For 'Smoothee Golden Delicious', there was no effect of treatment on fruit set or yield per tree and fruit set was quite heavy. However, soy oil (4%) applied at pink and full bloom, and 4% lime-sulfur plus 4% fish oil applied at full bloom resulted in increased average fruit size. No concentration effect of LS on fruit set was observed although 4% LS plus 4% fish oil resulted in the most spurs with single fruits, the fewest spurs with 4 fruits and the largest fruit size. Return bloom in the Silver Spruce orchard was not significantly affected by treatment but was highest in the 4% lime-sulfur plus 4% fish oil had the greatest return bloom per limb.

When the results of both orchards are combined (cannot be analyzed statistically), some inferences can be made by observation. Fruit thinning by 2% LS plus 2% fish oil applied at full bloom resulted in the lowest fruit set, the most blank or resting spurs, among the most spurs with only one fruit . There appeared to be a slight concentration effect with 4% LS resulting in the most spurs with only one fruit and least spurs with for fruits.

2002 Trials

As reported above, four field trials were established in at bloom in 2002. However, due to management and climatic issues, only one trial persisted until harvest.

In the 'Smoothee Golden Delicious' orchard in 2002, bloom was relatively heavy but fruit set was light on all trees compared to 2001 (Table 2). Yields were heavier than in 2001 and fruit size was significantly smaller than previous years. A horticultural assessment of the trial indicates that because of relatively heavy bloom but poor fruit set due to heavy June-drop, treatment differences were not as dramatic in 2001 as they were in 2002.

No treatment reduced fruit set compared to the control in 2002. However, 2% NaCL applied at first bloom and repeated at full bloom tended to reduce the flowers per limb by approximately 36%.

Lime-sulfur at 4% in combination with fish oil or mineral dormant oil, or in combination with vegetable oil emulsion (VOE) applied at full bloom (FB) tended to reduce fruit set, although not statistically different than the controls. VOE applied at FB in combination with LS resulted in the most blank or "resting" spurs, and the greatest percentage of spurs with single and double fruits. Additionally, VOE + LS resulted in the best combination of yield and average fruit size with no significant increase in russet compared to the controls. However, LS applied at very high concentrations (10%) resulted in significantly reduced fruit size.

Although preliminary studies in 2001 indicated both a concentration and timing response to lime-sulfur applications, this did not appear as consistently in field studies in the second season. Treatments including 2%LS + 2% fish oil applied twice (at FB+PF, and 2% LS + 1% JMS at both FB+PF reduced fruit set. Additionally, trees with these treatments had more "blank" or resting spurs than controls, and fewer spurs with two or more fruit; thus more spurs with single fruit. Lime-sulfur at 4% in combination with fish oil or dormant oil, or in combination with VOE applied at FB tended to reduce fruit set, although not statistically different than the controls. VOE applied at FB in combination with LS resulted in the most blank or "resting" spurs, and the greatest percentage of spurs with single and double fruits. Additionally, VOE + LS resulted in the

best combination of yield and average fruit size with no significant increase in russet compared to the controls.

From our lab studies, we believe that the thinning effect of LS sprays is caused by several effects including dehydration of pistils caused by the high solution pH and strong osmotic strength of the solution, and by photosynthetic inhibition of leaves. From field observation and from our greenhouse studies, high concentrations or repeated applications of LS may permanently reduce Pn and limit tree and fruit growth.

From other trials in Washington and Arkansas, and from our laboratory work (outside of this project), there does not appear to be a significant repeatable concentration effect of lime-sulfur although a minimum concentration of 1.5 - 2.0% is needed to be effective. We have not observed significant differences in the time of treatment between full bloom and petal fall applications although full bloom applications tend to be more effective at fruit thinning. Lime-sulfur is not as effective alone as it is in combination with oil and it is most effective in combination with fish oil. Research by other workers has indicated lime-sulfur and fish oil may also be an effective fruit thinner if applied 1-15 days after petal fall as a post bloom thinner. Additionally, it appears that multiple applications may be the most effective. The effect of multiple applications of lime-sulfur on return bloom has not been fully evaluated but needs additional study.

Grower Involvement

Growers were involved by three means for these studies. First, a grower-cooperator (Ela) was a cooperator and co-investigator for the project. To develop the survey and the treatments used, grower input and advice of organic growers in Colorado and other states was solicited by phone and email. The growers became an *ad hoc* advising panel for the project. Second, the research - both the survey and field trials - were conducted with grower cooperators. Growers were solicited to participate in the survey by mail and informed of the project. The majority of the field trials were put in grower orchards. However, this developed a series of problems as exemplified in 2001 when a trial was inadvertently harvested prior to data collection, and in 2002, when a grower cooperator decided at the *last moment* that the risk of the trial was too high and we could not use the orchard for studies. It was too late to solicit another replacement orchard and set-up the trial as it was very time-dependent. Thus, that trial was lost. Additionally, one of the remaining grower trials used in 2002 was not an ideal horticultural site and was frost prone. As a result the study, after being established and treatments applied, was lost due to an isolated spring frost which affected the trial area. The investigators understand these limitations and issues with using growers sites. However, those problems were out-weighed by the benefit of using growers sites which were certified-organic when other commercial orchards and research farm sites are not certified and do not follow a holistic organic management strategy. Lastly, growers were involved in some of the data collection, visual assessments, and discussion of apparent results providing grower-based ideas for data interpretation.

Communication and Presentation of Results and Significant Findings.

The results of this study were be presented in several means and at several venues. A report of the survey was presented at the First Symposium on Organic Tree Fruit Production, Grand Junction, CO, May 2001. Results of the survey and the field trials were presented at grower meetings in both Colorado and at the Arkansas-Oklahoma Horticulture Industries Show. Results have been shared with members of COCMA and published in a Gerber Products Company R&D newsletter and newsletter to contract growers. A field day workshop for growers in CO was conducted in summer 2002. Further, an abstract was be submitted and presented at the Southern Region of the American Society for Horticultural Science annual meeting.

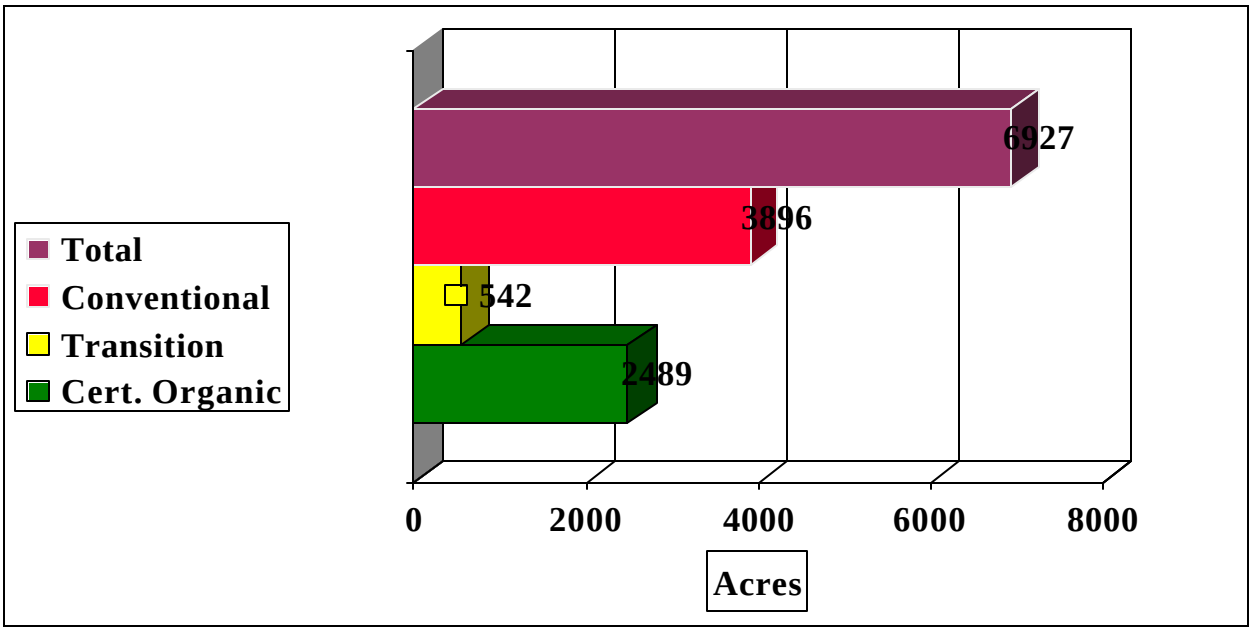

Figure 1. Planted acreage of apples in conventional, transitional and certified organic orchards of survey respondents.

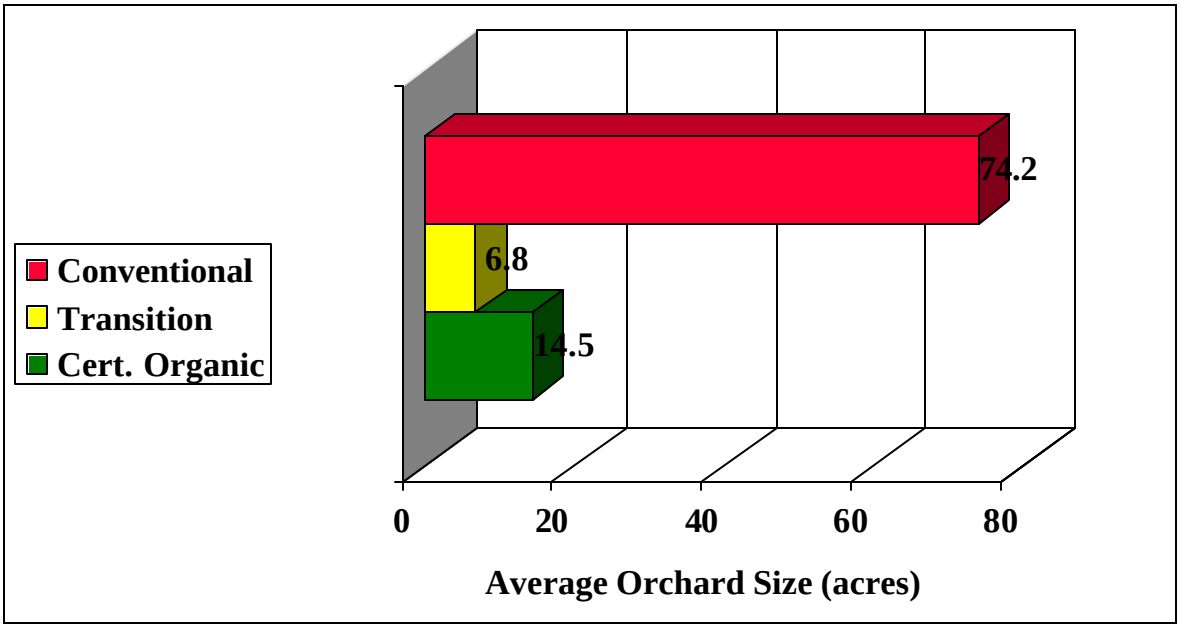

Figure 2. Orchard size of survey respondents.

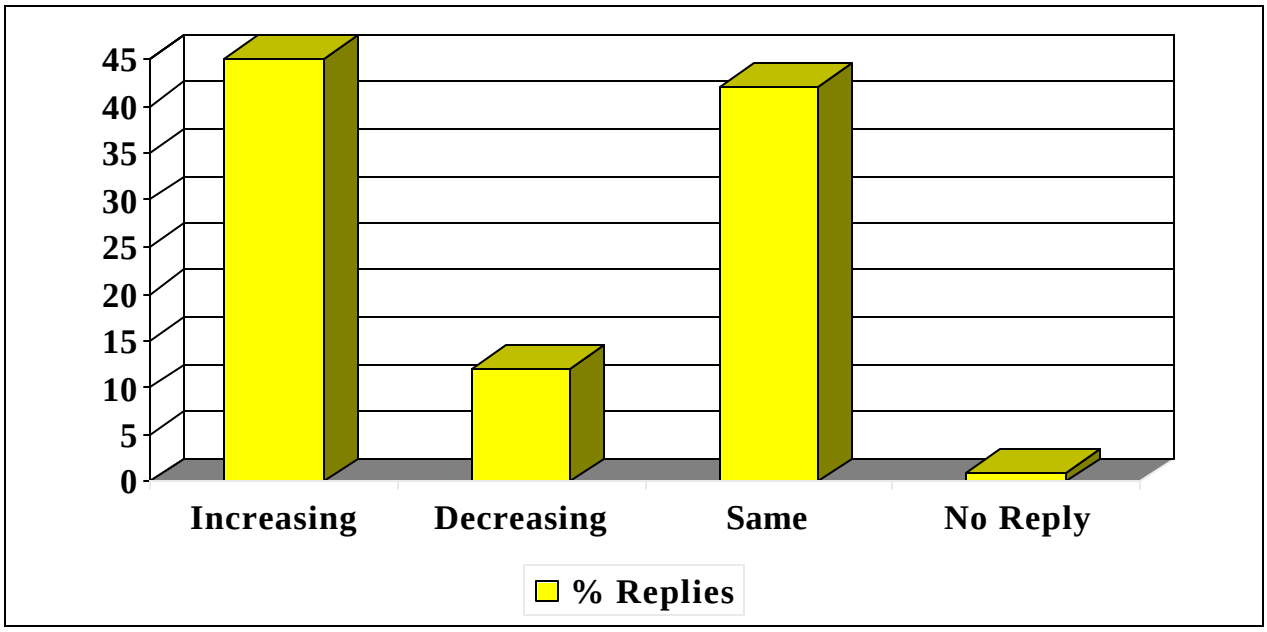

Figure 3. Frequency of response to the question, “What is happening to your certified organic apple production acreage?”

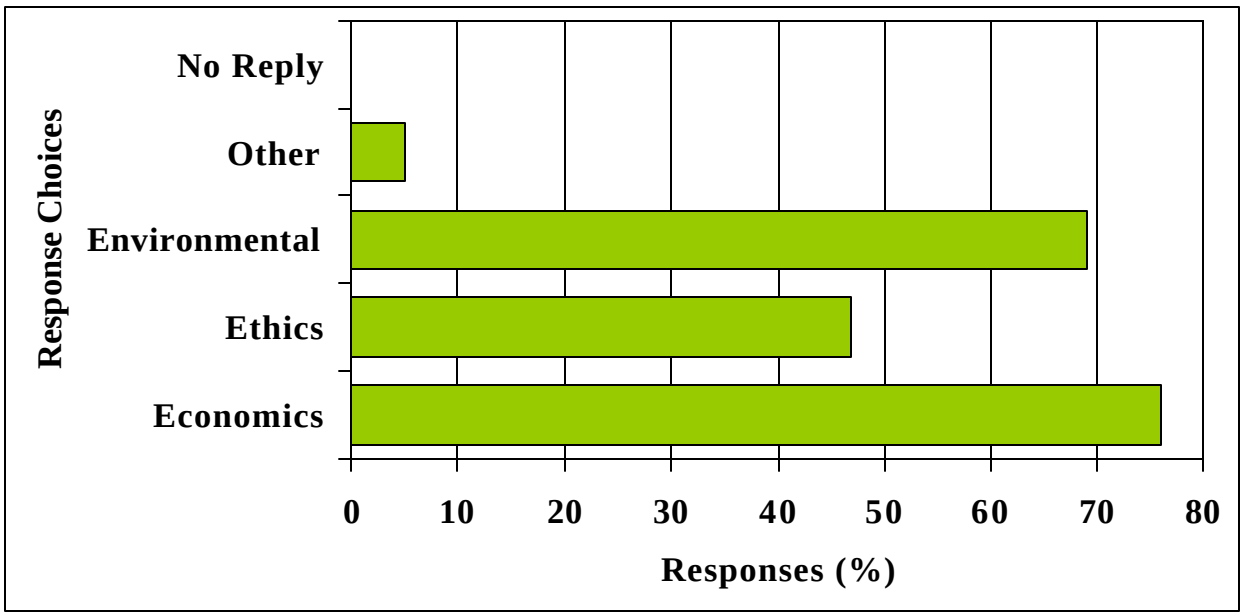

Figure 4. Frequency of response to the question, “Why do you produce organic apples?”

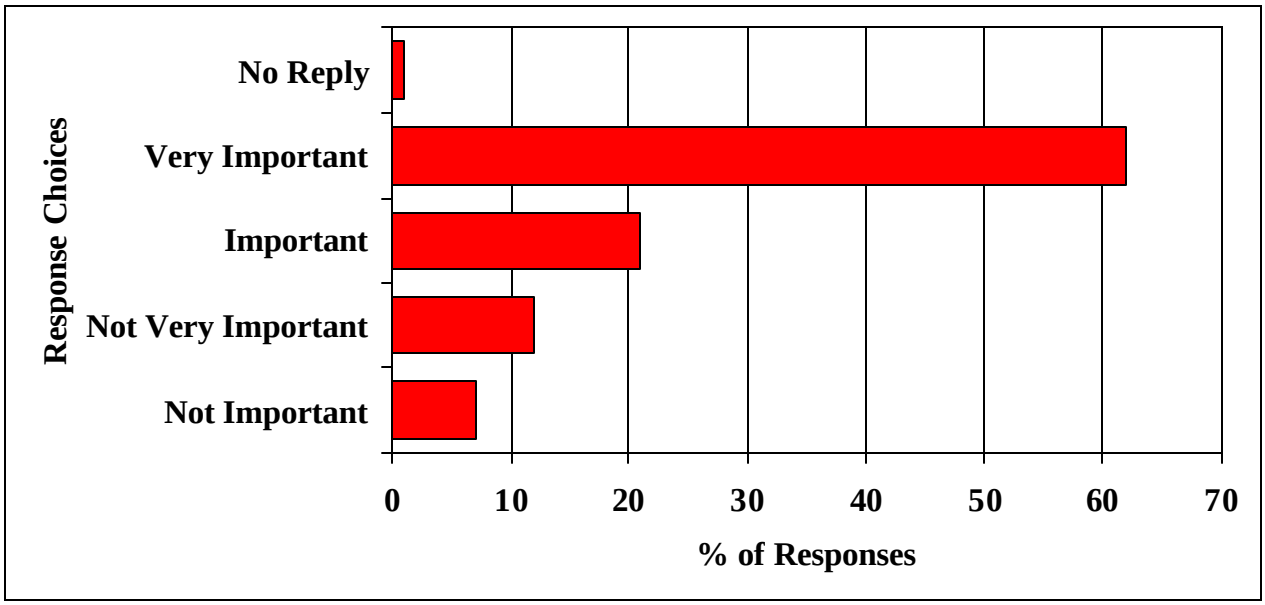

Figure 5. Survey responses to the question, “How important is an organic alternative thinning method to your production operation?”

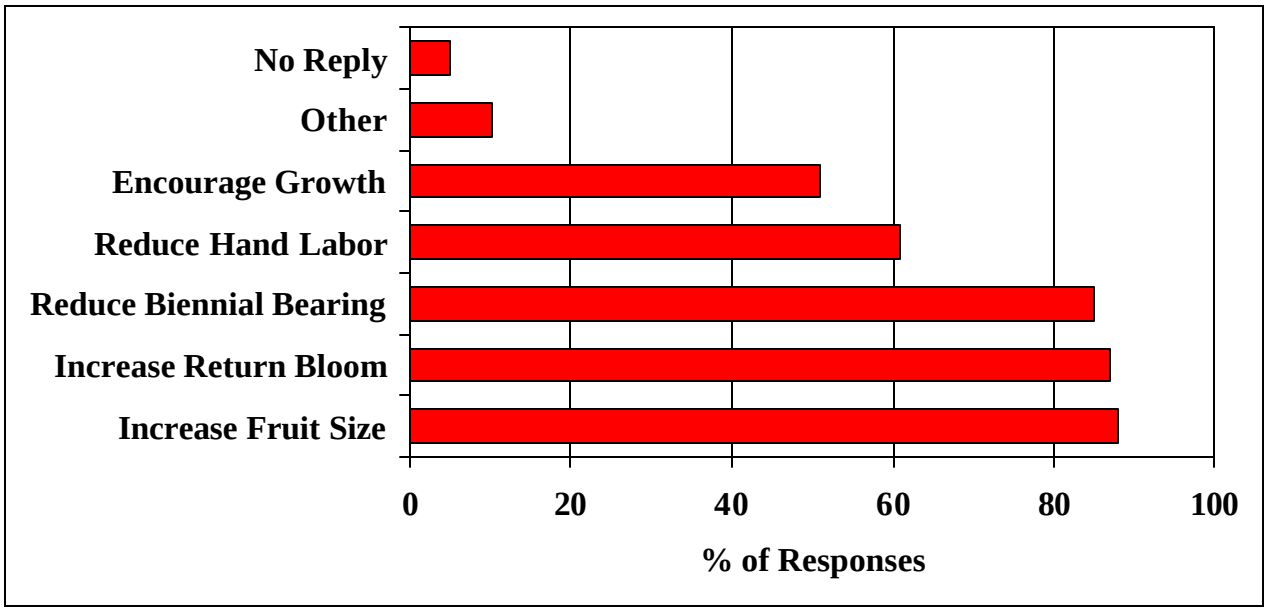

Figure 6. Survey responses to the question, “Why do you want to thin and manage the crop load on your organic apple crop?”

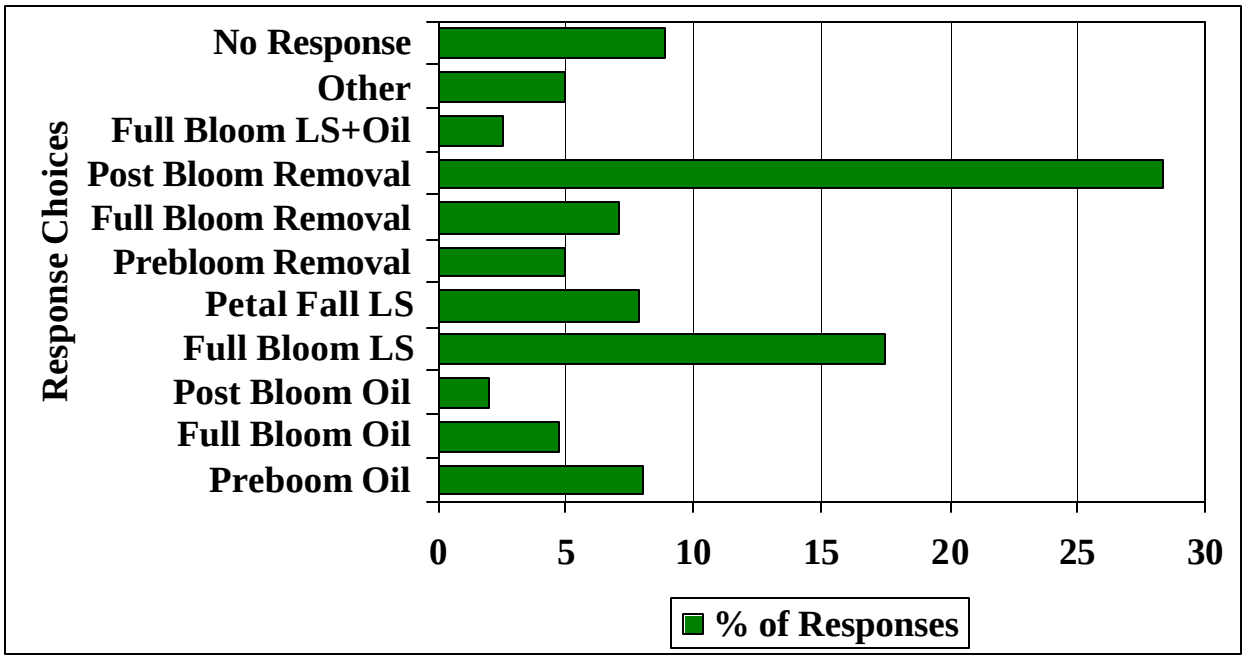

Figure 7. Survey responses to the question, "What do you currently use as a method to thin apples and manage crop load in your organic apple orchard?"

Figure 8. Average survey response to "Rate the success of your fruit thinning and crop load management strategy." 0 = no success, 3 = Acceptable/reasonable success, 5=Excellent/reliable success.

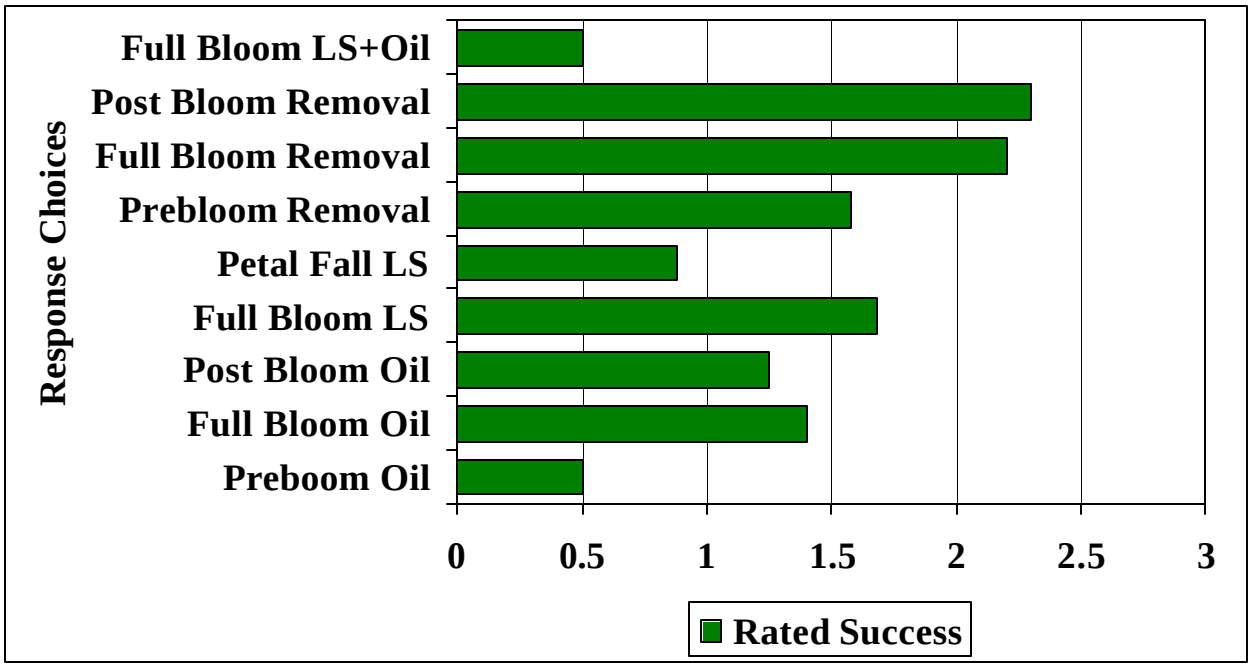

Table 1. Affect of alternative fruit thinning treatments on fruit set in two certified organic orchards, Rogers Mesa, CO, 2001.

Treatment[z]	Fruitlets / 100 Blossom Clusters	% Blanks	% Singles	% Doubles	% Triples	% Quads+	Yield/tr (Kg)	Avg Frt (G)
			'**Empire' - Alvey Orchard, CO, 2001**					
Control (unsprayed check)	115.8a	4.5ab	57.4a	30.2	9.4	3.0	-	-
Soy oil 4% @ Pk+FB	82.7ab	0.0a	66.4	26.6	5.2	1.8	-	-
2%LS + Soyoil 4% Pk + 2% CFO @ FB	90.9ab	6.8ab	60.9	27.0	4.5	7.6	-	-
2% LS + 2% CFO @ FB	70.3b	10.9b	69.8	22.5	5.7	2.0	-	-
4% LS + 4% CFO @ FB	89.5ab	0.5a	71.0	24.0	3.5	1.5	-	-
5% LS + 2% CFO @ PF	78.1ab	6.8ab	55.4	30.9	11.5	2.2	-	-
			ns	ns	ns	ns		
			'Smoothee Golden Delicious' - Silver Spruce (Ela) Orchard, CO, 2001					
Control (unsprayed check)	158	7.1bc	55.0a	32.6	11.3	1.1	54.2	125.9b
Soy oil 4% @ Pk+FB	155	0.0c	56.7ab	33.9	7.6	1.8	52.6	153.3a
2%LS + Soyoil 4% Pk + 2% CFO @ FB	145	11.4b	66.8b	24.8	7.9	0.5	57.5	142.0ab
2% LS + 2% CFO @ FB	150	17.9a	60.6ab	26.3	10.9	2.1	56.4	140.0ab
4% LS + 4% CFO @ FB	143	0.7c	66.7b	26.7	6.3	0.3	82.2	153.3a
5% LS + 2% CFO @ PF	151	12.7b	59.2ab	30.9	8.8	1.1	53.8	124.2b
	ns			ns	ns	ns	ns	ns
			Average of Test Sites					
Control (unsprayed check)	137	5.5	56	31	10	2		
Soy oil 4% @ Pk+FB	119	0	61	30	6	2		
2%LS + Soyoil 4% Pk + 2% CFO @ FB	118	9.1	64	26	6	4		
2% LS + 2% CFO @ FB	110	14.4	66	25	8	2		
4% LS + 4% CFO @ FB	117	0.6	69	25	5	1		
5% LS + 2% CFO @ PF	115	9.8	57	31	10	2		

[z] LS = Lime Sulfur; CFO = Crocker's Fish Oil; Pk = Pink stage of bloom; FB = Full Bloom; PF = Petal Fall

Table 2. Affect of alternative fruit thinning treatments on fruit set and yield of a certified organic apple orchard, Rogers Mesa, CO, 2002.

Treatment	Fruits/LCSA cm2	Fruitlets / 100 Blossom Clusters	% Blanks	% Singles	% Doubles	% Triples	% Quads+	Yield/tr (Kg)	Avg Frt (G)	Russet Rating
'Smoothee Golden Delicious' - Silver Spruce (Ela) Orchard, Rogers Mesa, CO										
Control	2.6abc	89.5	7.1c	5.8c	15.8b	21.1ab	50.1a	90b	112.8ab	3.4
4%LS + 2%CFO @ FB + PF	2.3bc	80.4	14.5bc	19.5ab	22.6ab	22.2ab	21.2bc	129a	110.8ab	3.5
4%LS + 2% Oil @ FB+PF	2.6abc	77.9	17.3abc	13.3bc	26.0a	25.6a	17.9c	135a	109.6ab	3.0
4% VOE @ FB + 4%LS @ PF	2.5abc	77.3	24.0ab	23.0a	24.4ab	17.9ab	10.7c	117ab	119.4a	3.4
10% LS + NF@ FB	2.5abc	88.2	12.6bc	14.5abc	24.6ab	25.6a	22.3bc	126a	97.0b	2.6
10% LS + NF @ FB + PF	2.5abc	91.6	12.0bc	14.7abc	18.7ab	21.3ab	33.3b	120ab	113.3ab	3.0
2%NaCL @ 1st and FB	1.9c	80.6	13.9bc	10.9bc	19.6ab	23.3ab	32.4b	146a	109.1ab	3.1
2%NaCl @ 30% bloom +2%LS + NF + 4% VOE @ 80%BL	2.9a	89.1	29.9a	17.3ab	22.8ab	14.0b	16.0c	123ab	112.0ab	3.1
		ns								ns

[z] LS = Lime Sulfur; CFO = Crocker's Fish Oil; NF = NuFilm surfactant @ 0.25%; VOE = Vegetable Oil Emulsion; Pk = Pink stage of bloom; FB = Full Bloom; PF = Petal Fall

Russet rating: 0 = no russet, 3 = maximum acceptable russet, 5= heavily/severely russetted and unmarketable fruit.

Publications and Presentations resulting from or related to this project.

Publications:

Rom, C. R. 2002. Demonstrating the need for alternative apple fruit thinning methods for organic growers. In, Clark, J.R, and M.E. Evans, eds. Horticultural Studies 2001. Arkansas Agricultural Experiment Station Research Series 494: 24-25.

Related work

Bajwa, V. and C. R. Rom. 2005 Screening potential alternative chemical thinning treatments for apple. HortScience 40:(accepted; to be published).

Rom, C.R., Z. Niu, and V. Bajwa. 2004. Solution characteristics affect pollen germination and growth, and pistil viability: Implications for developing chemical blossom thinners for apple. HortScience 39:798

McAfee, J.D. and C. R. Rom. 2003. The Effects of Potential Organic Apple Fruit Thinners on Gas Exchange and Growth of Model Apple Trees: A Model Plant Study of Transient Photosynthetic Inhibitors and their Effect on Physiology and Growth. In. Evans, R., and D. Karcher (eds). Horticulture Studies 2002. Arkansas Agricultural Experiment Station Research Series 506:74-78.

McAfee, J. and C. R. Rom. 2003. The effects of potential organic apple thinners on gas exchange and growth of model apple trees: A model plant study of transient photosynthetic inhibitors and their effect on physiology and growth. Discovery 4:59-64.

McAfee, Jason and C. R Rom. 2003 The effects of potential organic apple fruit thinners on gas exchange and growth of model apple trees: A model plant study of transient photosynthetic inhibitors and their effect on physiology and growth. HortScience 38:1265

Fallahi, E., C. R. Rom, and B. Fallahi. 2003. Influence of organic blossom thinners on fruit set and quality of apples, peaches, and plums. HortScience 38:690

Presentations:

Rom, C.R. 2005. Alternative methods of fruit thinning. Arkansas-Oklahoma Horticulture Industries Show, Jan. 2005.

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