Final Project Report to the NYS IPM Program, Agricultural IPM 2003

Title: An Organic Apple Production System For New York

Project Leader(s):
Terence Robinson, Dept. of Hort. Sci., NYSAES, Cornell University, Geneva, NY 14456
Art Agnello, Dept. of Entomology, NYSAES, Cornell University, Geneva, NY 14456
Harvey Reissig, Dept. of Entomology, NYSAES, Cornell University, Geneva, NY 14456
Jim Schupp, Dept. of Hort. Sci., NYSAES, Cornell University, Highland, NY 14456
Heidi Noordijk, Graduate Student, Dept. of Hort. Sci. Highland NY 12528

Cooperator(s):
Deborah I. Breth, Cornell Coop. Ext., Lake Ontario Fruit Team, Albion, NY 14411
Stephen A. Hoying, Cornell Coop. Ext.-Lake Ontario Fruit Team, Newark, NY 14568
James Bittner, Fruit Grower, Singer Farms Olcott, NY (Grower Cooperators)
Steve Clark, Fruit Grower, Milton, NY (Grower Cooperators)
Charles Mead, Fruit Grower, Red Hook, NY (Grower Cooperator)

Type of grant:
Pheremones, biorationals; microbials; organic pesticides

Project location(s):
Throughout the Northeast

Abstract:
Several NY apple growers have indicated they see a marketing opportunity for NY grown organic apples (both fresh and processed products) and have requested a Cornell University led effort to develop a system of organic apple production for NY. In 2003 we studied apple maggot management, and fruit thinning control tactics that are organically approved. We have evaluated an organic approved insecticides Entrust and Dipel for apple maggot control in the late season. Entrust gave good control of the internal worm complex including apple maggot. Entrust was slightly better than to Dipel. The late season control obtained with Entrust needs to be combined with early season pest control with kaolin clays (Surround) which we reported on last year. With organic approved thinning agents we had excellent success. The Fish Oil/Lime Sulfur combination gave excellent thinning efficacy and a wide window of application (full bloom to post petal fall). NC-99 also gave significant thinning but gave more phytotoxicity. Both products also resulted in a small improvement in fruit size.

Background and Justification:
Organic apple production in NY has remained small and limited to a few farms due to the intense disease and insect problems encountered with organic apple production in the NY climate. Several NY apple growers have indicated they see a marketing opportunity for NY grown organic apples (both fresh and processed products) and have requested a Cornell University led effort to develop a system of organic apple production for NY. Two grants (Cornell Organic Farming Grants Program and Organic Farming Research Foundation in California) in 2000 and 2001 allowed a multidisciplinary project at Cornell University to begin to develop a system of organic apple production for the eastern US. Grants from the NYS IPM program in 2001, 2002 and 2003 have allowed us to continue the work.

In NY state, a large number of both native and introduced insect and mite species attack apples grown in commercial apple orchards. Control of this pest complex without common pesticides is particularly challenging, because apple orchards in NY are commonly in close proximity to semi-wooded areas with an abundance of wild apple and hawthorn species that can harbor fairly large populations of certain apple insect pests. Controlling apple diseases with fungicides approved for use in organic food production involves old and well-documented technology. Sulfur and lime-sulfur are effective for controlling most diseases if they are applied correctly (Burrell, 1945).

A second major management problem in organic apple orchards is the lack of suitable approaches to thin the crop. Fruit thinning is essential to control biennial bearing in apples. It also increases fruit size in the current season while increasing return bloom in the next season. In conventional orchards fruit thinning is accomplished by the use of growth regulating chemicals; however, in organic blocks hand thinning which is expensive is the only current approach.

Objectives:

1. Develop an organically approved arthropod management system that will lead to the production of apples suitable for the fresh and processed organic fruit market.
2. Develop alternative chemical fruit thinning approaches for use in certified organic apple orchards that will result in annual cropping and large fruit size.

Procedures:

OBJECTIVE 1. ORGANIC ARTHROPOD MANAGEMENT.

A trial was set up during the 2003 growing season to compare the efficacy of Entrust, which is a new formulation of the natural compound Spinosad formulated for organic growers, and Dipel for control of late season pests in an organic apple orchard. These materials were compared in two adjacent five acre plots set up in a planting of apples that had been marketed for the last several years as organic fruit. These two blocks were set up in a mixed planting of 'McIntosh', 'Cortland', and 'Delicious' apples planted on MM-106 rootstocks that were ca. 3-4m high. The treatments of Dipel 2X (1.0 lbs/A) or Entrust (2.0 oz/A) were applied with an airblast sprayer calibrated to deliver 100 gpa on July 14, 21, 28, August 4, 11, 18, 25, and September 1. These late season sprays were primarily targeted against later summer generations of internal lepidoptera (codling moth, and oriental fruit moth) and apple maggot. On October 7, 400 'Delicious' apples were harvested from each plot (50 randomly selected apples on each of 8 sampled trees) and examined for various types of insect damage.

OBJECTIVE 2 DEVELOPMENT OF ORGANIC THINNING STRATEGIES

Studies were conducted in Modena, NY, Geneva, NY and at Lansing, NY to evaluate organically acceptable blossom and post bloom thinners.

Experiment 1: Alternatives to carbaryl in thinning combinations (Clarke-Hudson Valley) A field experiment was conducted on Gala/M.9 trees to determine if combinations of Fish Oil and Lime Sulfur could be used instead of carbaryl in thinning programs. Fish oil was applied at 2% (vol:vol), and LS was applied at 2.5%. Carbaryl was applied at 1 pt. / 100 gallons and Accel was applied at 53 oz. / 100 gallons. All treatments were applied with an air-blast sprayer. Fish oil and Lime Sulfur or Carbaryl were applied at petal fall and then followed by either no treatment or 6BA at 10 mm fruit size. Two additional treatments at the 10mm timing compared the combination of fish oil, lime sulfur and 6BA or the combination of carbaryl and 6BA. Leaf damage, fruit set, yield, fruit size, fruit color and russet were evaluated.

Experiment 2: Organic thinning of Fuji apple (Mead-Hudson Valley) A field study was conducted with Fuji/M.9 trees to determine if bloom applications of Fish Oil and Lime Sulfur could help thin Fuji without resulting in pygmy fruits. Fish oil was applied at 2% (vol:vol), and LS was applied at 2.5%. Carbaryl was applied at 1 pt. / 100 gallons and Accel was applied at 53 oz. / 100 gallons. All treatments were applied with an air-blast sprayer. Leaf damage, fruit set, yield, fruit size, fruit color and russet were evaluated.

Experiment 3: Best application time of fish oil + lime sulfur sprays for thinning response. (Cornell Orchards – Lansing) A field study was conducted on Gala/M.9 apple trees to determine the best application timing for optimum thinning response with fish oil + lime sulfur sprays. Fish oil and lime sulfur were applied at petal fall+7 day, PF+14 days and PF+21 days. Single and double applications were also compared. Fish oil was applied at 2% (vol:vol), and LS was applied at 2.5%. All treatments were applied by high-pressure handgun. Fruit set, yield, fruit size, fruit color and russet were evaluated. Fruit growth was measured periodically throughout the growing season. Leaf damage was rated, and photosynthesis was measured periodically, to evaluate the effect of the treatments on tree physiology.

Experiment 4: Alternatives to fish oil for combination with lime sulfur in thinning sprays. (NYS Exp. Station – Geneva) A field study was conducted at the New York State Agricultural Experiment Station in an 13 year old block of Empire/M.9 apple trees with a spacing of 6' X 12' and trained to a vertical axis system. The trial compared the effectiveness of lime sulfur with various surfactants. A randomized complete block experiment was used with blocking done based on location in the field. There were 5 single tree reps per treatment. Each test tree had a guard tree on each side. Tree row volume for a dilute spray was 200 gal/acre. Trees were sprayed with an airblast sprayer at 100 gal/acre using a 2.0X concentration of thinning chemicals. The surfactants (oils, Regulaid and Silwet) were not concentrated. The full bloom sprays were applied on May 14, 2003 at 80% full bloom. The petal fall sprays were applied on May 22, 2003. Fruit set was measured on two tagged limbs per tree where the number of flower cluster and number of fruits harvested were recorded. Plots were harvested and fruit number and yield were recorded. A sample of fruit was collected for analysis of fruit quality and seed number.

Experiment 5: Evaluation of lime sulfur rate and spray water volume. (NYS Ag. Exp. Station - Geneva) A field study compared several bloom, petal fall and fruitlet thinning sprays on fruit size and cropload of seven-year old Gala/M.9 apple trees. The full bloom sprays were applied on May 17, 2003. The petal fall spray were applied on May 27, 2003 and were applied with either 200, 100, or 50 gallons of water per acre. The 10mm sprays were applied on June 6, 2003. Except for the petal fall sprays the trees were sprayed with an airblast sprayer at 100gal/acre using a 2.0X concentration of chemicals. The surfactants (oils, Regulaid and Silwet) were not concentrated. Calculated tree row volume was 200gal/acre. A randomized complete block experiment was used with blocking done based on location in the field. There were 5 single tree reps per treatment. Each test tree had a guard tree on each side. Fruit set was measured on two tagged limbs per tree where the number of fruits set per flower cluster was calculated. Plots were harvested and fruit number and yield were recorded. A sample of fruit was collected for analysis of fruit quality and seed number.

Results and Discussion:

OBJECTIVE 1. ORGANIC ARTHROPOD MANAGEMENT SYSTEM.

Internal lepidoptera were the most serious pests in this orchard and entrust was slightly more effective than the Dipel treatments against this pest complex (Table 1). Plum curculio damage was also lower in the Entrust plots, although the late season timing tested in this program should have had only minimal effects on controlling this pest, as well as the other early season

pests damaging fruit, tarnished plant bug and rosy apple aphids. These late season sprays would also have had very little effect on early damage from the obliquebanded leafroller. Both materials provided similar control of late season oblique leafroller damage. The overall percentages of clean fruit were somewhat higher in both treatments than in previous years in this orchards when other materials or techniques had been used to control insect pests. It appears that both of these materials can be quite effective in controlling late season pests such as internal lepidoptera, apple maggots and obliquebanded leafroller, even in orchards that have severe pressure from these pests. In the future, it would be desirable to test these materials as control techniques in organic apple orchards in combination with an early season program of Surround (kaolin clay) applied to control the plum curculio and early generations of internal lepidoptera.

OBJECTIVE 2. ORGANIC THINNING STRATEGIES

Experiment 1: Gala trial, Clarke, Modena: Application of FOLS at petal fall caused a significant reduction in cropload and resulted in a significant improvement in fruit size while carbaryl applied at petal fall did not reduce cropload or improve fruit size (Table 2). Many NY growers apply carbaryl at petal fall with the hope that it will cause some thinning. These results indicate that often carbaryl at this timing is ineffective. Sprays of 6BA alone at 10mm did not reduce cropload or increase fruit size. However when FOLS was applied at petal fall and followed by 6BA at 10mm fruit size then excessive thinning was obtained and the largest fruit size of any of the treatments. In contrast when carbaryl was applied at petal fall followed by 6BA at 10mm fruit size there was marginal thinning and a modest increase in fruit size. When FOLS was combined with 6BA at the 10mm timing excessive thinning resulted while when carbaryl and 6BA were combined only marginal thinning was achieved.
These results suggest that
• The combinations of FOLS preceding or tank mixed with 6BA can significantly over-thin Gala during a cloudy spring.
• Fruit size of Gala can be increased by FOLS, while treatment with 6BA or combinations of FOLS and 6BA give the greatest increase in fruit size.
• FOLS may precondition Gala trees for increased thinning with later application of6BA.

Experiment 2: Fuji trial, Mead, Red Hook: Fuji is a hard to thin variety and becomes biennial if not thinned to a relatively low cropload. In this experiment FOLS applied at bloom reduced cropload significantly but did not improve fruit size(Table 3). In contrast carbaryl at petal fall was only marginally effective in reducing cropload. The combination of FOLS at bloom and carbaryl at PF reduced cropload more than either product alone; however fruit size was not increased. Treatments with FOLS had greater russeting than either Carbaryl at petal fall or the untreated control.
Treatment with NAA and Carbaryl at the 10 mm stage did not reduce cropload but did result in a high percentage of pygmy fruit. All other treatments including the unthinned control had significantly fewer pygmy fruits. FOLS or FOLS followed by carbaryl had relatively low amounts of pygmy fruits. Applications of 6BA plus carbaryl at the 10mm fruit size reduced cropload, increased fruit size significantly and had the lowest percentage of pygmy fruits. The addition of oil as a surfactant to the 6BA/Carbaryl mixture did not improve thinning efficacy or fruit size. 6BA sprays did not increase russetting relative to the control.
These results suggest that
• FOLS applied at bloom can effectively thin Fuji and results in reduced pygmy fruits but FOLS results in increased fruit russet.
• Sevin applied at petal fall is ineffective thinning Fuji.
• Use of NAA on Fuji results in a large proportion of pygmy fruits while use of 6BA results in fewer pygmies.
• 6BA was the most effective thinning treatment for Fuji with respect to reducing crop load and increasing fruit size.

• Early thinning with FOLS combined with post-bloom application of 100 ppm 6BA may greatly improve crop load management of Fuji over the current recommendation of Sevin followed by NAA.

Experiment 3: Timing of FOLS with Gala, Cornell Orchards, Lansing, NY: FOLS caused a significant reduction in cropload at PF+7 days and at PF+ 21 days but at PF+14 days if caused excessive thinning. The double applications of FOLS also caused excessive thinning (Table 4) and significant foliage damage. The PF+14 day application was preceded by an application of captan that may have resulted in excessive captan uptake from the fish oil. This could have caused the excessive thinning. Applications of FOLS at any timing reduced leaf photosynthesis for 7 days followed by a 7-10 day recovery(Figure 1). Double applications of FOLS resulted in a longer suppression of leaf photosynthesis. Pn rates were reduced within 24 hours after FOLS application and the rate of recovery was negatively related to the extent to which Pn is reduced.
These results suggest that
• FOLS applied 7 to 21 DAPF cause dramatic reductions in leaf photosynthesis rates.
• Leaf damage and excessive overthinning can result when FOLS is applied about the same time as captan especially during a cloudy, rainy Spring.

Experiment 4: Fish oil alternatives (Geneva): In 2003, cool weather followed bloom which delayed fruit growth so that chemical thinners were applied about 7 days later than the average year. Rainfall was higher than normal and sunshine lower than normal for the whole month of June resulting in slower than average fruit growth. Rainfall continued to be adequate through the whole season so that irrigation was not required in 2003. At harvest fruit size of Empire was medium (~150g or 120 count fruit size)

Bloom density was very moderate and with a moderate fruit set (65%) cropload on untreated control trees was moderate (5.1) (Table 5). Both ATS and FOLS applied at bloom reduced cropload, fruit number per tree and yield per tree. Fruit size was increased numerically but not significantly. Neither product affected any fruit quality attribute compared to the controls. Single degree of freedom contrasts showed there was no difference in performance of ATS and FOLS at full bloom.

When ATS and FOLS were applied at petal fall neither chemical significantly reduced cropload but FOLS appeared to perform slightly better than ATS. At petal fall ATS significantly reduced fruit size compared to the controls or FOLS. Thus ATS applied at full bloom caused significant thinning but no increase in fruit size. When it was applied at petal fall it caused no thinning but reduced fruit size. Contrast analysis showed no significant difference in the performance of FOLS at full bloom vs. petal fall.

Lime sulfur alone applied at petal fall did not significantly reduce fruit set or fruit numbers compared to the controls. However, the addition of fish oil did reduce fruit numbers and increased fruit size. Neither the addition of ultra fine spray oil, Regulaid or Silwet to lime sulfur sprays improved the thinning effectiveness of lime sulfur. The addition of vegetable oil did improve thinning but did not improve fruit size.

These results suggest that
• Applications of ATS are only effective at full bloom while at later timings ATS negatively affects fruit growth.
• Applications of Lime sulfur are ineffective as thinning sprays unless an oil is used as a surfactant. In this study either fish oil or vegetable oil improved the thinning efficacy of lime sulfur. Other surfactants did not.

Experiment 5: FOLS rate & spray volume (Geneva): In 2003, cool weather followed bloom which delayed fruit growth so that chemical thinners were applied about 7 days later than the average year. Rainfall was higher than normal and sunshine lower than normal for the whole month of June resulting in slower than average fruit growth. Rainfall continued to be adequate through the whole season so that irrigation was not required in 2003. At harvest fruit size of Gala was medium (~140g or 120 count fruit size)

Bloom density was very heavy and with a moderate fruit set (70%) cropload on untreated control trees was high (16) (Table 6). Both ATS and FOLS applied at bloom reduced cropload, fruit number per tree and yield per tree. However only FOLS significantly increased fruit size. Neither product affected any fruit quality attribute compared to the controls. Single degree of freedom contrasts showed at full bloom there was no difference in performance of ATS and FOLS except that FOLS improved cropload adjusted fruit size compared to ATS. ATS caused a significant reduction in cropload adjusted fruit size.

When FOLS was applied at petal fall it had a similar thinning effect as when applied at full bloom but it had very little effect on fruit size. There was no difference in performance of lime sulfur whether fish oil, ultrafine spray oil or vegetable oil were used as the surfactant.

The volume of spray water did not have a significant effect on the thinning efficacy of FOLS when analyzed by ANOVA or contrast analysis (Figure 2). However regression analysis of the volume of water showed that the dilute spray gave better thinning results than did the 2X or 4X applications (Figure 2). There was no effect of spray volume on fruit size.

The rate of Lime sulfur and fish oil did not affect thinning performance or fruit size. The low rate of FOLS (2.5gal lime sulfur and 2gal of Fish oil) gave very similar results at both 2X and 4X as did the high rate (5gal lime sulfur and 4 gal fish oil)

These results suggest that
- Applications of FOLS at full bloom are preferable to ATS applications since they both gave similar thinning but the FOLS improved fruit size while ATS did not.
- At petal fall the type of oil surfactant did not affect the thinning efficacy of lime sulfur. Fish oil, ultrafine spray oil and vegetable oil all gave similar results.
- At petal fall the greater the spray volume of water the greater the thinning efficacy of FOLS sprays. This would indicate that dilute sprays provide better coverage of flowers and young spur leaves giving greater effect.
- The rate of lime sulfur and fish oil did not affect thinning performance of this combination at either 2X or 4X spray volumes.

Conclusions

Our work on arthropod management in organic orchards in 2003 was focused on late season insect injury. The new spinosad insecticide 'Entrust' was very effective in controlling apple maggot and late season obliquebanded leafroller. However early season plum curculio damage was still high in our test blocks. In 2001 and 2002 years we did research on methods to control plum curculio. Our best results were with kaolin clay (Surround) sprays. In the future, it would be desirable to test Entrust and Dipel for late season insect control in combination with an early season program of Surround (kaolin clay) applied to control the plum curculio and early generations of internal lepidoptera. This approach should offer organic apple growers a successful program for insect control in NY state. The percentage of clean fruit will likely not be as high as obtained with conventional insecticides but will be substantially better than in the past.

Fish oil plus lime sulfur continues to show great promise as an alternative thinner. Thinning by FOLS at bloom or at petal fall was superior to petal fall sprays of carbaryl in 2003 trials. Based upon the results from four years of study, the best timings in terms of thinning efficacy combined with fruit sizing effects have been from timings in the bloom-to-petal fall window. Future studies with FOLS should focus on this narrower window.

Another timing question focuses on spray interval. Our photosynthesis data shows that Pn rates are reduced within 24 hours after FOLS application and that the rate of recovery is negatively related to the extent to which Pn is reduced. By tightening the interval between sprays to be closer than the seven day spray schedule used in 2003, we may be able to optimize the thinning response. We also may be able to better understand the relationship between light levels and thinning response to FOLS by manipulating light levels with shade cloth.

All treatments with the PF14 timing in the post-bloom timing study in Lansing NY caused overthinning and leaf drop in 2003, due in part to an interaction with captan fungicide. The Spring was characterized by a cool, cloudy weather. This climate may have increased chemical uptake by the leaves. While phytotoxicity was not severe in most of our 2003 trials, this was the first cool cloudy spring since FOLS research was initiated and it points to the need to the need to reduce risk of damage as much as possible before FOLS is commercialized.

On an anatomical basis, the leaf's CO_2-O_2 exchange could be affected by differences in cuticle thickness, stomate size or number, differences in the thickness of the leaf's photosynthetic tissues, or even differences in chloroplast structure. We need to examine whether FOLS affects the photosynthetic apparatus itself, stomatal structure, or whether phytotoxicity affects Pn only through loss of effective leaf area.

Also relating to safety, our 2002 and 2003 trials suggest that we may be able to get good results in the northeast with reduced rates of both oil and lime sulfur, and that it may not be necessary to concentrate these materials. We propose a further year of study on rates and spray volume using lower rates.

In ongoing trials the use of surfactants with lime sulfur have not been shown to be more effective than lime sulfur alone. Vegetable- and petroleum-based oils have been good alternatives to fish oil. We propose to drop surfactants from further evaluation and continue with studies tank mixing lime sulfur with alternative oils.

Washington obtained a label for FOLS for thinning apples in 2003, retroactive to last Spring. Who should move forward with registration of FOLS in NY, and when? Should we conduct expanded on-farm FOLS demonstration plots in 2004?