Final Project Report to the NYS IPM Program, Agricultural IPM 2000 – 2001

Title:
AN ORGANIC APPLE PRODUCTION SYSTEM FOR NEW YORK

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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 2001 we studied insect pest management, fruit thinning, and weed control tactics that are organically approved. We have evaluated two organic approved insecticides (Surround and Aza-Direct) in season long programs. They both provided some pest control but less than half of the fruit was free from insect damage. Handgun treatments were better than airblast treatments. Both of the products showed some promise but organic growers will still have to accept considerably more insect damage than with conventional pest management products.

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 was only tested at full bloom. Both products also resulted in improved fruit size. There was some phytotoxic effects of both products and a small amount of fruit russetting from multiple applications of fish oil/lime sulfur. We must still evaluate the effect of the thinning agents on return bloom in the spring of 2002..

We successfully modified and improved a weed flaming unit that gave promising results in 2001 for cost effective weed control in organic apple orchards. The use of a shroud allowed

faster travel times and more effective weed suppression. This method should allow organic apple growers to limit weed competition and improve tree growth, yield and 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 allowed a multidisciplinary project at Cornell University to begin to develop a system of organic apple production for the eastern US.

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.

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.

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). However, both of these products can cause phytotoxicity. Sulfur is especially phytotoxic if applied to trees at or near the same time as spray oils or other products with an oil-based carrier are applied to foliage. Producers of organic apples must learn to use these products without causing fruit russetting or other phytotoxicity.

A fourth major problem with organic apple production in NY is weed control. In conventional orchards, weeds are controlled with an early spring application of residual herbicides followed with 2-3 spray applications of contact herbicides. The few existing organic apple orchards in NY control weeds by mowing and limited hand weeding around trees. However, the competition from weeds severely reduces trees growth of young trees and reduces yield, and fruit size in older trees. Propane flamers could become an economical method of weed control for organic farmers, providing a non-chemical method of controlling weeds and pests. Propane may also be more economical than the alternative herbicides and flaming also has no farmworker hazard, reentry period, or necessity for a pesticide license. With flamers, weeds are usually not burned, rather the operation proceeds at a speed such that surface vegetation is merely scorched, and essential enzymes are denatured, which disables the plants' metabolism. Weeds then wither and succumb over a period of several hours, without actually burning up. This conserves the plant residues as organic matter and ground mulch for the soil. If done properly the weeds still look normal right after flaming, remaining green and still standing. After a few minutes to a few hours they start to wilt and die. Another advantage to using flamers is that soil is not disturbed, so new weed seeds aren't brought to the surface. Potential new weed seeds thus remain buried and dormant, unlike what happens in tilling practices. Cultivation has the disadvantage of bringing dormant weed seeds to the surface, breaking dormancy and recreating weed problems in just a few weeks. Problematic orchard weeds like pigweed (Amaranthus spp.) or lambsquarters (Chenopodium album) are especially prone to regenerate after tillage of cultivation practices, and seeds from these weeds can remain dormant in the soil for decades. Flaming works relatively well for controlling annual weeds, but perennials such as quackgrass (Agropyron repens) may grow back rapidly after flaming or mechanical tillage. Similar problems of weed regrowth also occur with non-residual herbicides such as paraquat, while flaming is usable in organic production and leaves no chemical residue on the crops or in groundwater. Flamers have the disadvantage that they could a ignite and burn mulches or other flammable materials. They are best be used following rain, or when there is dew on the surface vegetation to impede combustion of weeds. Flaming speeds vary greatly, because some applications require slower speeds than others. This is affected by the type of flamer, application rate, and atmospheric temperatures, all of which may vary greatly. On a cold day the flamer must travel more slowly to achieve the necessary minimum temperatures for weed control. It is more difficult to flame after a rain, because heat goes into evaporating the water before it can affect weeds or pests. However, the risk of combustion in weed residues, and smoke generation are also reduced in wet conditions. An advantage of flaming relative to tillage is that flaming is possible when soil is too wet for effective cultivation. The addition of a shroud around a burner can reduce the amount of fuel necessary, as it contains heat so that less escapes and the wind does not dissipate kinetic energy. Inside the shroud the heat is also more uniform and constant.

Objectives:

1. Develop an integrated, sustainable arthropod management system that will lead to the production of apples suitable for marketing as organic fruit.
2. Develop alternative chemical fruit thinning approaches for use in certified organic apple orchards that will result in annual cropping and large fruit size.
3. Evaluate the phytotoxicity and russetting on a range of apple varieties by organic disease control measures.
4. Develop alternative weed control approaches for use in certified organic apple orchards that will result in similar tree growth, yield, fruit size and leaf nutrient levels as conventional herbicides.

Procedures:

During the 2001 season, we collaborated with 2 N.Y. organic growers to evaluate insect control, fruit thinning tactics and weed control.

Objective 1. Organic arthropod management system.

In an effort to evaluate current organically approved insecticides, a field trial was established to compare two programs on a season long basis in an commercial organic setting. A western New York certified organic orchard was chosen for this project. Sprays were applied by the grower with a FMC airblast sprayer (300 psi) using 100 GPA. Applications of organic approved insecticides started at petal fall (5 May) and continued until the final cover spray (14 Aug). The orchard was divided into two treatments: 1) Surround WP (50.0 lbs. form/A) applied weekly for all sprays (13 applications); 2) Surround WP (50.0 lbs. form/A) applied weekly for five applications and then Aza-Direct EC (32.0 oz form/A) applied weekly for the remainder of the cover sprays (8 applications). Surround is a formulation of kaolin clay, which is a slurry of clay particles that is intended to form a barrier film, that acts as a broad spectrum agricultural crop protectant against insects and mites. Azadirachtin (commercial formulation GWN 1535) is a chemical extracted from the Neem tree which has provided control of many of the key apple insect pests such as second generation of codling moth and apple maggot. All of the orchard received applications of one of the two treatments thus there was no untreated control, and there were no replication of treatments. The use of Surround in both treatments for the petal fall and early cover sprays was intended for the control of plum curculio. The plot that received the Aza-Direct cover sprays was converted to this spray regime only after 340DD (Base 50o) was reached, after which PC is no longer ovipositing. Harvest evaluations were conducted by randomly selecting 500 fruit on 10 September from each treatment and inspecting them for damage. Data was subject to analysis by SuperAnova (Abacus concepts, Fisher's Protected LSD

Test P<0.05 and transformed Arcsin (Sqrt X) prior to analysis). Economic aspects, such as the cost of these materials, marketability of the fruit and labor intensity was also taken into consideration upon the final overview of the project. Also in this orchard, two rows were excluded from these treatments and put into another trial to test the efficacy of other insecticides against apple maggot and the internal lepidoptera complex (oriental fruit moth, codling moth and lesser apple worm). These applications were made with a handgun (450 psi) and used both of the materials applied with an airblast sprayer in the rest of the orchard. This allowed us to compare the results of efficacy between application methods.

OBJECTIVE 2 DEVELOPMENT OF ORGANIC THINNING STRATEGIES

A study was conducted in Modena, NY and at Olcott, NY to evaluate organically acceptable blossom thinners. In addition we evaluated fish oil plus lime sulfur as a post-bloom thinner. Mature Gala trees on M.9 rootstock in the Hudson Valley were thinned with 4 % vol.: vol. NC 99, a calcium / magnesium brine solution (Genesis Agri Products, Inc., Union Gap, WA); 2% fish oil (Crocker's Fish Oil, Quincy, WA), tank mixed with 2.5 % liquid lime sulfur (FOLS); or 3 pt. per 100 gal. Wilthin (AMADS, Entek Corp., Brea, CA), and were compared to an un-thinned control. All thinners were applied as a single spray at 80% bloom (May 4). NC 99 and FOLS were also applied as a double application, with one spray at 20% bloom (May 3), plus a second spray at 80% bloom. FOLS was also applied as a double application at petal fall and at petal fall plus seven days. Treatments were applied with an air blast sprayer calibrated to deliver 150 gallons per acre and the chemical thinners in this study were measured to deliver the dilute equivalent.

In the western NY trial, mature Rome and Delicious trees on MM.111 rootstock were sprayed with 4 % NC 99 (v/v); 2.5% Crocker's fish oil tank mixed with 2% liquid lime sulfur (FOLS); or 3 % Ammonium Thiosulfate (ATS) and were compared to an un-thinned control. All thinners were applied as a single spray at 80% bloom (May 13). FOLS was also applied as a double application at petal fall and at petal fall plus seven days. Treatments were applied with an air blast sprayer calibrated to deliver 100 gallons per acre and the chemical thinners were applied at 100 gallons/acre.

With both experiments, fruit set, yield and fruit size were measured. Repeat bloom will be measured in the spring of 2002.

OBJECTIVE 3 EVALUATION OF PHYTOTOXICITY AND RUSSETTING BY ORGANIC FUNGICIDES.

We did not conduct phytotoxicity evaluations of organic approved fungicides due to limited funding.

OBJECTIVE 4. DEVELOPMENT OF ALTERNATIVE WEED CONTROL APPROACHES.

This research was conducted as an independent research project by Kevin Bittner, and undergraduate student in the Plant Science major at Cornell's College of Agriculture and Life Sciences, with Dr. Ian Merwin advising. The goal was to refine and test a prototype shrouded flame weeder developed by Ian Merwin several years ago. The research was conducted at Singer Farms, operated by the Bittner family in Barker NY, from January to September 2001. The prototype flame burner was built from components that included the tank, valve assembly, two burners, control solenoids, and a skid mounted steel shroud. A plate was welded to a set of rear pallet forks for the tank to sit on (Figure. 1). The burners were put on the end of a weed sprayer bar that fits on the forks of a tractor with a lift mast or front-end loader. The forks with the tank went on the back of the tractor and the bar with the burners went on a lift mast on the front (Fig. 2). A hose was routed along the hood of the tractor to connect the two. Later the valves were moved from the back of the burners to the hood of the tractor to prevent them from breaking off under low limbs. Final refinements involved the tank carrier and valve setup. The bar and lift mast were replaced by a mounting bracket for a Muller rototiller and brush sweeper. This allowed the burners to float freely upon the ground surface. A frame was then built near the balance point of the shroud to support it from two points, one on each side (Fig.

3). This was welded to a square tube that fits the Muller bracket. The bracket has its own single action hydraulics for lifting and allows the shroud to float over clumps of sod and groundhog holes (Figs. 4-6). This bracket arrangement also allowed a width adjustment for different orchard or vineyard tree spacings. The burners were then bolted to the back of the shroud facing inward. A hinge previously welded onto the shroud allowed the burners to be adjusted for angle. Roundstock skids were then made up to assist the shroud in floating over any rough areas as well as provide replaceable wear points. For use around larger trees the right side of the shroud can be unbolted and the burners can be angled towards the trees, enabling control of weeds in between the trees. All the electronics and valves were relocated inside the cab of a tractor, to protect them from the weather and tree branches. Protecting these components may help extend the life of the machine. For all practical purposes this flamer was set up to be adjustable for diverse planting densities of trees, ranging from dwarf blocks to semi dwarf trees. During the initial year of testing (2000) we operated the machine in empty lots during the dormant season, and determined that everything operated effectively. During the summer of 2001 we tested the flamer under different field conditions. Tests were completed in a commercial ten acre tart cherry block of Montmorency on Mahleb rootstock that was uniform and already had good weed control established. In 2000 the block has had rotating paraquat and glyphosate herbicide applications. The trees were spaced 22 by 20 ft. We used the flamer at different speeds and pressures and shrouded and unshrouded as well as shrouded with one side missing or a door to allow the flames to get between the trees.
There were nine treatments.

1. paraquat
2. shrouded flamer at 2 mph and 25 psi.
3. shrouded flamer at 4 mph and 25 psi
4. shrouded flamer at 2 mph and 40 psi
5. shrouded flamer at 4 mph and 40 psi
6. unshrouded flamer at 2 mph and 25 psi
7. unshrouded flamer at 4 mph and 25 psi
8. unshrouded flamer at 2 mph and 40 psi
9. unshrouded flamer at 4 mph and 40 psi.

The measurements consisted of weed height before and a few days after each application, visual estimation of % ground covered with weeds, and the types of weeds. Due to mechanical problems with the tractor, we were only able to complete one replicate all these treatments during the summer of 2001. Prior to the treatment with the flamer, the weeds were mowed to three inches high. The flame and paraquat treatments were then applied on July 11, 2001. A week later the percent of foliage remaining was estimated visually.

Results and discussion:

OBJECTIVE 1. ORGANIC ARTHROPOD MANAGEMENT SYSTEM.

The insect control programs with Surround or Surround/Aza-Direct gave only partial control of direct fruit pest but not complete control as with conventional pesticides (Table 1). Very few significant differences were found between the treatments when compared for insect damage. The Surround only program controlled internal lepidoptera significantly better than the combination program of Surround and Aza-Direct. Although the remainder of the insect categories were not significantly different from each other, overall the Surround only treatment had a significantly higher percentage of clean fruit. This is due to the accumulation of damage from each of the different pests, because in most cases the combination treatment of Surround and Aza-Direct had slightly higher percentages of damage. The one exception to this is occurrence of apple maggot where Aza-direct resulted in a lower damage level than Surround. This was due to the poor coverage of Surround when applied with an airblast sprayer. In contrast when Surround was applied with a handgun sprayer perfect apple maggot control was obtained, as well as significantly better efficacy against internal worms (Table 2). When Aza-Direct was applied by hand gun, activity against internal lepidotera was better than by airblast sprayer but was poorer for apple maggot. This is probably due to a varietal difference because the handgun plots were setup on 'Cortland' trees, and the data taken from the airblast plot was on "Delicious'. Knowing that coverage from hand applied treatments is significantly better than airblast applications, indicates that Aza-Direct is not very ineffective for AM control, especially with a susceptible variety like 'Cortland'.

Results from this study show that the best organic apple production protocol presently available results in less than half of the fruit being free of insect damage when the control treatments are applied by conventional airblast equipment. Few alternative insecticides or applications equipment exist to these material. The relatively poor insect control levels achieved are a detriment to organic apple production in NY. Application technology for these particular products has not yet been perfected, but recent studies have shown that hand application results in better coverage. This may be a viable option for those looking to increase the amount of insect free fruit produced by their organic orchards.

Most of the organic apples sold in NY are sold for processing, but there are small niche markets that have limited amounts of fresh fruit. In both markets fruit generally sells for twice the amount of conventional grown products. By increasing the percentage of clean fruit growers could also increase gross returns, but this may still not be enough to make the system economically feasible.

The organically approved insecticides we used are about five to six times more expensive than conventional insecticides. Combined with the problem of increased number applications and the problem of increased labor involved with these processes, especially if handgun application is utilized, result in a very expensive insect control program (Table 3). Our estimates of insecticide costs show that the two treatments we evaluated would cost 5-7 times as much as conventional insecticides.

Growing apples organically does have positive aspects as well. If the quality of fruit is high enough, the price that it fetches may cover the input costs and still make a profit for the grower. Competition for the organic market is small and consumers concerned about the pesticides being used for conventional growing are probably willing to pay considerably more for certified organic products. This increased effort by both the grower and consumer then prompts not only industry, but also researchers to develop better materials and techniques. Also, most of the organically certified materials tend to be "softer" and offer more of an opportunity for biological control, even further reducing the amount pesticides needed.

With all aspects of this type of growing system considered, a grower must be completely prepared to make the investment into this market. The increasing interest of organic consumers has had an effect on the number of growers attempting to grow organic produce. With the development and research of efficient materials and techniques, producing a high quality certified organic product may be possible. However, consumers willing to pay premium prices for this type of produce will be the driving factor behind the market.

Objective 2. Organic Thinning Strategies

The fruit thinning treatments with the 2 organic approved chemical (FOLS and NC99) resulted in significant cropload reductions in 2001 (Table 4). NC 99 applied twice and FOLS applied at 80% bloom reduced fruit set, while the non-organic approved blossom thinner, Wilthin, was ineffective (Table 4). Post-bloom FOLS reduced fruit set more than all other treatments. NC 99 reduced yield by a third when applied twice during bloom. FOLS, whether applied once or twice during bloom, also reduced yield by a third, while the post-bloom applications of FOLS reduced yield by 58%. Double applications of both FOLS and NC 99 increased fruit size (Table 2). The largest fruit resulted from the post-bloom FOLS treatment. None of the treatments affected seed number (data not presented).

Both NC 99 and FOLS caused leaf burning and double applications during bloom resulted in the greatest amount of damage (Table 3). Two sprays of FOLS during bloom slightly increased fruit russet.

Both NC 99 and FOLS show strong potential as organic thinners for apple. In fact, the results of trials in 2000 and 2001 show such potential that we are now considering developing the use of these materials as potential replacements for carbaryl in conventional thinning programs. Carbaryl alternatives may become necessary, as a result of future FQPA rulings, and because of export restrictions imposed by buyers in the United Kingdom. Further research is needed to evaluate the use of these thinners in combination with conventional post-bloom materials. Further research is needed to compare the efficacy of alternatives to fish oil in both organic and conventional production systems. Fish oil is malodorous and relatively expensive. Its contributions to the thinning activity and phytotoxicity are unknown. Horticultural oils or other penetrants may be more effective, less harmful to the trees, and more cost-effective.

NC 99 and FOLS caused petal browning and a marginal leaf burn, and double applications caused more severe injury than single applications. These materials have been applied during warm, dry bloom periods in both 2000 and 2001. Additional experience applying these thinners in more typical wet cool seasons is needed before we can be confident that the damage to fruit or foliage isn't economically harmful. We can conclude at this point that organic growers who use these chemicals as thinners will have to accept a noticeable amount of leaf burn resulting from their use but that commercially acceptable fruit thinning can be achieved.

The mode of action of these chemicals is not limited to desiccation of flower parts, as shown by the efficacy of the post-bloom treatment. This finding has great value, as the timing of true blossom thinners requires great precision, which contributes to frequent failure of the thinning sprays, limits the number of acres that can be effectively treated, and contributes to grower stress. It now appears that the effective timing window of these thinners is much broader, and additional research is needed to determine the limits of effective timing. Further studies are planned to determine the actual mode(s) of action, as an understanding of how these chemicals cause fruits to thin would be of great value in assessing their safety and reliability as thinners.

OBJECTIVE 4. DEVELOPMENT OF ALTERNATIVE WEED CONTROL APPROACHES.

Results from our weed control project with the flamer are preliminary since only one replication was treated due to problems with the tractor; however the results were encouraging. The paraquat treatment resulted in about a 95% foliage kill rate. The shrouded flamer at the slower speed and higher temperature (Treatment 4) had the best results compared with paraquat—around 90 percent weed suppression. The fastest application rate with the shroud (Treatment 3) had the same results as the slowest application rate without the shroud (Treatment 8)—around 55 percent. The shroud nearly doubled the effectiveness of the flamer. The prototype flame weeder will be transported to a research farm at Cornell University in Ithaca NY, and further tests will be completed during the summer of 2002 to determine its practical applications for non chemical weed control in orchards.

The economics of flame weed control are more expensive than traditional residual herbicides which are used by most conventional growers. However the cost of flame weeding is comparable to the cost of multiple applications of contact herbicides. The cost of propane was comparable to that of herbicides depending on the prices of those chemicals and the fuel. It would take about the same number of operator-hours per acre, but the propane leaves no soil or groundwater chemical residue.

Table 1. Fruit Damage of 2 Organic Insecticide Programs. 2001

Pest	Mean % Fruit Damage	
	Surround	Surround/Aza-Direct
Internal Lepidoptera	20.4 a	34.0 b
Spring OBLR	0.2 a	0.4 a
Summer OBLR	5.0 a	8.0 a
Apple maggot	9.0 a	3.6 a
Plum curculio	25.4 a	32.8 a
Tarnished plant bug	0.4 a	0.8 a
Clean	44.6 b	29.2 a

Means within a row followed by the same letter are not significantly different (Fisher's Protected LSD Test, P<0.05). Data transformed Arcsin (Sqrt X) prior to analysis.

Table 2. Comparison of Handgun vs. Airblast Application Method on Efficacy of Two Organic Insecticides.

Treatment	% Internal Lepidoptera	% Apple Maggot
Surround Handgun*	3.5 a	0.0 a
Aza-Direct Handgun*	6.9 a	42.0 c
Surround Airblast**	20.4 b	9.0 b
Aza-Direct Airblast**	34.0 c	3.6 ab

* - Data taken from 'Cortland' trees
** - Data taken from 'Delicious' trees
Means within a column followed by the same letter are not significantly different (Fisher's Protected LSD Test, P<0.05). Data transformed Arcsin (Sqrt X) prior to analysis.

Table 3. Pesticide Cost Analysis of Organic Insecticide Programs.

Material	Rate/A	Cost	Cost/A/ Application	Cost/A/Season
Guthion 50	1.5 lbs./A	$8.13 lb.*	$12.20	$85.40 (7 applications)
Surround WP	50.0 lbs./A	$0.65/lb.*	$32.50	$422.50 (13 applications)
Aza-Direct EC	32.0 oz/A	$1.48/oz*	$47.36	$615.68 (13 applications)

*- Prices quoted from UAP Northeast 10/19/01

Table 4. Effect of organic blossom thinners on fruit set and yield of Gala in the Hudson Valley, NY, 2001.

Treatment	Fruit Set (%)	Yield/tree (lb)
Control	79 a	111 a
NC99 X 1	62 ab	109 a
NC99 X 2	47 bc	75 ab
FOLS X 1	52 b	75 ab
FOLS X 2	57 ab	69 ab
FOLS PF + FC	25 c	47 b
Wilthin	76 a	101 a

Table 5. Effect of organic blossom thinners on fruit size of Gala in the Hudson Valley, NY, 2001.

Treatment	Fruit Diameter (in)	Fruit Weight (g)
Control	2.4 b	116 b
NC99 X 1	2.5 b	126 b
NC99 X 2	2.8 a	150 a
FOLS X 1	2.5 b	124 b
FOLS X 2	2.8 a	151 a
FOLS PF + FC	2.8 a	167 a
Wilthin	2.4 b	117 b

Table 6. Effect of organic blossom thinners on phytotoxicity to Gala in the Hudson Valley, NY, 2001.

Treatment	Leaf Burn	Russett
Control	0 d	1 b
NC99 X 1	2 b	1 b
NC99 X 2	3 a	1 b
FOLS X 1	1 c	1 b
FOLS X 2	3 a	2 a
FOLS PF + FC	3 a	2 a
Wilthin	0 d	1 b

Figure 1 . Modified flamer mounted on front of tractor.

Figure 2. Front view of unit on tractor. For scale, the tractor is 50 inches wide.

Figure 3. Operator's view of mounted flame weeder from cab of tractor

Figure 4. Flamer raised for easy transport and repairs or adjustments.

References: (if applicable)