Investigating a Non-OP Approach to Insect Pest Management on Apple

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For the past forty-five years commercial fruit growers in the Northeast have relied heavily on organophosphate class of insecticides (OP's) for insect pest management. The onset of insecticide resistance began with the early non OP insecticides, such as the arsenicals. Resistance continued to develop to the newly emerging synthetic insecticides (DDT and its analogs) in the 1950's, which stimulated the development and use of the OP's in fruit pest management. The OP's in general are relatively inexpensive, have a very broad and effective spectrum of insecticidal activity, and until fairly recently, had provided excellent control for the diversity of insect pests feeding on fruit, foliage and wood of fruit trees throughout the Northeast.

Increasing concerns for food safety and worker protection have led to greater restrictions on the most widely used OP's. New legislation stemming from the 1996 Food Quality Protection Act (H.R. 1627) has, or will in the near future, reduce pesticide residue tolerances. This has begun with the scrutiny of the OP class, and will continue on to the carbamate and pyrethroid classes of insecticides. The recent elimination of methyl-parathion (Penncap-M™) uses on tree fruit, the future phase out of azinphos-methyl (Guthion™) in 2012, the restricted uses of chlorpyriphos (Lorsban™) limited to the early growing season have spurred producers to alter their insect pest management strategies. Moreover the increased restrictions for the use of phosmet (Imidan™), decreasing OP tolerances of re-entry intervals (REI) and pre-harvest intervals (PHI), have resulted in greater difficulty in managing pests such as San Jose scale, obliquebanded leafroller and apple maggot in apple production. This reduction in the availability of OP insecticides for pest management has prompted the examination and use of replacement materials to obtain control of difficult to manage orchard pests.

Given these pest management constraints, Cornell University research entomologists have conducted trials to demonstrate both the efficacy of replacement materials on the pest complex and inquiry into the possible adverse effects these materials may have on phytophagous and predatory mites.

Procedure

In studies conducted by Cornell University's Hudson Valley Laboratory entomologists, evaluations of the potential use of OP replacement materials were made in a block of 'Rome' trees at the Stone Ridge Orchard in Stone Ridge, NY. Materials and rates used in the comparison trial are presented in Tables 1 & 2. They consisted of a 'grower standard' including the organophosphate Imidan 70WP and a bio-rational bacterium metabolite, spinosyn, SpinTor™ 2SC (Trmt. 1), Imidan 70WP and three synthetic pyrethroid (SP) combinations of Asana™ 0.66 XL, Warrior™ 1CS, and Danitol™ 2.4EC (Trmt. 2), three SP combination treatments of Asana 0.66 XL, Warrior 1CS, and Danitol 2.4EC with or without late summer oil (Trmt. 3 & 4), a non-OP / non-SP treatment using the neonicitinoid, Calypso™ 4F and SpinTor 2SC (Trmt. 5), a pyrethroid / carbamate combination of Asana 0.66 XL and season long Sevin™ XLR (Trmt. 6), and the untreated control (Trmt. 7).

Individual treatments were made to single-tree plots replicated four times in a complete replicated block design beginning at petal fall and continuing through the season. Applications were made using a truck-mounted high-pressure sprayer and 'pecan' handgun applied dilute to drip at 300 psi., delivering approximately 2.5 gallons per tree. Insecticide dilution rates were based on a 'standard' 300 GPA orchard. All treatments received Sevin XLR Plus at 10 mm fruit diameter for crop load adjustment. Treatments were applied for petal fall on 1 June, 1st cover on 17 June, 2nd cover on 30 June, 3rd cover on 13 July, 4th cover on 2 August, 5th cover on 17 August.

Evaluations of insect damage and fruit ratings were made at harvest. Phytophagous and predatory mite evaluations were

> **Converting our commercial tree fruit pest management strategies from an organophosphate-based program to a reduced risk approach should be a transitional process. Although pyrethroids provide excellent broad spectrum control of fruit feeding pests, and have lower mammalian toxicities than OP's, when a pyrethroid is used, even once during the growing season, biological control is drastically reduced. Some of the newly developed insecticides have novel modes of action and may require more precise timings to optimize efficacy. Becoming familiar with the use of reduced risk materials will take a greater effort on the part of the farm manager.**

made throughout the season. European red mite eggs were also collected in October from 3-inch, 2nd year wood samples to determine the overwintering mite egg density and presence of predatory mite (Figures 1 and 2).

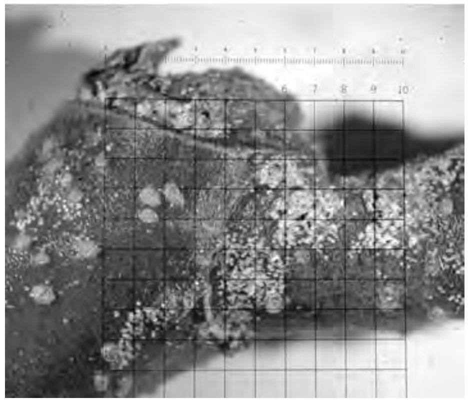

Figure 1. Microscope grid used to tally overwintering European red mite eggs on 2nd year apple branch.

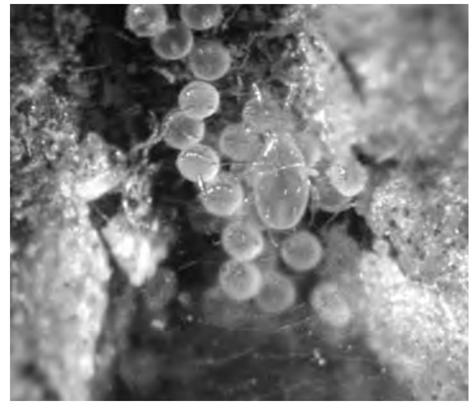

Figure 2. Phytoseiid mite and webbing atop overwintering European red mite eggs.

Results and Discussion

All insecticide treatments significantly lowered incidence of tarnished plant bug (TPB) damage to the fruit compared to the untreated (Table 1). Early treatments of Sevin XLR, the pyrethroid Asana XL and the neonicotinoid, Calypso 4F, gave better control of TPB than the standard OP of Imidan 70WP. All of the treatments were significantly better than the untreated against the plum curculio, apple maggot, and stink bug complex, yet no significant differences were observed between treatments in managing these fruit feeding insects. San Jose scale damage to fruit was reduced significantly by a season-long program of Sevin XLR compared to all other treatments. The greatest percent of 'Extra Fancy' fruit were observed in the non-OP treatments with significantly higher percentages (97.7%) produced using the Sevin XLR and Asana program.

Both foliar feeding and predatory mite activity are often a function of pest management strategies. Results from previous studies conducted at the Hudson Valley Lab demonstrated that a late season pest management program employing limited pyrethroid use targeted toward apple maggot resulted in a mite 'flare-up' response in mite populations. This has at least in part been attributed to the elimination of biological control agents that maintain mite populations below economic thresholds. Yet in studies employing season-long pyrethroid applications made on a 14-day schedule, no mite flare-ups were observed, presumably due to the insecticidal suppressive mode of action of pyrethroids on mite populations.

In this 2005 study, mite populations began to build very late in the growing season with no treatment exceeding economic threshold at any time. By the end of the season some light bronzing was observed in the untreated control treatment. To measure the season-long presence of the European red mite we used

Table 1

Effective and Economic Alternatives to Azinphosmethyl:
Field Evaluation of Phosmet and Non-OP Schedule1, Stone Ridge Orchard, Stone Ridge, N.Y. - 2005

Treatment	Formulation amt./100 gal.	Timing	% Damaged [2, 3, 4] fruit: TPB	PC	AM	SB	SJS	Fruit rating as % grade: Extra Fancy	US #1	Utility Grade	Culls
1. Imidan 70WP	20.0 oz.	PF, 2C	2.0 bc	0.0 a	0.0 a	0.2 a	8.3 b	89.0 b	0.7 a	0.2 a	8.7 b
+ Damoil	1.0 gal.	PF, 2C									
Sevin XLR Plus	16.0 oz.	1C									
Spintor 2SC	2.5 oz.	3-5C									
2. Imidan 70WP	20.0 oz.	PF, 2C	3.3 c	0.3 a	0.0 a	0.0 a	5.9 b	89.7 b	2.9 b	0.1 a	6.6 b
+ Damoil	1.0 gal.	PF, 2C									
Sevin XLR Plus 4EC	16.0 oz.	1C									
Asana 0.66 XL	5.8 oz.	3C									
Warrior 1CS	1.71 oz.	4C									
Danitol 2.4EC	3.6 oz.	5C									
3. Asana 0.66 XL	5.8 oz.	PF	0.8 ab	0.3 a	0.0 a	0.1 a	5.7 b	92.4 bc	0.7 a	0.1 a	6.6 b
Sevin XLR Plus 4EC	16.0 oz.	1C									
Warrior 1CS	1.71 oz.	3-4C									
+ Damoil	1.0 gal.	3-4C									
Danitol 2.4EC	3.6 oz.	5C									
4. Asana 0.66 XL + oil	5.8 oz.	PF, 2C	0.2 a	0.0 a	0.0 a	0.0 a	4.5 b	95.2 cd	0.0 a	0.0 a	4.7 ab
Sevin XLR Plus 4EC	16.0 oz.	1C									
Warrior 1CS	1.71 oz.	3-4C									
+ Damoil	1.0 gal.	3-4C									
Danitol 2.4EC	3.6 oz.	5C									
+ Damoil	1.0 gal.	5C									
5. Calypso 4F	1.5 oz.	PF	1.0 ab	0.1 a	0.0 a	0.0 a	5.2 b	93.0 bc	0.9 ab	0.0 a	5.5 b
+ Damoil	1.0 gal.	PF, 2C									
Sevin XLR Plus 4EC	16.0 oz.	1C									
Spintor 2SC	2.5 oz.	3-5C									
6. Asana 0.66 XL /oil	5.8 oz.	2C	0.2 a	0.1 a	0.0 a	0.0 a	1.4 a	97.7 d	0.2 a	0.0 a	1.9 a
Sevin XLR Plus 4EC	16.0 oz.	PF-1,3-5C									
7. Untreated		-	7.4 d	4.1 b	0.8 b	1.3 b	7.9 b	78.0 a	6.3 c	0.5 a	14.6 c

1 Data from ' Rome'. Mite sampled by examining 25 terminal leaves per tree using mite brushing machine to remove mite onto soaped glass plates for evaluation.
2 Mean separation by Fishers Protected LSD (P=<0.05). Treatment means followed by the same letter are not significantly different. Untransformed means presented.
3 Treatments were applied for petal fall (PF) on 1 June, 1st cover on 17 June, 2nd cover on 30 June, 3rd cover on 13 July, 4th cover on 2 August, 5th cover on 17 August.
4 Tarnished plant bug (TPB): *Lygus lineolaris* (P. De B.), Plum curculio (PC): *Conotrachelus nenuphar* (Herbst), Apple maggot (AM): *Rhagoletis pomonella* (Walsh), Stink Bug complex (SB): *Euschistus servus* (Say), *Acrosternum hilare* (Say), San Jose scale (SJS): *Quadraspidiotus perniciosus* (Comstock)

cumulative mite-days (CMD) to calculate the number of mites found on each leaf sampled per day projected throughout the season (Table 2). The greatest number of European red mite CMD's was observed in the untreated control trees (Trmt.7). The lowest CMD's were observed in the season-long pyrethroid program employing a tank mix of Danitol and oil late in the season (Trmt.4), followed by the Imidan 'grower standard' (Trmt.1). Monitoring of season-long mite populations did not reveal significant differences among treatments for predatory mites, and none of the treatments attained > 0.1 predatory mite / leaf during the growing season.

There is a tendency for European red mites to lay a greater number of overwintering eggs on branches of apple when mite populations are allowed to increase during late season. To evaluate the potential of these treatments on the subsequent year's mite populations, we counted the number of European red mite eggs at the end of the season. We observed the greatest number of eggs (923.7 eggs/section) in the Imidan 'grower standard'(Trmt.1). The lowest numbers of overwintering eggs (235.6 eggs/section) was observed in the untreated control trees (Trmt.7). We counted the number of predatory mites (*Amblyseius fallacis* (Garman)) and observed the lowest numbers of these phytoseiid mites in the Imidan 'grower standard'(Trmt.1). The highest numbers of predatory mites were observed in the pyrethroid treatment where Danitol was used without oil (Trmt. 3). There was neither a strong correlation between the numbers of European red mite eggs and CMD, nor a strong correlation between European red mite eggs and phytoseiid mite presence.

Conclusions

The non-OP's, such as Calypso 4F and SpinTor 2SC, and the pyrethroids provided excellent broad-spectrum activity on fruit feeding pests. Based on cumulative mite days, the season-long application schedule of Calypso 4F, SpinTor 2SC and the pyrethroids resulted in significantly fewer CMD's than did the untreated control and were not significantly different from the season long application schedule of the organophosphate treatment. Season-long pyrethroid treatments with and without the use of a summer oil program did not 'flare' foliar feeding mites. Pyrethroid schedules are commonly known to be detrimental to predacious mites during the growing season, especially to the biological control agent *Typhlodromus pyri* used in European red mite management.

During our experiment, significant differences of predacious mites were observed during evaluations of overwintering eggs at the end of the season. The highest A. fallacis numbers were observed in the Danitol 2.4EC treated trees (Trmt. 3). A rebound of A. fallacis is relatively common when late season spikes of European red mite occur. This phenomenon was not uniformly observed in this study. The non-OP / non-pyrethroid treatment using Calypso 4F and SpinTor 2SC also gave excellent control of fruit feeding pests without negatively impacting mite populations.

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Table 2

Effective and Economic Alternatives to Azinphosmethyl:
Field Evaluation of Phosmet and Non-OP Schedule[1], Stone Ridge Orchard, Stone Ridge, N.Y. - 2005

	Treatment	Formulation amt./100 gal.	Timing	Cumulative mite days[4] ERM 22 June	ERM 5 July	ERM 25 July	ERM 8 Aug.	ERM 22 Aug.	Total Cumulative mite days	Phyto-seiid mite[3] / 3" cutting	ERM OW mite eggs[4] / 3" cutting
1.	Imidan 70WP	20.0 oz.	PF, 2C, 6C	0.2	0.4	3.2	8.9	14.3	27.0	0.4 a	923.7 d
	+ Damoil	1.0 gal.	PF, 2C								
	Sevin XLR Plus	16.0 oz.	1C								
	Spintor 2SC	2.5 oz.	3-5C								
2.	Imidan 70WP	20.0 oz.	PF, 2C	0.5	0.5	5.6	8.6	18.2	33.5	0.9 ab	621.3 cd
	+ Damoil	1.0 gal.	PF, 2C								
	Sevin XLR Plus 4EC	16.0 oz.	1C								
	Asana 0.66 XL	5.8 oz.	3C								
	Warrior 1CS	1.71 oz.	4C								
	Danitol 2.4EC		5C								
3.	Asana 0.66 XL	5.8 oz.	PF	0.2	0.7	11.0	13.0	30.5	55.4	1.3 b	670.4 cd
	Sevin XLR Plus 4EC	16.0 oz.	1C								
	Warrior 1CS	1.71 oz.	3-4C								
	+ Damoil	1.0 gal.	3-4C								
	Danitol 2.4EC	3.6 oz.	5C								
4.	Asana 0.66 XL + oil	5.8 oz.	PF, 2C	0.3	0.5	3.0	4.1	3.8	11.7	0.7 ab	355.5 ab
	Sevin XLR Plus 4EC	16.0 oz.	1C								
	Warrior 1CS	1.71 oz.	3-4C								
	+ Damoil	1.0 gal.	3-4C								
	Danitol 2.4EC	3.6 oz.	5C								
	+ Damoil	1.0 gal.	5C								
5.	Calypso 4F	1.5 oz.	PF	0.1	0.3	8.0	17.4	38.6	64.5	0.7 ab	496.7 bc
	+ Damoil	1.0 gal.	PF, 2C								
	Sevin XLR Plus 4EC	16.0 oz.	1C								
	Spintor 2SC	2.5 oz.	3-5C								
6.	Asana 0.66 XL /oil	5.8 oz.	2C	0.0	0.5	12.0	23.9	19.7	56.1	0.9 ab	565.2 bc
	Sevin XLR Plus 4EC	16.0 oz.	PF-1,3-6C								
7.	Untreated	-	-	1.0	1.8	23.3	34.3	53.9	114.3	0.6 a	235.6 a

1 Data from ' Rome'. Mite sampled by examining 25 terminals leaves per tree using mite brushing machine to remove mite onto soaped glass plates for evaluation.
2 Mean separation by Fishers Protected LSD (P=<0.05). Treatment means followed by the same letter are not significantly different. Untransformed means presented.
3 A predatory phytoseiid (AMB): *Amblyseius fallacis* (Garman)
4 European red mite (ERM): *Panonychus ulmi* (Koch)