2006 NYS IPM Agricultural Grants Program – Final Report

Title: Management programs for internal Lepidoptera in apples using pheromone mating disruption and in-season fruit inspection

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Abstract: During the last 5 years, severe outbreaks of two species of internal Lepidoptera (worms) have occurred in apple production regions in western NY. These outbreaks have caused severe financial losses to growers throughout this region because numerous loads of apples have been rejected for fresh or processing markets. Initial studies conducted have shown that neither the currently available organophosphate (OP)-based technology nor programs relying on more selective reduced-risk products can provide adequate, cost-effective control of these pests in high-risk commercial orchards within these outbreak areas. This escalating incidence of severe fruit damage in commercial orchards clearly poses a threat to the continued viability of the industry within the region. The objectives of this year's study were to: 1) Compare the effectiveness of three different pheromone dispensing systems for mating disruption of oriental fruit moth and codling moth in commercial apple orchards; 2) Use a repeated fruit sampling protocol and pheromone trap monitoring to determine the need for and subsequent timing of special insecticide sprays against oriental fruit moth and codling moth in both disrupted and non-disrupted orchards. Three different pheromone products—Isomate ties (CM/OFM combo or M-100 plus CTT), MSTRS-OFM packets, and Hercon Disrupt Micro-Flakes (CM and/or OFM) plus a sequential fruit sampling procedure were evaluated in codling moth and/or oriental fruit moth management programs in 9 commercial orchards of varying pest pressure. The CM products were included only in the three orchards where codling moth was deemed to be the primary pest, in combination with a 4-spray program of Cyd-X granulosis virus. All pheromone treatments generally suppressed catches of CM, OFM, and lesser appleworm moths to very low levels, although some breakthrough did occur, so trap shutdown was not absolute in all cases. The fruit sampling procedure, comprising on-tree inspection of at least 100 fruits per plot for each of 7 weeks during July and August, was convenient to implement and appeared to effectively allow detection of low-level infestations at a very early stage, so that the growers could be notified of any extra needed control measures in a timely fashion. Fruit damage at harvest was low in all treatments, and statistically comparable to the grower standard program at 6 of the 9 sites. At two sites, the damage was significantly lowest in the Isomate site, and in one site, the Isomate and MSTRS treatments sustained significantly higher (1.8–2.9%) damage than did the grower's standard program (0.1%), although proximity to a large bin storage area could have contributed substantially to this result.

Background and Justification

Growers in the northeastern US are already threatened by reduced availability in the future of broad-spectrum, relatively inexpensive, effective insecticides such as OPs, because of changes resulting from the implementation of the Food Quality Protection Act. In addition, they are faced with low commodity prices from increased domestic and foreign competition, as well as higher production costs. During the 2003-04 growing seasons, initial studies showed that mating disruption using standard pheromone ties, which require considerable hand labor to apply, can help provide good control of oriental fruit moth (OFM) in apples. Those studies also showed that pheromone trap catch thresholds and fruit sampling can help growers determine the need and timing for special insecticide sprays against this pest. However, additional work was needed to include management of a related key pest, codling moth (CM), and to further evaluate the thresholds and original fruit sampling plan, which required inspecting 1000 apples/block and was too time consuming for growers or pest managers to use.

Although they have been present for years, these pests have only recently become a source of concern to NY growers. However, because of pesticide resistance and other ecological factors, they must now make special efforts to control them for the first time. The initial reaction of many growers who discover internal worms in their fruit is to respond with multiple preventive (and possibly unwarranted) applications of harsh broad-spectrum and specialty pesticides, often combined with mating disruption. Because these are usually made without any formalized evaluation of the need or effectiveness of the specific tactics employed, it is very difficult to assess whether these programs are worthwhile or justified. This work addresses the need for delivery of information and technology to reduce severe pest outbreaks through sustainable agricultural tactics that will have minimal environmental impact and possibly allow expanded crop marketing in specialty markets such as organic outlets.

Conducting these trials as on-farm research demonstrations ensures maximum exposure of the techniques and results, which are being shared with stakeholders through both extension and research venues, for evaluation at both the farm and academic level of interest.

Objectives

1. Compare the effectiveness of three different pheromone dispensing systems for mating disruption of OFM and CM in commercial apple orchards.
2. Use a repeated fruit sampling protocol and pheromone trap monitoring to determine the need for and subsequent timing of special insecticide sprays against oriental fruit moth and codling moth in both disrupted and non-disrupted orchards.
3. Project evaluation

Materials & Methods

This trial was conducted in mixed plantings of fresh and processing apples on nine commercial farms in Wayne, Orleans and Niagara Counties, NY. A low-density pheromone "packet" dispenser, a sprayable plastic micro-flake, and two types of standard polyethylene "twist-tie" dispensers were compared for efficacy in managing three internal-feeding Lepidoptera species, codling moth (CM), *Cydia pomonella*; oriental fruit moth (OFM), *Grapholita molesta*; and lesser appleworm (LAW), *Grapholita prunivora*, when applied against the 2nd and 3rd generations of these pests. Apple varieties included Cortland, Empire, Fuji, Gala, Golden Delicious, Honeycrisp, Ida Red, McIntosh, Monroe, Mutsu, Red Delicious, Rome, and 20-Ounce.

Objective 1.

Internal worm management programs were tested in nine "low-" to "high-risk" commercial orchards, using three different pheromone dispensing technologies, as well as a fruit sampling procedure to assess the need and timing for special pesticide sprays directed against the 2nd and subsequent generations of these species. The pheromone treatments used were: 1) Isomate polyethylene ties; 2) MSTRS OFM high-yield, low-density pheromone packets; 3) Hercon Disrupt Micro-Flake, a sprayable plastic laminate, all applied against the 2nd and subsequent generations of CM, OFM, and LAW. Codling moth was not a target species in all sites, so specific Isomate and Hercon products were used as appropriate to each farm's pest pressure; the MSTRS product was available only for OFM. The OFM products were directed additionally against LAW, as these two species have similar pheromone blends. In all cases, growers managed the first generation broods of these pests with their conventional pesticide applications that were directed primarily against plum curculio and obliquebanded leafroller occurring at and immediately following petal fall.

The Isomate (CBC America Corp., Commack, NY) products were applied between 14–22 June, and included the following:

- Isomate-M 100, a polyethylene rope (or "tie") containing 232.1 mg of OFM pheromone blend (88.5 : 5.7 : 1.0% of Z:E8-12:OAc : Z8-12:OH), deployed at a rate of 250 ties per ha (100 per acre).
- Isomate-CM/OFM TT, a "twin tube" assembly of two "ties" containing 423.6 mg of a multi-species blend for all 3 species: 58.4% E8,E10-12:OH, 9.23% 12:OH, 1.87% 14:OH, 21.25% Z8-12:OAc, 1.36% E8-12:OAc, and 0.23% Z8-12:OH, deployed at a rate of 500 ties per ha (200 per acre).
- Isomate-C TT, a "twin tube" assembly of two "ties" containing 382.4 mg of CM pheromone blend (53.0 : 29.7 : 6.0% of E8,E10-12:OH : 12:OH : 14:OH), deployed at a rate of 500 ties per ha (200 per acre).

A pheromone packet treatment, using "MSTRS" technology (Metered Semiochemical Timed Release System, AgBio Inc., Westminster, CO) consisted of food-grade plastic enclosing a 6.4 x 6.4 cm natural fiber pad containing 2.63 g of OFM pheromone (85.4 : 5.5 : 0.9% of Z:E8-12:OAc : Z8-12:OH), which was deployed in a grid pattern at a density of 25 per ha (10 per acre). A pole+hoop applicator was used to position the dispensers, hung by a wire loop, in the top one-third of the tree canopy. Deployment of these dispensers took place from 20–23 June.

The Disrupt Micro-Flake (Hercon Environmental, Emigsville, PA) products were 3 x 3 mm solid matrix laminate chips impregnated with either:

- OFM pheromone (7.83 : 0.51 : 0.08% Z:E8-12:OAc : Z8-12:OH), applied at a rate of 47.3 g a.i. per ha (19.2 g a.i. per acre), or 560 g of flakes per ha (8 oz of flakes per acre); OR
- CM (4.66% E8,E10-12:OH) pheromone, applied at a rate of 51.9 g a.i. per has (21 g a.i. per acre), or 1.2 kg of flakes per ha (1 lb of flakes per acre).

Applications were made using a modified leaf blower (Arena Turbo-Tac) mounted on an ATV traveling at 6–7 mph down the rows. The flakes were stuck to the tree foliage using an acrylic sticker (Micro-Tac) applied as they were blown from the machine. All the Micro-Flake treatments were applied (at 3 sites) between 29 June–14 July. Several attempts were made to apply these treatments at 3 additional sites, but these were prevented by equipment malfunction caused by jams in the hopper feeder mechanism and sticker blockages in the flake auger.

Records were kept of the amount of time required for application of each type of pheromone dispenser, and although there was some variability due to differences in the orchards' physical characteristics and treatment combinations, the following average times were determined: Isomate-M, 37 min/A/person; Isomate CM/OFM, 34 min/A/person; MSTRS, 14 min/A/person; Hercon, 5 min/A (one person driving, but a second was needed to assist, and setup time required was considerable).

Treatments were originally designed to match the species pressure at each site: where OFM (plus possibly LAW) was the primary concern, plots were set up for Isomate-M 100, MSTRS-OFM, and Hercon-OFM; where CM was also assumed to be present, plots would receive either Isomate-CM/OFM or a combination of Isomate-CTT + M 100, plus Hercon-OFM + CM; no MSTRS plots were to be set up in these sites, as there is no MSTRS product available for CM. Farms with high CM pressure additionally received a 4-spray program of Cyd-X granulosis virus (Certis USA, Columbia, MD), at 3 oz/A, timed at 1st hatch plus 10 d later for each of the 2 generations. Because not all of the farms had a presumed high risk of CM damage (in addition to OFM), only 3 of the 9 were intended to receive CM pheromone treatments — Bates Rd., Eagle Harbor, and Hartley. However, because of the equipment failure, the Hercon-CM plot at Eagle Harbor was scrapped, as were Hercon-OFM plots at DeBadts and Hance. (A unique treatment combination of MSTRS-OFM + Hercon-CM was applied in one plot at Bates Rd. because of a last-minute request by the consultant to include CM disruption treatments on this farm.) Table 1 shows the final treatments set up at each site.

Pheromone treatment efficacy in depressing adult male trap catch was monitored by using 9 Pherocon IIB traps per plot (3 each for CM, OFM, and LAW, located at either end plus the center of a middle row), each baited with a standard Scentry rubber septum lure, and checked weekly from 4 May to 25 August. In addition, a similar group of 9 traps in a non-disrupted check plot nearby was monitored as well, to maintain information on background levels of each of these species and for purposes of fruit injury comparison at harvest. Lures in all traps were changed at the end of June, and additionally at the beginning of August for CM.

Objective 2.

The fruit sampling protocol consisted of weekly on-tree fruit inspections conducted from mid-July through August, comprising 300 fruits per plot (20 on each of 15 trees) during the first week and 100 fruits per plot (10 on each of 10 trees) on subsequent weeks, to detect the initial occurrence of any larval fruit damage in time to curtail further infestation. Whenever an inspection session resulted in the detection of at least one damaged fruit, the grower or his consultant was notified so that they could determine whether a special spray of a selective pesticide was needed for control of internal Lepidoptera. An evaluation of larval fruit-feeding damage at harvest was made by taking random samples of 1000 fruits from each plot (20 from each of 5 trees along each plot edge, and 20 from each of 30 trees distributed throughout the plot interior) and examining them for internal and surface injury. Pre-harvest samples were taken between 18–27 Sept.

Results

Trap catches of adults were generally suppressed to low levels in all pheromone treatment plots during the mid- and late summer, although some breakthrough captures did occur, particularly for codling moth, so trap shutdown was not absolute in all cases (Fig. 1). Two sites with notable CM catches were Bates Rd (Fig. 1A), where the Hercon-CM (used in combination with the MSTRS OFM) successfully depressed catch numbers after its application on 7 July, and Hartley (Fig. 1B), where there was a substantial breakthrough in one of the Hercon traps during the first week in August. Oriental fruit moth pressure was considerable at Hance, Hartley (Fig. 1B), and Zingler (Fig. 1C), but all treatments showed low trap numbers throughout the season; likewise, lesser appleworm was very numerous at Bates Rd., Eagle Harbor (Fig. 1A), Hance, Hartley (Fig. 1B), and Zingler (Fig. 1C), but the respective OFM pheromone treatments effectively depressed these trap numbers as well.

The fruit sampling procedure was simple and convenient to implement, requiring 10–15 min per plot, and appeared to effectively allow detection of low-level infestations at a very early stage, so that the growers could be notified of any extra needed control measures in a timely fashion. Incidence of fruit injury was extremely low except at Hartley, Hance, and Eagle Harbor, each of which required two notifications of damage to the grower or their consultant (Table 1). These farms, as well as Bates Rd. (one notification), did receive 1–2 directed applications of Assail against encroaching larval populations as a result. No damaged fruits were found during the 7 weekly samples at Endres, Kappus, Pepe, and Zingler. Interestingly, in contrast to the 2005 trials of these treatments, if the currently proposed trap catch thresholds of 10 OFM and 5 CM/trap/week had been used as a basis for making control sprays, our management recommendations would have been much less conservative than they were using the evidence of fruit-feeding damage; only one notification would have been made, at the Hartley site.

Fruit damage at harvest caused by internal-feeding Lepidoptera at harvest was very low in all treatments, and at 6 of the 9 sites there was no statistical difference between the pheromone plots and the respective Grower Standards (Table 2). Only 2 of the 9 sites, Bates Rd. and Hartley, had significantly less fruit damage in one of the pheromone plots—Isomate, in both cases—than in the non-disrupted Grower Standard, and at one site, Hance, fruit damage was actually higher in the pheromone treatments than in the Standard. In this case, proximity to a large bin storage area was undoubtedly a contributing factor. This is likely a situation where the use of farm-wide mating disruption would have been a potential solution.

Discussion

Although the pheromone treatments tested were generally a useful component of the internal lepidopteran management programs in these orchards, some factors, as before, can be identified as potentially contributing to less than perfect fruit quality: plot size not large enough to overcome the possibility of immigration by mated females; population pressure sometimes too high to be effectively disrupted by the pheromone treatments; and the pheromones being applied against only the 2nd and subsequent generations, leaving the potential for the 1st generation to contribute to fruit damage. The in-season fruit inspection regimen continues to appear effective and reliable, but there remains a difficulty in convincing growers to wait for evidence of even a low level of damage in their orchards before applying a special spray against these pests. Pesticide use against these species could be reduced in situations of low to moderate population pressure, where mating disruption could be relied upon to adequately mitigate potential fruit infestations. In general, considering the overall levels of pest pressure occurring in these orchards, and the economics (considering both materials and labor) of implementing these pheromone treatments, it is possible that internal worm problems in many higher-risk NY orchards could be adequately addressed by adjusting pesticide spray schedules or with the use of selective products for a limited number of designated sprays.

According to current records of infested loads received at major fruit processors in western NY, approximately 50 growers submitted a total of 113 loads with detectable worm infestation injury during this year's harvest period; these would nominally be the designated beneficiaries of the current work. The added cost of using mating disruption against these pests could range from $35 (OFM) to $100 (CM plus OFM) per acre, and a 4-spray program of Cyd-X granulosis virus for CM would cost approximately $105 per acre. A number of selective insecticides with proven effectiveness against internal worms are available, at costs ranging from $35–45 per acre per application. Although these tactics represent a substantial increased cost in a crop protectant program, they may be necessary to avoid the higher price of having even a single load rejected by the fruit buyer.

Ongoing work in this area will be directed at optimizing farm-wide management strategies, in order to improve the effectiveness of each of these types of tactics and diminish the potential for immigrating adults to overcome more localized control programs.

(Project Location) – The results of these findings would generally be most applicable in the western NY fruit region, but would also be applicable in all tree fruit-producing areas of the state, as well as other comparable areas in the Northeast.

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Table 1. Detection of worm-infested apples during summer fruit inspection dates in pheromone- treated plots, 2006.

		Number Detected						
	No. fruit inspected	300	100	100	100	100	100	100
	week of:	**7/10**	**7/17**	**7/24**	**7/31**	**8/7**	**8/14**	**8/21**
Site	**Treatment**							
Bates Rd.	Isomate (OFM, CM) + Cyd-X	0	0	0	0	0	0	0
	MSTRS (OFM)+Hercon (CM)+Cyd-X	0	0	0	2	0	0	0
	Hercon (OFM, CM) + Cyd-X	0	0	0	0	0	—	0
	Grower Standard	0	1	0	0	0	0	0
DeBadts	Isomate (OFM)	0	0	0	0	0	0	0
	MSTRS (OFM)	0	0	0	0	0	0	0
	Grower Standard	0	0	0	0	3	0	0
Eagle Harbor	Isomate (OFM) + Cyd-X	0	1	0	1	1	0	0
	Grower Standard + Cyd-X	0	4	0	0	0	0	0
Endres	Isomate (OFM)	0	0	0	0	0	0	0
	MSTRS (OFM)	0	0	0	0	0	0	0
	Hercon (OFM)	0	0	0	0	0	0	0
	Grower Standard	0	0	0	0	0	0	1
Hance	Isomate (OFM)	0	0	4	0	2	0	0
	MSTRS (OFM)	0	1	0	0	2	0	4
	Grower Standard	0	0	1	0	0	0	0
Hartley	Isomate (OFM, CM) + Cyd-X	0	0	0	1	8	14	0
	Hercon (OFM, CM) + Cyd-X	1	2	7	3	11	11	2
	Grower Standard	0	0	0	0	5	12	5
Kappus	Isomate (OFM)	0	0	0	0	0	0	0
	MSTRS (OFM)	0	0	0	0	0	0	0
	Grower Standard	0	0	0	0	0	0	0
Pepe	Isomate (OFM)	0	0	0	0	0	0	0
	MSTRS (OFM)	0	0	0	0	0	0	0
	Grower Standard	0	0	0	0	0	0	0
Zingler	Isomate (OFM)	0	0	0	0	0	0	0
	MSTRS (OFM)	0	0	0	0	0	0	0
	Grower Standard	0	0	0	0	0	0	0

Table 2. Percent deep (internal) and sting (surface) fruit injury[1] at harvest in pheromone-treated plots, 2006.

Site	Treatment	Sting	Deep	Clean
Bates Rd.	Isomate (OFM, CM) + Cyd-X	0.0a	0.1a	99.9a
	MSTRS (OFM) + Hercon (CM) + Cyd-X	0.1a	0.4a	99.5ab
	Hercon (OFM, CM) + Cyd-X	0.1a	0.3a	99.6ab
	Grower Standard	0.1a	0.6a	99.3b
DeBadts	Isomate (OFM)	0.0a	0.0a	100.0a
	MSTRS (OFM)	0.0a	0.0a	100.0a
	Grower Standard	0.0a	0.0a	100.0a
Eagle Harbor	Isomate (OFM) + Cyd-X	0.1a	0.3a	99.6a
	Grower Standard + Cyd-X	0.3a	0.4a	99.3a
Endres	Isomate (OFM)	0.0a	0.2a	99.8a
	MSTRS (OFM)	0.0a	0.1a	99.9a
	Hercon (OFM)	0.0a	0.1a	99.9a
	Grower Standard	0.0a	0.0a	100.0a
Hance	Isomate (OFM)	0.1a	2.8a	97.1a
	MSTRS (OFM)	0.0a	1.8a	98.2ab
	Grower Standard	0.0a	0.1b	99.9c
Hartley	Isomate (OFM, CM) + Cyd-X	0.1a	0.3a	99.6a
	Hercon (OFM, CM) + Cyd-X	0.1a	2.7b	97.2b
	Grower Standard	0.2a	4.0b	95.8b
Kappus	Isomate (OFM)	0.0a	0.0a	100.0a
	MSTRS (OFM)	0.0a	0.0a	100.0a
	Grower Standard	0.0a	0.2a	99.8a
Pepe	Isomate (OFM)	0.0a	0.0a	100.0a
	MSTRS (OFM)	0.0a	0.0a	100.0a
	Grower Standard	0.1a	0.0a	99.9a
Zingler	Isomate (OFM)	0.0a	0.0a	100.0a
	MSTRS (OFM)	0.0a	0.1a	99.9a
	Grower Standard	0.0a	0.0a	100.0a

[1]Within a site, values in the same column followed by the same letter are not significantly different at *P*=0.05 level (Fisher's protected lsd test).