

**Project Title:** Verifying Environmental Benefits and Enhancing Grower Adoption of Ecologically-Based IPM in Pennsylvania Apple Orchards.

**Preparation Date:** November 11, 2007

**Institution or Agency Conducting the Research:** Pennsylvania State University

**Proposal Number:** AG060422

**Project Director:** David Biddinger

**Principle Investigators:** Jim Frazier, Matt Harsh

**Reporting Period:** August 2006 through November 2007

**Expenditures for the Period:** Provided by the Research Accounting Office

**Progress Towards Meeting the Objectives:**

As stated in the first report, funding for the grant came too late for the 2006 field season. Most of the field work began in late April 2007

*Objective 1: Verify how ecologically based IPM conserves beneficial arthropods and enhances biological control and how to measure these as an IPM option for grower enhancement payments.*

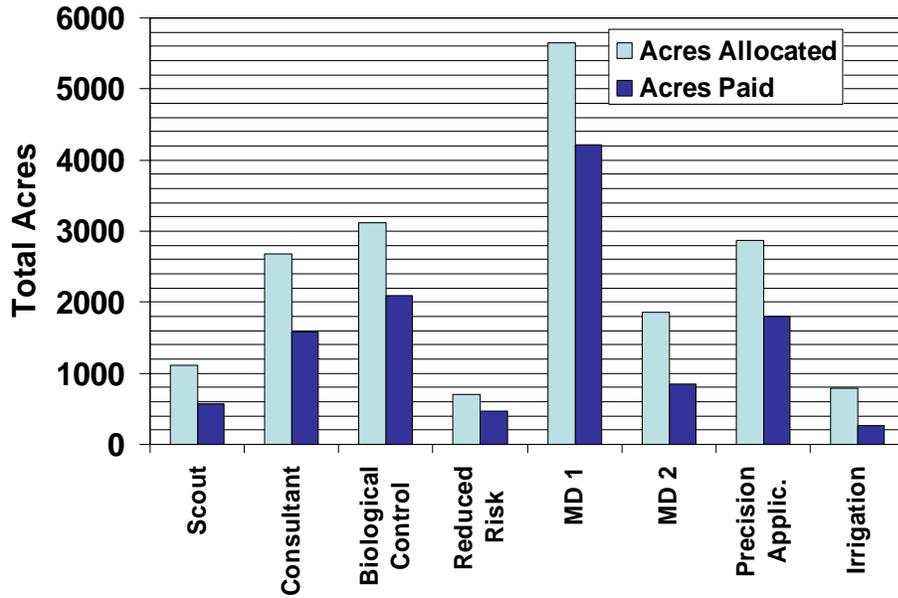
A. Measures of NRCS Conservation Program Benefits to the Environment and to Fruit Growers

Based on data from the 2005 National Agricultural Statistics Surveys (NASS) and my 22 years as a research entomologist in tree fruit, we have attempted to develop metrics on the benefits of NRCS conservation programs in AMA & EQIP since 2004 in Adams County, PA. With the help of the district conservationist, Walter Alberran, we examined all fruit IPM contracts and entered the data on type of practice, acres contracted, and dollars committed to each contract into an excel spreadsheet (attached). Using the data from our first 4 year USDA Risk Assessment and Mitigation Program grant (RAMP) on pesticide use (Figs. 1-3, Attachment 1) and the price lists given to us for specific insecticides and miticides in tree fruit from United Ag Products (UAP) in 2005, we developed metrics on the benefits of reduced risk IPM and other IPM programs funded by NRCS in fruit. By extrapolating the Adams County data further and including the NASS pesticide use data for PA in 2005, we were able to establish a baseline of pesticide use. We could then translate pesticide reductions seen in the various IPM options into actual lb ai /A values and calculate the value of those savings to the growers. These values are on the conservative side since we are using 3 year old NASS data and pricelists (prices for almost all products have increased, especially for oil). A number of contracts are ongoing and have not yet been paid out and a number of contracts were cancelled for non-compliance or at the grower's request for various reasons. Most cancelled contracts were for building a Pesticide Handling Facility.

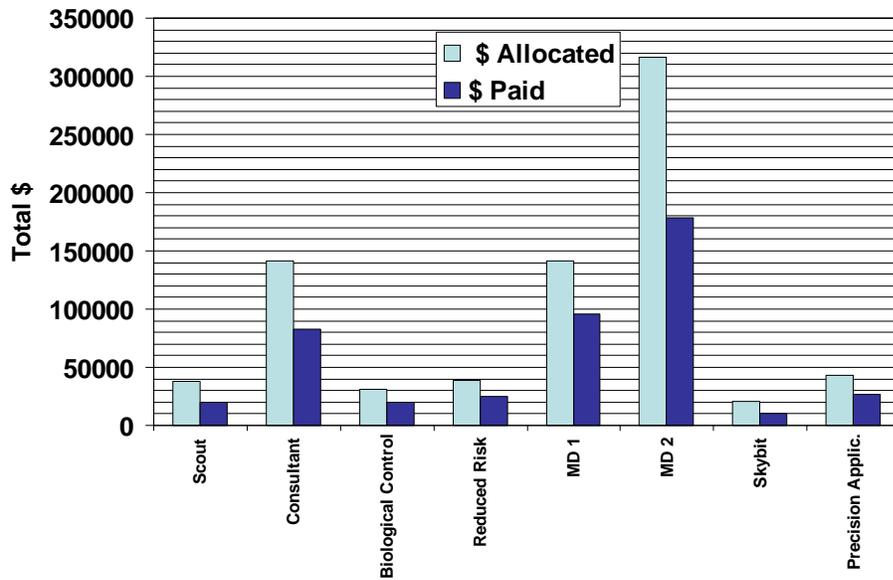
As an example: NRCS has invested \$38,500 on reduced risk IPM programs on 707 acres. The four year RAMP program found an average of 4.44 lb ai/A of insecticide in the standard apple IPM program for PA and 0.85 lb ai/A on average in the reduced risk IPM plots for an average pesticide reduction of 80.4%. If reduced risk IPM was implemented on all 22,500 acres of PA apple orchards this would result in a reduction of **40.42 tons ai of insecticides each season** most of which are toxic OP and carbamates. In the modest 707 acres of reduced risk IPM contracted in Adams county so far, 3,139 lb ai of insecticide would have normally been applied if managed conventionally. With the 80.4% reduction in ai from reduced risk IPM, only 615 lb ai of environmentally much safer insecticides will be applied. This is a direct savings of 2,524 lb ai of toxic OP and carbamate insecticides. Information of this type documenting the environmental benefits of specific types of IPM programs, led to ecologically based IPM components such as mating disruption, biological control, and reduced risk IPM receiving a much higher priority in the EQIP ranking sheets for PA in 2008 season.

The benefits from other NRCS IPM programs could also be calculated as success stories for IPM and NRCS if the data in contracts were just recorded. Currently, all IPM contracts are recorded merely as code 595 and numbers of acres, but determining the crop and specific IPM practice implemented in a contract are impossible to track. With this in mind, Walter Alberran and I developed the attached IPM plan to also serve as a detailed contract of what IPM programs are being implemented on which acres and on what crop. Detailed specifications of each IPM program being contracted are then attached to each grower contract to document what is expected of the grower by NRCS. We plan to continue to record this information into our own Excel spreadsheet to develop IPM metrics for Adams county, but this should also be done at the state and national levels. Using the RAMP apple data from all 7 eastern apple producing states, it is estimated that an average of 6.5 lb ai/A are used on 186,000 acres of apple in the east. This equates to almost 605 tons ai of insecticides used in eastern apples each season of which, 504 tons ai could be saved each season by converting all apple acres to reduced risk IPM. Reduced risk IPM is more expensive than the conventional IPM programs now being used, so the benefit to growers may not be obvious, but the environmental impact of reducing toxic OP and carbamate insecticide use in a single eastern crop by over 500 tons ai would be huge. This approach and some of the data were presenting in the EPA headquarters in Crystal City, VA on Oct. 2-3, 2007 at the National IPM Committee Joint Meeting of CSREES, EPA, NRCS and state universities to the great interest of all parties. The NE IPM center is incorporating some of the information we have gathered into an apple IPM success bulletin.

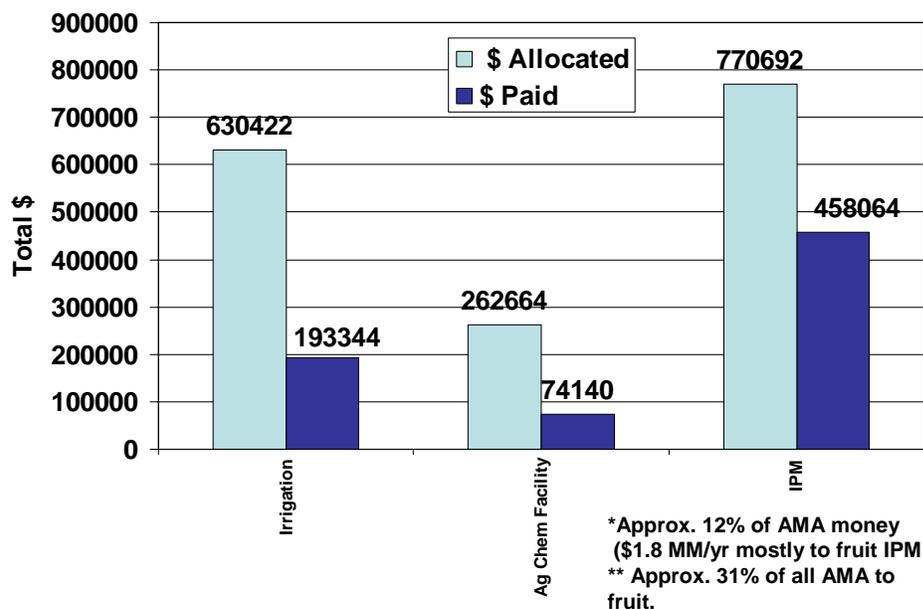
**Fig. 1 Adams Co., PA AMA/EQIP 2004-7**



**Fig. 2 Adams Co., PA AMA/EQIP 2004-7**



**Fig. 3 Adams Co., PA AMA/EQIP 2004-7 Contracts**



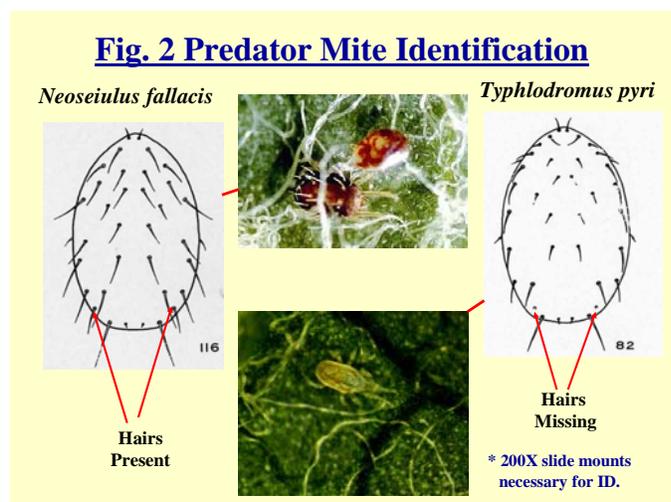
Biological Mite Control with *Typhlodromus pyri* (Scheuten) 2007

Pennsylvania was known internationally for a very successful IPM program based on biological control of mites in apple orchards by the lady beetle, *Stethorus punctum* from about 1978 – 1998 (Fig. 1) The introduction of several new classes of insecticides toxic to *Stethorus* (some neonicotinoid and IGR chitin inhibitors) and cheaper, more effective miticides practically eliminated this predator from orchards. The replacement of one of the older very toxic carbamate insecticides (methomyl) with some of these new pesticides allowed the survival of beneficial mites of the family Phytoseiidae. The discovery in 2003 of the new predatory mite, *Typhlodromus pyri* (Scheuten) in apple orchards in a USDA-RAMP program using only reduced risk insecticides (Fig.2) was a perfect replacement for *Stethorus*. If conserved using nontoxic insecticides, *T. pyri* is at least 10 times more effective than *Stethorus* in reducing pest mite injury.

**Fig. 1 *Stethorus punctum***

- Reduced miticide use by 50% in PA from late 1970s to mid 90s.
- Saved growers \$20 million over 15 year period.
- Reduced miticide use by over 2.2 million pounds.





Predatory mite data was taken in 2006 & 2007 in the 6 paired plots of reduced risk (RAMP) and conventionally managed apple orchards (5-10 acres in size). The RAMP sites have not received broadspectrum OP, carbamate, or pyrethroids sprays since 2001 and have transitioned away from the ecology found in conventional grower orchards. Pest and predator mite counts were made 3-4 times during the 2006 season and were intensified in 2007 to every 2 weeks. We have slide mounted a sub-sample of about 2,100 specimens for identification from the RAMP and conventional orchards for both years and found *T. pyri* to be the dominant predator in 5 of the 6 sites. We found an introduced Mediterranean species, *Amblyseius andersonii* Garman to be the dominant predator in the State College site where it apparently escaped from greenhouses and became established in the apple orchards. Both species were giving complete biological mite control of spider mites in all 6 sites in all of the RAMP and most of the grower conventional sites. We also evaluated eleven sites with eight growers who are participating in a 900 acre Area-wide Pheromone Mating Disruption Approach to Control Two Major Fruit Pests in Pennsylvania Orchards (PDA Contract ME 445577) by Hull and Krawczyk in 2007. Pest and predatory mite leaf counts are being made twice during the season in at least one mating disruption block of all participating apple growers and in the conventional orchards of each of the four sites. A subsample of 312 predatory mites has been saved from these leaf counts and slide mounted for identification to species. Currently, *T. pyri* (Scheuten) is the dominant Phytoseiid predatory mite in nine of the orchards with the less effective and reliable *Amblyseius fallacis* (Garman) being dominant in only two sites.

The success of *T. pyri* in the first RAMP program in giving complete control of European red mite combined with NRCS incentives through the Agricultural Management Assistance (AMA) program from 2004-7 has greatly encouraged growers to adopt practices that will conserve this predator in both conventional and reduced risk orchards. Because *T. pyri* is organophosphate resistant, by eliminating pyrethroid and carbamate sprays as outlined in the NRCS AMA 595 specification (<http://paipm.cas.psu.edu/1218.htm>) by Biddinger, most of the participating RAMP growers and some of the AW mating disruption plots now have established populations of *T. pyri* in conventional orchards. These 'modified' conventional tactics indicate that fruit growers are learning and listening to what we have to say about the biological control of mites, but it is blurring the differences in mite control between reduced risk and conventional types of IPM programs.

We have now assisted in the transfer and establishment of *T. pyri* into over 297 acres with 20 growers (Tables 1 & 2). *T. pyri* is more mobile than originally thought. It appears to be able to emigrate (by wind or transfer of bulk bins) into adjacent blocks and become established within a season or two if the pesticide program is benign. After becoming established, they become the dominant mite predators within a season and give complete pest mite control. We now estimate that approximately 8,000 of Pennsylvania's 22,000 acres of apple are in the process of transitioning to *T. pyri* as a sustainable component of biological mite control. Our predatory mite program has been so successful, that fruit research stations from Rutgers University, Michigan State University, West Virginia State University, and Virginia Tech have all started field sites with *T. pyri* from the Penn State Fruit Research & Extension Center at Biglerville.

**Table 1. Pennsylvania State University and grower "seed" sites available for the introduction and/or augmentation of the predatory mite, *T. pyri*, populations into commercial apple orchards.**

Block	County	Acreage
Lerew Orchards	Adams	500
S. Slaybaugh	Adams	200
D. & S. Slaybaugh	Adams	500
D. & J. Wenk	Adams	500
Pullig Greening Block	Adams	30
E. Diveley Jr.	Adams	45
E. Diveley Sr.	Adams	25
W. Schulteis	Adams	20
Doc Oyler	Adams	20
PSU Biglerville	Adams	40
PSU Arendtsville	Adams	20
		<b>Total: 1,900 acres</b>

**Table 2. *T. pyri* introduction or augmentation sites in Pennsylvania apple orchards from 2005 to July 2007.**

Block	County	Date	Source	Acreage
<b>2005</b>				
Boyer RAMP	Bedford	5/27, 6/14	Diveley Sr. Greening Bl.	5
D. Slaybaugh RAMP	Adams	5/26	Diveley Sr. Greening Bl.	10
D. Slaybaugh IPM, Adams Co.	Adams	6/1, 6/7	Diveley Sr. Greening Bl.	10
S. Slaybaugh RAMP	Adams	6/7	Lerew RAMP Bl.	6
S. Slaybaugh IPM	Adams	6/2, 6/7	Diveley Sr. Greening Bl.	7
D. Wenk RAMP	Adams	5/24	Lerew RAMP Bl.	5
D. Wenk Weaner Mtn.	Adams	5/24	Diveley Sr. Greening Bl.	7
J. Wenk Trellis Bl.	Adams	6/10	Lerew RAMP Bl.	7
Harner Farms RAMP	Centre	7/20	Lerew RAMP Bl.	5
<b>2006</b>				
A. Hale	Adams	5/19	E. Diveley Jr.	20
D. Garretson	Adams	6/1	PSU Biglerville #1	30
W. Schulteis	Adams	6/13	Diveley Sr. Greenings	20
M. Rice	Adams	6/18	PSU Biglerville #1	10
PSU Arendtsville	Adams	6/15, 6/23	E. Diveley Jr.	10

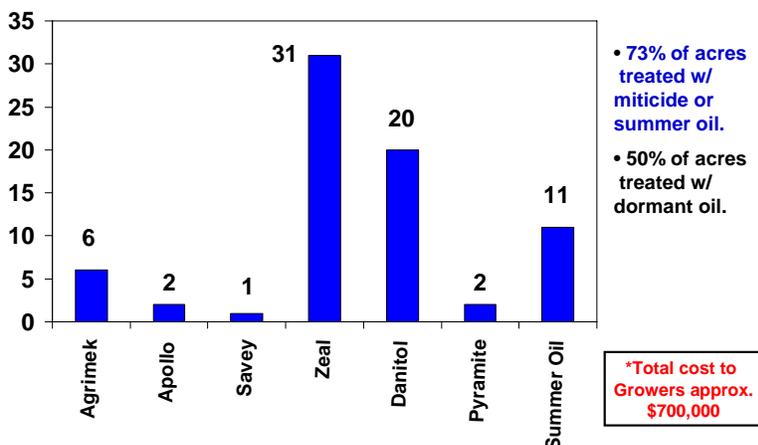
Orchards				
PSU Biglerville #4A	Adams	6/15	PSU Biglerville #1	5
WV University Station – H. Hogmire	Kearneysville, WV	6/30	Diveley Sr. Greenings	5
<b>2007</b>				
Neil Starner	Adams	6/26, 6/28	Aville #1, D. Wenk	50
James Duffy	Adams	6/19, 6/21	Aville #1	50
Brad Hollabaugh	Adams	7/1	PSU Station Raff Bl.	5
Rutger’s University Fruit Research Station – P. Shearer	New Jersey	7/5, 9/12	PSU Station Raff Bl.	10
Michigan State University Fruit Research Station – John Wise	Fennville, Michigan	7/20	PSU Station Raff Bl.	10
Virginia Tech Fruit Research Station – Chris Bergh	Winchester, Virginia	9/12	PSU Station Raff Bl.	10
<b>Number of Sites:</b> 22		<b>Transfers:</b> 24		<b>Total: 297 acres</b>

To date NRCS has paid approximately \$30,000 to growers (at \$6-18/A over a 3 year contract) through the AMA& EQIP programs on approximately 3,000 acres (Attachment 1). Using the NAAS data, we developed Table 3 which shows an annual cost of almost \$700,000/year on miticides and oil for mite control. The cost of miticides and especially oil has greatly increased since 2005, but we will use the 2005 figures as a baseline for comparison. Figs. 3-4 indicate that approximately 2,200 lb active ingredient (ai) of miticide and almost 55,000 gallons of oil are applied each season to the 22,000 acres of PA apples.

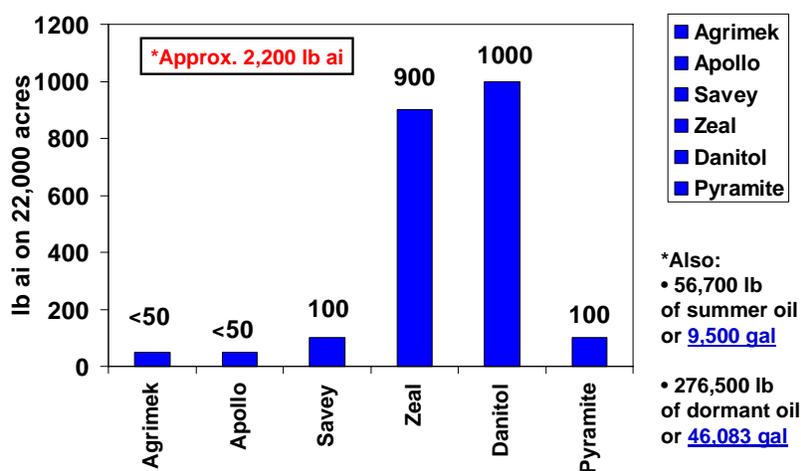
Table 3. Miticide use and cost based on data from National Agricultural Statistics Survey Data for PA in 2005.

Miticide	% A Treated in 2005 (22,000 A)	Total Acres	Rate/A	Cost/A	Total Cost
Agrimek	6%	1,320	10 fl oz	\$51.34	\$67,769
Apollo	2%	440	4 fl oz	\$42.45	\$18,678
Savey	1%	220	3 oz	\$47.25	\$10,385
Zeal	31%	6,820	2.5 fl oz	\$57.38	\$391,322
Danitol	20%	4,400	12 fl oz	\$13.92	\$61,28
Pyramite	2%	440	4.4 oz	\$26.62	\$11,713
Summer Oil	11%	2,420	1 gal	\$4.40	\$10,648
Dormant Oil	50%	11,000	3 gal	\$10.41	\$114,510
				<b>Total</b>	<b>\$686,293</b>

**Fig. 3 Miticide Use in PA Apple Orchards 2005**  
**% of 22,00 Acres Treated**



**Fig. 4 Miticide Use in PA Apple Orchards 2005**  
**Amount Applied**



Once established and the guidelines for pesticide use are followed, *T. pyri* is a completely sustainable biological control agent capable of reducing the use of miticide and oil use by at least 90%. Based on these figures, it can be extrapolated that the \$30,000 that NRCS invested on 3,000 acres in this program, actually saved growers \$117,000 in miticide/oil costs and reduced miticide use by 310 lb ai and oil by 4,900 gallons (Fig. 5). As stated earlier, the acreage established with growers has expanded to at least 8,000 acres in the state. At this level, growers are reducing miticide use by 800 lb ai/year and oil by 12,700 gallons/yr for a savings of approximately \$300,000/year (Fig.6).

**Fig. 5 Bottom Line To PA Apple Growers**

**Presently w/o *T. pyri***

- Miticides and oil represent about 30% of arthropod control costs on 22,000 acres.
  - 2005 cost for miticides on 22,000 acres was about **\$561,000.**
  - 2005 cost for dormant & summer oil is about **\$125,000.**
- Over **1 ton of miticide AI/ year** & about **55,000 gallons of dormant & summer oil.**
- Resistance to most current miticides & non-target effects.

***T. pyri* Conserved/Introduced**

- Only a dormant oil application is necessary to supplement *T. pyri* & scale control every other year.
  - total cost is **\$50,000/year.**
- **Almost no miticide AI** & only 10,000 gal of dormant oil.
- Sustainable long-term.
  - No resistance.
  - Basis for RR & organic IPM.
  - Applic. to stone/small fruits.

**Fig. 6 NRCS Program Metrics for *T. pyri***

**NRCS IPM Acres**

- Invested **\$31,000** on **3,100 acres** at **\$6/A** - later **\$18/A.**
- Reduced miticide use by **310 lb ai** on those acres worth **\$99,000.**
- Reduced **4,900 gallons of oil** worth **\$18,000.**

**NRC Grower Expanded IPM Acres**

- Grower/PSU transfers & natural migration to **8,000** acres in 3 years.
- Reduced by **800 lb ai** worth **\$250,000/yr** each season.
- Reduced oil by **12,700 gallons** worth **\$45,000/yr.**

We have developed a very good data base of pesticide impacts on predatory mites in general which is now available through the *Pennsylvania Tree Fruit Production Guide* for growers and the public alike either as a hard copy or free in electronic format from the Penn State Fruit Research and Extension Center website (<http://frec.cas.psu.edu/>). In order to continue the spread and conservation of *T. pyri* in PA apple orchards, we continue field testing and bioassays with all pesticides, especially those newly registered, to inform growers of the impacts their management choices will have on what should be a completely sustainable biological mite control. While fruit growers currently have a large number of miticides available, resistance has develop in pests mites to many of these in less than 3 seasons and the cost of these products for many

growers is approximately 30% of their total insecticide budget and the use of miticides alone is clearly not a sustainable practice. We have determined that a unique insect growth regulator type of miticide known as Envidor® (spiridiclofen), is very effective in controlling pest mites without harming *T. pyri* populations. This makes it an ideal tool to control pest mites when *T. pyri* is being established into new orchards or to supplement mite control when predator/prey ratios have shifted negatively due to the use of harmful pesticides. Further establishment of *T. pyri* in areas outside of Adams County and with new growers, would move these values closer towards complete biological mite control in PA apple orchards (Fig. 5).

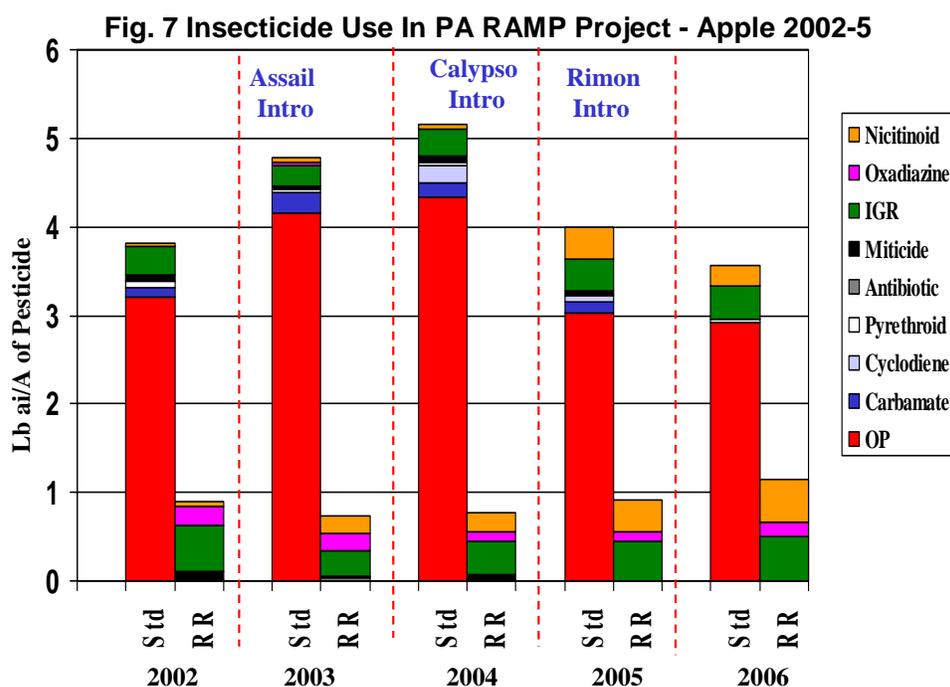
Occasional flare ups of pest mites due to the introductions of new pesticides, movement of other mites from the ground cover during drought years and the need for dormant oil applications to control occasional outbreaks of San Jose Scale will mean that complete elimination of miticides and dormant oil will probably never occur. Biological control with *T. pyri* in PA apples is a model for sustainability and has the potential to work in other crops such as peaches/nectarines, grapes, Christmas trees, and small fruits. But only if reduced risk IPM programs can also be developed for these crops and the use of broadspectrum insecticides such as organophosphate and pyrethroids are eliminated and *T. pyri* populations established through similar conservation programs.

### Leafroller Biological Control

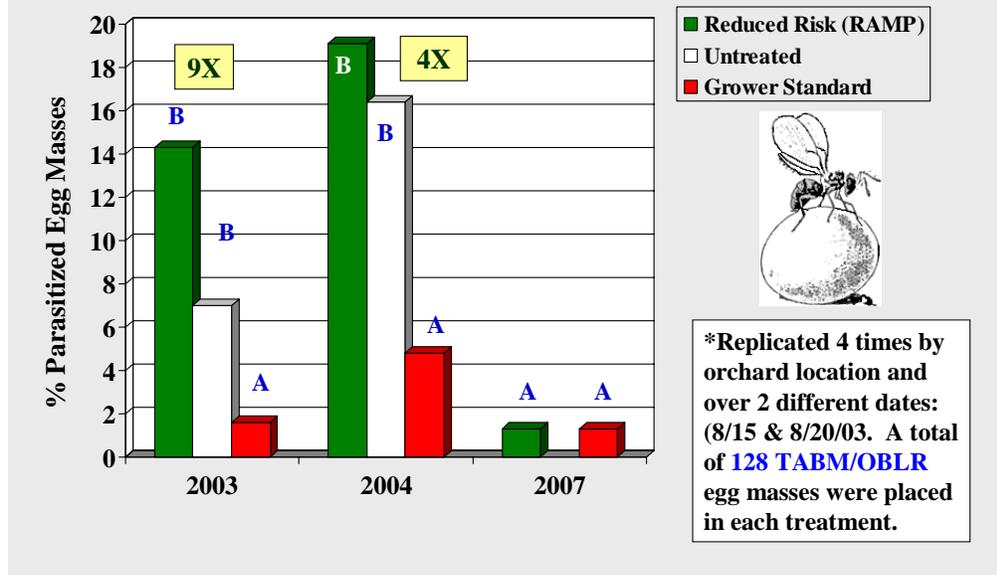
Leafrollers were too low to measure in 2007 because of the increased use of the Insect Growth Regulator (IGR) insecticide novaluron (Rimon®) in most of the RAMP and conventional grower plots. This product is primarily targeted towards the internal fruit feeding moths, codling moth and Oriental fruit moth, but is very effective on all species of leafrollers and has residual activity against these pests of at least 45 days. Pesticide resistance to the OP insecticides azinphosmethyl and phosmet in Adams County in 2006, necessitated the shift by many growers away from these mainstays in apple pest control to the use of alternative insecticide chemistries, but especially the neonicotinoid insecticides (acetimidiprid & thiacloprid) and novaluron. OP resistance in 2006 resulted in control failures of internal worms at harvest for many growers and a large increase in the resident populations of these pests in the 2007 growing season. While all of these products have been used in reduced risk IPM orchards in the past and were giving superior control to those in adjacent conventional IPM orchards, the increases in pest pressures, meant additional applications of neonicotinoids were made in 2007 than in the past and that the leafroller-specific IGR, methoxyfenozide (Intrepid®), was not used but was replaced by the more broadspectrum product novaluron.

Although both are IGRs, methoxyfenozide is specific only to moth pests, has a different mode of action than novaluron and is documented to be one of the safest insecticides ever developed to non-target and beneficial organisms. It is also, unfortunately, weak under high codling moth population pressure. Novaluron gives much better codling moth control, but as a chitin synthesis inhibitor type of IGR, it is toxic to the eggs and developmental stages of many arthropod biological control agents other than predatory mites. It is also very toxic to aquatic arthropods. USDA-PMAP& RAMP grants in western US apple orchards have demonstrated novaluron and neonicotinoid insecticides are very toxic to many predators such as ladybugs, lacewings, assassin bugs, minute pirate bugs and parasitic hymenoptera, including *Trichogramma sp.*

Because of the difficulties in collecting adequate numbers of leafroller larvae in the field to evaluate for parasitism, we employed a technique of using sentinel egg masses (EM) of leafrollers from our lab colonies to evaluate levels of parasitism possible from wild populations of egg parasitoid, *Trichogramma minutum*. Each egg mass consists of about 100-150 eggs laid on to wax paper. We stapled four EM on each of 4 trees in either the RAMP or conventional blocks in at each of 5 grower sites on August 15, 2007 (64 EM /block or 128 eEM/grower site X 5 sites = 640 EM). This timing coincides with egg laying by natural populations of leafrollers. After 2 days of exposure in the field, the EM were brought into the lab for rearing to determine levels of parasitism. This technique was used to evaluate *Trichogramma* parasitism in 2003 & 2004 in 4 of the RAMP sites and found relatively high levels of egg parasitism before novaluron was registered for use in apple and when neonicotinoid insecticide use was less than half that used in 2005 and 2006 (Fig. 7). While all spray records for the 2007 season are not yet available, preliminary analysis indicates that neonicotinoid use and novaluron use approached the maximum of 0.5 lb ai/A for both types of pesticides and egg parasitism was much lower (Fig. 8).



**Fig. 8 Mortality of Sentinel Leafroller Egg Masses To *Trichogramma* In 2003, 2004, & 2007 Apple Ramp Trials**



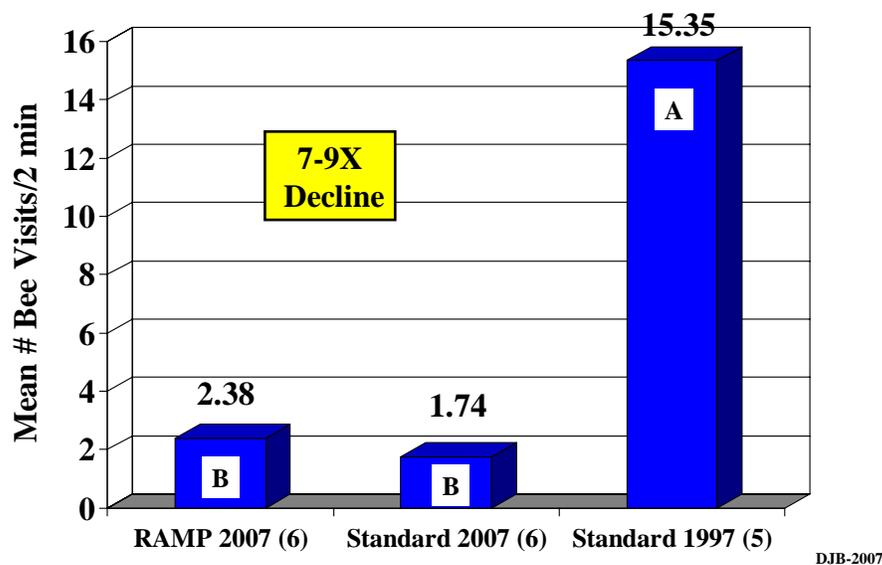
### Aphid Biological Control

The greatly increased use of neonicotinoid insecticides toxic to both aphids and internal moth pests and the use of novaluron toxic to aphid predators, meant that aphid populations were extremely low in 2007 and measurements were impossible

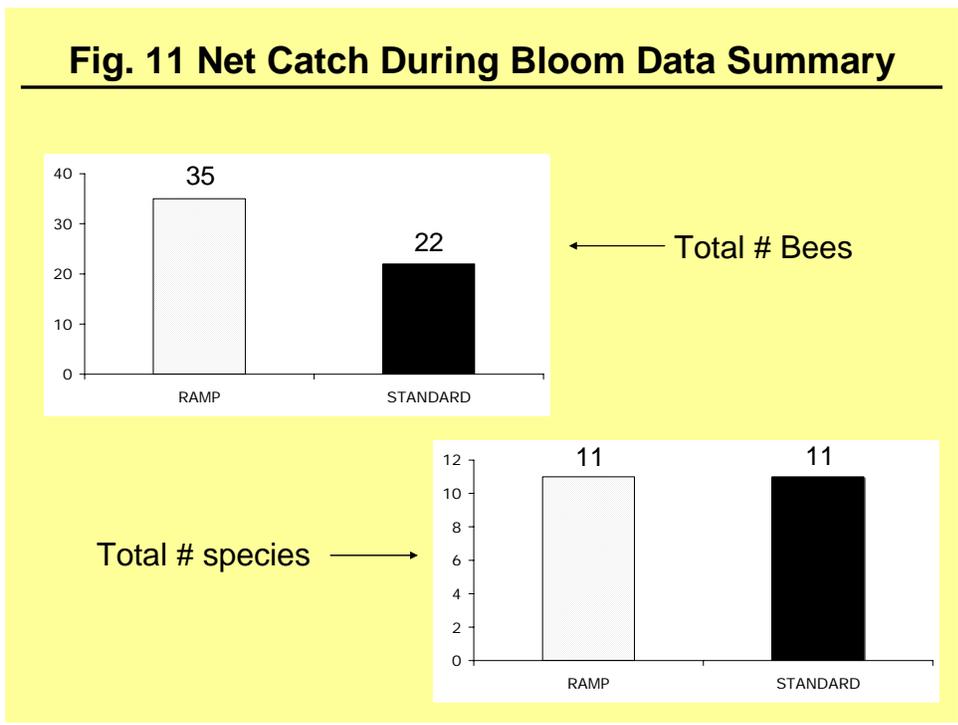
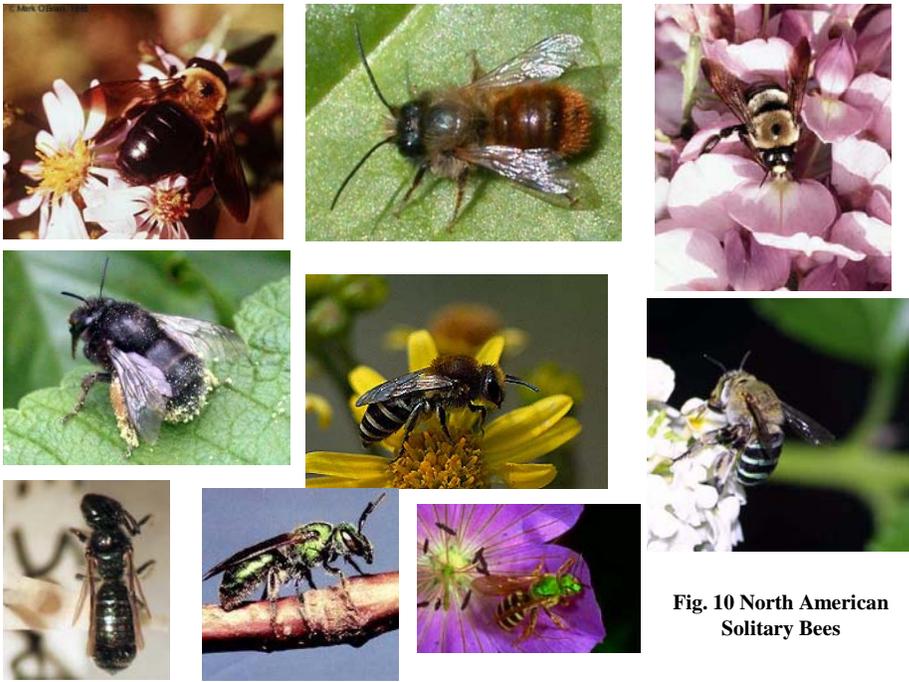
### Solitary Bee Survey

The neonicotinoid insecticides (imidacloprid, acetemiprid, thiacloprid, clothianidin, & thiamethoxam) are key components of the reduced risk pesticide programs we have been implementing over the last 5 years, but are implicated as one of the possible causes of Colony Collapse Disorder (CCD). Recently, it was determined by a team of researchers at Penn State that the main causative agent is the Israeli Acute Paralysis Virus, but that additional stress conditions such as parasitic mites and pesticides are necessary for the development of CCD symptoms. Apples have the widest variety of neonicotinoid insecticides registered for use and because they are often used just before or after bloom in apple, some bee keepers have tried to restrict the use of these pesticides by apple growers that are using their bees for pollination. We therefore not only surveyed the paired RAMP and conventional sites for all pollinators, but also placed 3-4 honey bee hives from Penn State University into each type of orchard (reduced risk with neonicotinoid vs. conventional w/o) in 3 of the RAMP grower sites. Hives were placed -7 days after the pink stage application of neonicotinoid and were withdrawn at petal fall. Pollen and honey samples have been tested for the presence of over 170 insecticides, fungicides and herbicides to determine if the pesticide programs in apple are contributing to the decline of honey bees through CCD. Analyses of the data are not yet complete and we do not understand the significance yet. Many different types of pesticides were found in the pollen and honey samples at varying levels in plots under both types of management, but the levels of



**Fig. 9 Honey Bees in PA Apple Orchards**

A recent National Academy of Sciences national survey has documented a decline in pollinators of all types across the U.S and our data is consistent with the decline in honey bees, but not with the increases in solitary bees. About 30,000 species of solitary bees exist worldwide with about 3,500 in North America with most species much more effective at pollination than the honey bee (<http://www.attra.org/attra-pub/nativebee.html>) (Fig. 10.) The extremely high counts of solitary bees in the Harner orchard, may indicate that the increase in solitary bees may be correlated as much or more with landscape ecology than pesticide use patterns. Although numbers of solitary bees were higher in the reduced risk IPM plots from the net samples during bloom, the biodiversity was not (Fig. 11). The Harner site is a diversified vegetable, tree fruit, and Christmas tree farm surrounded by urban areas where plant diversity and nesting sites are abundant. Solitary bees prefer to nest in untilled soil, tree holes and buildings and appear to be conserved in apple orchards with the less toxic pesticide IPM programs developed since 1997 for apple.



This conservation of solitary bees in stable, less toxic apple orchards is also supported from our pan trap survey during 2007. All 6 RAMP/Conventional paired sites were sampled each week for 25 weeks during 2007 using blue, yellow, and white pan traps. The six sites each had two treatments (RAMP block or Std block) that were subsampled with two traps of each color in each block. Approximately 1,800 samples were taken during the season resulting in

approximately 700 bee specimens that were identified to species by Pennsylvania Department of Agriculture bee taxonomist, Rick Donovall. Surprisingly, we found a total of 57 species of solitary bees in all orchards in a single season with several new records for the state. This diversity is extremely high for an agricultural crop and even for natural areas. Biodiversity was not significantly higher in the reduced risk sites compared to the conventional IPM sites (43 species vs. 40 species – Fig. 12, Table 5), but abundance was slightly higher. Analysis of this data is underway using a multivariate statistical approach known as principle component analysis and will be posted on the PA IPM/NRCS website when completed. In 2008, we plan to repeat the sentinel hive experiments to detect pesticide residues, the bloom bee counts and net samples, as well as the seasonal pan trapping and publish the results.

**Fig. 12 Bee Pan Trap Samples by Site 2007**

Name	# Specimens RAMP	# Specimens Standard	# Species RAMP	# Species Standard
1. Lerew	51	23	15	9
2. Diveley	87	37	20	21
3. D. Slaybaugh	10	15	6	9
4. S. Slaybaugh	32	22	12	10
5. D. Wenk	27	35	12	19
6. Harner	116	113	28	26
Means (+/- SE)	53.8 (16.4)	40.8 (14.8)	15.5 (3.1)	15.7 (3.0)

**Total # Species: 43 RR 40 STD**

**Table 5. List of Bee Species Collected In Pan and Net Samples from Apple Orchards 2007**

<b>Bee Name</b>	<b>Family</b>	<b>Net Sample During Bloom</b>	<b>Pan Trap</b>
<i>Agapostemon splendens</i>	Halictidae	N	Y
<i>Agapostemon texanus</i>	Halictidae	N	Y
<i>Agapostemon virescens</i>	Halictidae	N	Y
<i>Andrena barbara</i>	Andrenidae	N	Y
<i>Andrena bisalicensis</i>	Andrenidae	N	Y
<i>Andrena carlini</i>	Andrenidae	Y	Y
<i>Andrena ceanothi</i>	Andrenidae	N	Y
<i>Andrena crataegi</i>	Andrenidae	N	Y
<i>Andrena cressonii</i>	Andrenidae	N	Y
<i>Andrena daeckie</i>	Andrenidae	Y	Y
<i>Andrena kalmiae</i>	Andrenidae	N	Y
<i>Andrena nasonii</i>	Andrenidae	N	Y
<i>Andrena pruneri</i>	Andrenidae	Y	Y
<i>Andrena rugosa</i>	Andrenidae	Y	Y
<i>Apis mellifera</i>	Apidae	Y	Y
<i>Audrena commoda</i>	Andrenidae	Y	Y
<i>Augochlorella aurata</i>	Halictidae	N	Y
<i>Augochlorella pura</i>	Halictidae	Y	Y
<i>Bombus bimaculatus</i>	Apidae	Y	Y
<i>Bombus fervidus</i>	Apidae	N	Y
<i>Bombus impaticus</i>	Apidae	Y	Y
<i>Bombus perplexus</i>	Apidae	N	Y
<i>Bombus vagans</i>	Apidae	Y	Y
<i>Calliopsis andreniformis</i>	Andrenidae	N	Y
<i>Ceratina calcarata</i>	Anthophoridae	N	Y
<i>Ceratina dupla</i>	Anthophoridae	Y	Y
<i>Ceratina strenua</i>	Anthophoridae	N	Y
<i>Halictus confusus</i>	Halictidae	N	Y
<i>Halictus ligatus</i>	Halictidae	N	Y
<i>Halictus rubicundus</i>	Halictidae	N	Y
<i>Hylaeus affinis</i>	Colletidae	N	Y
<i>Hylaeus mesillae</i>	Colletidae	N	Y
<i>Hylaeus modestus</i>	Colletidae	N	Y
<i>Lasioglossum acuminatum</i>	Halictidae	Y	Y
<i>Lasioglossum athabascense</i>	Halictidae	N	Y
<i>Lasioglossum cinctipes</i>	Halictidae	N	Y
<i>Lasioglossum fuscipennae</i>	Halictidae	N	Y
<i>Lasioglossum leucozonium</i>	Halictidae	N	Y
<i>Lasioglossum pectorale</i>	Halictidae	N	Y
<i>Lasioglossum quebecensis</i>	Halictidae	Y	Y
<i>Megachile addenda</i>	Megachilidae	N	Y
<i>Megachile brevis</i>	Megachilidae	N	Y
<i>Melissodes bimaculata</i>	Anthophoridae	N	Y
<i>Melissodes despensa</i>	Anthophoridae	N	Y
<i>Nomada cvessonii</i>	Anthophoridae	N	Y
<i>Osmia bucephala</i>	Anthophoridae	N	Y
<i>Osmia pumila</i>	Anthophoridae	N	Y
<i>Peponapis pruinosa</i>	Anthophoridae	N	Y
<i>Stelis coarctatus</i>	Anthophoridae	N	Y
<i>Xylocopa virginica</i>	Apidae	Y	Y
<i>Xylocopa virginica</i>	Apidae	N	Y

*Objective 2: Continue to work with PA NRCS to develop IPM selection criteria for environmentally safer IPM practices to transition from the state level AMA program into the national level EQIP and CSP programs.*

We continue to partner with NRCS through the PA IPM program to update and link all NRCS grower incentive programs that pertain to IPM (<http://paipm.cas.psu.edu/nrcs.html>). NRCS signup forms and links to all NRCS programs are included and available to growers through this site and while we continue to support old contracts under the AMA program, IPM programs in 2007 are under EQIP and we are in the process of making the minor corrections necessary for supporting these same programs under that funding source.

In addition to the 7 IPM specifications in tree fruits, Christmas trees and fresh market sweet corn developed by Biddinger previously, we have developed specifications/job sheets for:

- Basic IPM (Scouting) and Grape Berry Moth Mating Disruption in for grapes (<http://paipm.cas.psu.edu/1338.htm>)
- Advance IPM tactic for Christmas trees – White Pine Weevil Monitoring & Control (<http://paipm.cas.psu.edu/1221.htm> )
- Step by Step Sign Up Guide to NRCS EQIP (<http://resources.cas.psu.edu/ipm/nrcs/eqipstepbysteppa2.pdf> )
- National Resource Defense Council Issue Paper review of IPM in NRCS conservation programs – “More IPM Please” (<http://resources.cas.psu.edu/ipm/nrcs/reports/ipmnrcs1.pdf> )
- PA IPM form for development of grower IPM plans and conservation contract development (See attachment).
- Press releases on changes to the 2008 NRCS EQIP program and signup <http://resources.cas.psu.edu/ipm/nrcs/newsrelease/PaNRCSEnvirQualIncenPro.pdf>

Other specifications still under development under the Penn State/NRCS cooperative agreement for 2008:

- Precision Agriculture in fruit crops – cost share in the use of application equipment and techniques to reduce pesticide spray drift, water volume, and to recycle pesticide drip with tunnel sprayers. Cultural shift in orchard spraying away from alternate-row middle spraying to complete sprays in order to improve spray coverage and slow the development of resistance to fungicides and insecticides.
- Remote weather sensors and Pest Phenology models – while growers have been funded for this for several years, no specification exists at this time.
- Basic IPM for vegetable crops such as cucurbits, tomato, potato, and small fruits.
- The integration of non-595 specifications that relate to IPM under the PA IPM website. Examples of these include rape cover crops, abandoned orchard removal and cover crops, windbreaks, pesticide handling facilities etc.

In pursuit of further developing IPM programs in specialty crops for NRCS starting in 2008 and to provide technical support, Penn State University and PA NRCS have developed a cooperative agreement through the PA IPM program that should receive final approval in the

near future. This would formalize and expand the support from commodity experts, continued updates and development of the PA IPM website for NRCS, and the training of NRCS staff in IPM for specialty crops for the 2008-2009 seasons.

A fruit grower field day at the Penn State Fruit Research and Extension Center provided an opportunity for regional and local NRCS staff to be further exposed to the unique needs and aspects of specialty crop IPM on July 12 for 5 hours. NRCS attendees included: Barry Frantz, Ben Smallwood, Joe Bagdon, & Walter Albarran. In addition, Penn State hosted a two hour session at the research station prior to the field day to support a headquarters CSREES/NRCS/EPA/University workgroup seeking ways to collaborate in order to help growers adopt Conservation IPM programs. The focus of the discussion was our collaboration of local NRCS and Extension in developing one of the most successful specialty crop IPM programs in the US. Six representatives from EPA, the above mentioned NRCS staff, and one representative from CSREES attended and most participated in the field day afterward. Several growers participating in the AMA fruit IPM program, Larry Elworth of the Center for Agricultural Partnerships (CAPS), representatives of the Pennsylvania Department of Agriculture (including the PA Deputy Secretary of Ag), and USDA ARS from Kearneysville completed the group of 22 attending. The discussion was mostly informative with the presentation in pdf format at: <http://paipm.cas.psu.edu/1446.htm> . The discussion that followed was useful and many contacts were made between the various working groups. Plans for follow up meetings were requested.

*Objective 3: Establish an Eco-Label Marketing Strategy:*

A Summary of The PA IPM Eco-label Market Review  
& Recommendations by Seeds To Shelf  
by Matt Harsh

As a component of the state level Conservation Innovation Grant (CIG) -*Verifying Environmental Benefits and Enhancing Grower Adoption of Ecologically Based IPM in Pennsylvania Apple Orchards*, a comprehensive marketing study of the potential for a Pennsylvania eco-label apple was commissioned. This study was conducted by Cynthia Barstow of Seed to Shelf from April 1, 2007 to July 1, 2007. The study has five main components: the current marketplace for “eco” foods, an overview of the current status of the global and domestic apple situations, an analysis of the eco-labels currently in the marketplace, analysis of interviews conducted with PA apple industry stakeholders (growers, packers, brokers, retailers), and recommendations for efforts in developing an eco-label. It is available in pdf format at the PA IPM/NRCS website at: <http://resources.cas.psu.edu/ipm/nrcs/reports/ipmecomarkreview.pdf> and has been shared with the Pennsylvania Department of Agriculture and incorporated into their research priorities for 2008.

Ecologically based production and marketing of food is certainly a growing marketplace. The label “organic” (federally regulated by the USDA since 2002) commands the lion’s share of this marketplace with wide consumer awareness according to the report. Consumers are also seeking authenticity, and trust in their food and food suppliers, and continue to be more health conscious in their food purchases. The concept of buying food that is produced locally continues grow as consumer become more aware the carbon/environmental impacts of their food purchases.

In examining the current global and domestic apple situations the report points out many key trends and issues that are impacting apple production in Pennsylvania. Chief among these are: changing consumer preferences, increasing choice/competition in the produce section, the rise of China as a major apple producer, buying locally, and a growing consumer interest in the environment.

Several eco-label regimes are extensively reviewed in the report. The most widely recognized eco-label reviewed is certainly “organic,” the use of which is regulated by USDA with strict certification standards required. Of the other eco-labels reviewed, Protected Harvest and the Food Alliance are noted for their strong programs and success in creating eco-labels for certain commodities and geographic areas. Red Tomato, an eco-label group based in the Northeastern US, is apparently experiencing some limited success with an apple eco-label simply called “eco apple”. They are working with a small number of New England growers and several food retailers to build a following for this label. One eco-label group that is mentioned throughout the entire report that should be acknowledged due to its lack of success is “Core Values - Northeast” by Mothers and Others. Several of the growers, packers and brokers interviewed reported having been involved with this program (now defunct) and having received no benefits whatsoever.

The report also examines consumer perceptions of eco-labels and how well they assess factors beyond just those related to food production. It is noted that “organic” deals strictly with direct production issues, while many other eco-labels cover a much wider range of factors such as conservation practices, worker treatment, food safety, etc. In short, it is noted that in fact some eco-labels could be viewed as having more environmental and community benefits and are more “sustainable” over the long term than food produced organically. However, at the consumer level, organic is viewed as the “gold standard” and that all others although well designed and intentioned, have little (large scale) recognition, aren’t well understood by consumers, and fail to return a price premium to producers.

Interviews conducted with apple industry participants at all levels of the apple value chain (growers, packers, brokers, processors, and retailers) are summarized and analyzed in the report. Growers generally felt that they are currently doing a very good job utilizing IPM principles and practices (and have been for a long time), but receive little credit for this. They had many ideas for ways to label and market the good environmental practices they implement and were open to the idea of an eco-label. However they felt that increased record keeping would be major barrier to adopting an eco-label regime, and they felt strongly that a price premium (at the farm level) would be needed to justify involvement. Many growers mentioned bad experiences with the Mothers and Others “Core Values” program. At the packer and broker level, there was little enthusiasm for an IPM eco-label. Most of those interviewed seemed more concerned about food safety and didn’t (currently) feel a push from their buyers to develop such program. For the one processor in the interview process, an eco-label was not out of the question, particularly if it would generate higher returns for producers. For direct to consumer retailers, there was little perception of a desire on the part of consumers to have IPM eco-labeled fruit; most felt that other attributes (i.e. local, fresh, quality) were far more important to their customers. For produce buyers, most were unfamiliar with the eco-label concepts presented to them with the exception of organic (which they saw a growing niche market for). They were certainly open to the idea of eco-labeled fruit, particularly if it were available, but were unsure as to the prospects for a price premium.

The report makes three key recommendations.

- First, work with Protected Harvest to develop a comprehensive eco-label regime for Pennsylvania apples, as long as \$100,000 can be secured to pay for grower certification and initial program development. Given the bad experience that many mentioned with the “Core Values” program, the report suggests that growers cannot be expected to bear the cost of certification and program set up.
- Second, work with an apple processor to develop a place-based, high quality, artesian type apple product that capitalizes on current consumer trends (i.e. local, authentic, trust, etc.).
- And third, develop a place-based recognition online that draws together certified fresh apples and processed apple product and capitalizes on the many unique characteristics (i.e. scenery, multi-generational farms, place, etc.) of the apple production in Pennsylvania.

Future Plans:

- Publish the predatory mite data accumulated from the 2003-2007 season to establish their sustainability in reduced risk apple IPM programs in the Mid-Atlantic region.
- Finish the analysis of the 2007 solitary bee survey data from the 6 paired plot reduced risk/conventional apple sites to determine if bees are conserved in the reduced risk plots despite the use of neonicotinoid insecticides. If the data is conclusive, publish it along with the new state species records. If not conclusive, repeat in 2008.
- Because of the apparent broadspectrum impacts on parasitic wasps & flies and pollinators, we plan to further restrict reduced risk IPM programs in the RAMP project to minimize neonicotinoid and chitin synthesis inhibitor IGRs use and replace them with more species specific control options that have just become available.

Thank you for your support of our research and extension efforts and feel free to contact me for additional information.

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Verifying Environmental Benefits and Enhancing Grower Adoption of  
Ecologically-Based IPM in Pennsylvania Apple Orchards.

**Executive Summary**

1. IPM Metrics for NRCS Conservation Program Contracts – specific contract information on IPM contracts in tree fruit for Adams county have been data based to the determine cost/benefits of specific IPM programs. Using data develop from Pennsylvania Department of Agriculture and USDA-RAMP grants pesticide reductions for biological mite control and reduced risk IPM programs were calculated to significant benefits to growers in terms of reduced miticide use and to the environment for 80%+ reductions in pesticide use. This data base can be used to calculate the benefits of other programs in the future. An IPM plan data sheet has been developed to simplify the contract development by NRCS and to make it much easier to gather specific information on IPM programs in specialty crops in the future.
2. Biological Control –
  - a. The biological mite control program with *T. pyri* funded by NRCS has been an unqualified success which has spread on its own to more than triple the acreage originally funded. For a small investment of around \$30,000 over a 3 year period, it has developed into one of the most sustainable IPM programs ever developed in the eastern apples.
  - b. Measuring the benefits on reduced risk IPM on apple has been more problematic due to the increased use of neonicotinoid and chitin inhibitor IGR insecticides, that while part of the reduced risk classification due to low mammalian toxicity, are almost as broadspectrum to non-target and beneficial arthropods as the organophosphate and carbamate insecticides they are replacing. Trichogramma egg parasitism was much lower in 2007 than in 2003 & 2004 because of the introduction and increased use of these compounds. Future reduced risk IPM programs will reduced the use of these type of compounds to a minimum to encourage the development of biological control on other secondary pests besides mites.
  - c. Pollinator diversity – surveys found honey bee numbers almost 10X lower in 2007 than in the same orchards in 1997. Solitary bee numbers, however, increased greatly in this 10 year period and appear to be compensating for the reduced honey bee populations that are dying from mites and CCD. CCD does not appear to be more likely in apple orchards using neonicotinoid insecticides, but continuing investigations into the role of pesticides in CCD will continue. Preliminary analysis of pan and net trap sample of pollinators indicate that the biodiversity of pollinators is not necessarily enhanced in reduced risk IPM orchards, however, abundance of some species appears enhanced. The surprisingly high number of 57 species of pollinators in apple orchards is generating interest in Penn State and the Pennsylvania Department of Agriculture to continue investigations to see if the stability of orchards allows them to serve as a reservoir of pollinator nest sites to enhance pollination of other crops.

3. PA IPM Eco-label Market Review – An extensive review of growers, distributors, fruit processing plants and consumers indicates that while the organic label is well recognized and thought to stand for something, consumers are confused as to what IPM or other eco-labels really mean and stand for. Fruit growers who are already implementing much higher level of ecologically based IPM practices do not necessarily see the need to go through another costly certification process unless there is a price premium to compensate them. It is clear that the trend in the future will be for growers to move toward the requirements of eco-labels in order to have access to distributors like Sysco and Walmart as a part of doing business in the future, but it is unclear as to how to get a price premium for increased costs of environmentally friendly practices and documentation. It is recommended to capitalize on the demand for locally grown fruits and vegetables and work with a eco-label group like Protected Harvest of Red Tomato to develop a comprehensive eco-label regime/criteria for Pennsylvania apples, but at a cost of at least \$100,000.