2007 Ohio State University IPM Reports

Study the Bioecology of Native Pollinators and their Association with Conventional and High Tunnel Fruit and Vegetable Production 2006 - 2007

Final Report: Dec. 5, 2007

Funding Provided by: The Ohio Integrated Pest Management Program

Principle investigators: Roger N. Williams, Roger A. Downer and Dan S. Fickle, Dept. of Entomology, OARDC/OSU, Wooster, Ohio 44691

Introduction:

This study was initiated in 2006 to expand our understanding of the role non-*mellifera* bee species play in the pollination of fruit and vegetable crops in Ohio. In 2006 voucher specimens were collected from documented hosts and a reference list of genus/species was created. The frequency of flower visits by non-*mellifera* and *mellifera* bees to specific hosts were also recorded. In 2007 we continued our study in hopes of adding new species to our list and gaining additional information about pollinator behavior and seasonal trends. A new sampling technique utilizing bee bowls was used for the first time in 2007. Observations and collections were made at two sites. The first site was a commercial fruit and vegetable operation near Moreland, OH. The second was a research site located on the Snyder farm of the Ohio Agricultural Research and Development Center of The Ohio State University in Wooster, OH. Site 1 was bordered on two sides by a large state wildlife area. Crops grown on this farm included tree fruits, blueberries, brambles, strawberries, tomatoes, pumpkins, melons, beans, corn, and a few others. Site 2 was similar in cropping, however, the area we were utilizing was composed of plots established for a square foot farming study. These raised beds contained dwarf apple, peach, raspberries, blueberries, strawberries, tomatoes and beans. Also in 2007 high tunnel plastic culture houses were added over four of the square foot study plots. This addition added a new area of interest to our pollination work. How does plastic cover affect foraging by pollinators?

It should be noted that pollinator activity in 2007 was considerably less than what we had observed in 2006. Also, over the past year there has been a great deal of publicity about colony collapse disorder (CCD). This disorder has only been noted in honey bees but the verdict is out as to whether the source of this disorder is entirely the Israel paralysis virus or a combination of things such as pesticides, parasites, weather, nutrition, and poor colony management. With all this concern being versed about CCD and honey bees, little has been noted about the affect these variables may be having on our native pollinators. After two seasons of observing pollinator activity at these two sites and seeing a real decline in activity from last season to this one we must question the factors responsible for this observed general pollinator decline at these sites.

Methods:

Observations of the pollinators visiting blueberries, strawberries, raspberries, were made from May to August at Moreland Fruit Farm (Site 1), Moreland, Ohio and Snyder Farm (Site 2), Wooster, Ohio.

A great deal of our collecting and observation efforts were concentrated on blueberries, strawberries and raspberries since both sites had these crops in common and at Site 2 they were present in the plots under plastic high tunnel and outside of the high tunnels which allowed us to make some pollinator comparisons at Site 2. Observations of the number and type of pollinators visiting flowers over a 10 minute period were made to determine the type and percentage of different pollinators frequenting the flowers. They were conducted at varying times of day from mid-morning to late afternoon. Bee pollinators were classified as *Apis* m*ellifera* (honey bees), *Bombu*s (bumble bees) or other (native bees) for this study.

From the total observations made for each crop or flower type, percentages were calculated to give a relative idea of how much pollination could be attributed to each of the three groups of Hymenoptera: honey bees, bumble bees or other native bees. It should be noted that cultured honey bee hives were present at both study sites.

In addition to visual observations and collection of bee specimens by hand we employed a new collection device known as colored bee bowls. These bowls were approximately 2 oz. in size and were white, florescent blue or florescent yellow in color. They were placed on the ground near the plantings at both Sites 1 & 2. At Site 2 they were also placed within and outside the plastic high tunnels. A small amount of soapy water was added to each bowl for entrapping the visiting bees. Bowls were collected 24 hours after deployment. Some species of native bees are attracted to the colored bowls but seldom are honey bees trapped in this manner. Specimens were strained through a small fish net and placed in Whirl-Pak™ plastic bags containing 70% alcohol. We recorded where, when and what color bowl the pollinators were collected from. Specimens were pinned, labeled, identified and placed in a reference collection. Bowl collections were made at Site 1 from 30 May to 16 Jul and at Site 2 from 21 Jun to 16 Jul.

Results:

Flower visitation: In 2007 we observed fewer flower visitations by bees overall than we did in the 2006 season. Many of our observation periods resulted in no documented flower visits by honey bees, bumble bees or other native bees. Although the numbers of documented flower visitations were fewer in 2007 we were able to calculate percentages for most based on positive observations. Observed pollination at Site 1 decreased in 2007 by 0 to 50% depending on the small fruit crop and at Site 2 by 25.8 to 80% (Table 1). Figures 1-4 show the relative percentage of pollinators visiting raspberries at Site 1 and Site 2 during both seasons. The most notable change at both sites was the increase in the percentage of bumble bees. At Site 1 they increased from 4.7% in 2006 to 69% in 2007, while the percentage of honey bees and other native bees dropped considerably in 2007. Site 2 showed a similar trend for bumble bees, 7.8% in 2006 to 38.9% in 2007, however the percentage for native bees was relatively the same and for honey bees it dropped from 84.3% in 2006 to 53.7% in 2007.

Flower visitations of blueberries during 2007 declined in both native bees and bumble bees at Sites 1 & 2. This helped to account for why the percentage of honey bee visitation was up in 2007 (Figs 5-8). Native bees dropped from 7.9% in 2006 to 5.6% in 2007 at Site 2 and for Site 1 from 37.1% in 2006 to 25.9% in 2007. Bumble bee visitation in blueberries was also down at Site 1, 51.6% in 2006 to 18.5% in 2007 and Site 2, 89.1% in 2006 to 66.7% in 2007. Honey bee visitation went from 11.3% in 2006 to 55.6% in 2007 at Site 1 and from 10.2% in 2006 to 27.8% in 2007 at Site 2. Numbers were indicative of a general downward trend in the number of native and bumble bees observed early in the 2007 season. Bumble bee numbers seemed to rebound in late spring and summer but other native bee populations seemed to be relatively low in 2007 as compared with observations made in 2006.

In strawberries Site 1 in 2006, 79% of the flower visitation was attributed to native bees. This figure increased to 100% in 2007 however, the frequency of flower visitation was down in 2007 indicating fewer bees working the strawberry blossoms (Table 1). Observations at Site 2 in 2006 indicated that 22.2% of the visits were contributed to native bees, 76.2% to honey bees and 1.6% to bumble bees. In 2007, Site 2 the percentage of native bees jumped to 70% followed by honey bees at 30% and no bumble bee visitations were noted (Figs 9-12).

Blackberries were only present at Site 1 where the trend continued to show a decline in the percentage of flower visitations by bumble bees and native bees when comparing data from 2006 and 2007 (Figs 13-14).

High tunnel plastic culture:

When comparing flower visitations to crops grown under high tunnel plastic culture with those grown outside of the tunnels we noticed a decline in honey bee activity within the tunnels. Under the plastic 26% of the flowers visited was attributed to honey bees as compared to 61.4% outside the high tunnels (Figs 15-16). It should also be noted that bee activity in general was extremely low in 2007 at Site 2 and those documented flower visits by honey bees in the high tunnels were to plants near the openings of the tunnels. In all, we had nine observation periods for which we compared flower visitations inside and outside the tunnels. Of those nine periods four (44%) were noted both inside and outside the tunnels as having flower visitations. In general we observed minimal bee activity at Site 2 in 2007 and despite number of bees observed yields for the fruits and vegetables for the most part were good. Strawberries were the one crop that seemed to produce less fruit within the high tunnels when compared with outside. The other crop we observed little bee activity on were cherry and grape tomatoes. However, yields on these crops within the tunnels and outside of them were extremely good. We did note that a large number of hover flies visiting the tomato flowers and suspect that they are providing some degree of pollination.

Bee bowls:

We utilized bee bowls as a sampling technique for the first time in 2007. Sampling was conducted from 30 May to 16 Jul at Site 1 and from 21 Jun to 16 Jul at Site 2. Site 1 yielded the largest number of bees collected with the colored bowls (136) while Site 2 yielded only 8 bees total. An equal number of bowls was set out at each site. If you look at just the collection period of 21 Jun to 18 Jul at both sites the number of bees collected was 115 for Site 1 and 8 for Site 2 (Fig 17). When we compared the number of bees collected by the three individual colors we found that blue collected the most bees and was statistically separable from white and yellow (Table 2). The number of specimens collected at Site 2 was on the low end for drawing any conclusions. However, Site 1 provided good numbers for analysis. A bar graph was generated showing bowl collections at Site 1 (Fig 18). The graph shows a distinct spike in blue bowl collections on 16 Jul. This number was four times that of any other collection period so we wondered what instigated the spike in blue bowl collections. After close examination of our specimens and identification of the bees collected we determined that a single bee species was responsible for this increase. It was the squash bee, *Peponapis pruinosa*. Since the squash bee responded almost exclusively to the blue colored bowls it seems to suggest that this color of fluorescent blue must resemble closely the wavelength of light emitted by the orange flowers of various vine crops.

Species list:

Five new species were added to our list of pollinators in 2007 with others yet to be determined. The new species were *Halictus lligatus*, *H. parallelus*, *H. confuses*, *Melissodes bimaculata* and *Peponapis pruinosa* (Table 3). Special thanks to Karen Goodell of the Ohio State University, Newark for her help in identifying some of our specimens.

Discussion:

In the winter of 2006/2007, more than 25% of the country's 2.4 million honeybee colonies were lost to CCD, Colony Collapse Disorder (Barrionueva 2007) (Nature 2007). Recent research has identified a virus imported from Australia as a possible link to CCD (Stokstad 2007). The virus known as IAPV or Israeli Acute Paralysis Virus was found in 96% of the bees collected from hives affected by CCD. Many scientists believe that CCD is not caused by a single factor but by many factors including pesticides, parasites, poor nutrition and stress. These factors may help to weaken the bee's natural defenses making them more vulnerable to infection and making the IAPV virus lethal. With honeybee loses estimated to be in the billions of bees and dollars researchers are wondering how other pollinators like bumble bees and other native bees can fill this niche in declining honeybee numbers. In order to answer these questions we need to learn more about alternative pollinators so we set out to gain information on the types of bees responsible for the pollination of fruit and vegetable crops in Ohio. In 2006 we determined that a large percentage of pollination was being performed by non-*mellifera* bee species. We continued to make observations of bee activity in 2007 and found that the ratios of the types of bees performing pollination varied from one year to the next. The fluctuations in the yearly bee populations we encountered were probably influenced by environmental factors such as changes in habitat, weather, pesticides, diseases etc. We also learned in 2007 that despite what seemed like minimal bee activity within the plastic high tunnels, yields for most crops were acceptable. However, strawberries which are one of the earliest flowering crops had reduced yields when compared with yields outside of the high tunnels. We have been told that pollination is critical to maintaining our food supply, but little has been written on what the minimum pollination requirements are for assuring adequate development and yields of commercial fruit and vegetable crops. What we have learned from our study thus far is that there is a great deal more we need to know before we can begin to develop management strategies that will benefit both bees and agricultural producers. Many questions have yet to be addressed. Besides identifying what species are performing pollination, and what are their habitat and host requirements we need to answer questions like. Does the IAPV virus infect other social nesting bees like *Bombus* sp. What pesticides are we applying to the environment and are they present in the pollen and nectar bees are collecting? Do these chemicals pose a threat to bee development and overall health? What are the consequences of urban development and the loss of viable bee habitat? These questions require a concerted effort by researchers to develop methods of identifying and estimating bee populations, determining habitat/environmental requirements and establishing protocols for urban and agricultural landscape management that are pro pollinator in nature. With an adequate understanding of the problems we face and the development of management techniques to overcome them, we will help to assure that our pollinator needs will be viable well into the future.

References:

Barrionuevo, A. 2007. Bees vanish and scientists race for reasons. NY Times. April 24, 2007.

Stokstad, E. 2007. Puzzling decline of U. S. bees linked to virus from Australia. Science. 317(5843):1304-1305.

Nature. 2007. Silence of the bees. PBS. http://www.pbs.org/wnet/nature/bees/update.html.

Table 1. Number of bee observation periods on small fruits at Sites 1 and 2 during 2006 and 2007.

Location	Crop	Total no. of observation periods	No. of observation periods bee activity was observed.	Percent activity
Site 1 (2006)	Strawberry	12	12	100%
Site 1 (2007)	Strawberry	18	13	72.2%
			Percent change	-27.8%
Site 2 (2006)	Strawberry	9	9	100%
Site 2 (2007)	Strawberry	20	4	20%
			Percent change	-80%
Site 1 (2006)	Blueberry	6	6	100%
Site 1 (2007)	Blueberry	20	10	50%
			Percent change	-50%
Site 2 (2006)	Blueberry	15	15	100%
Site 2 (2007)	Blueberry	36	9	25%
			Percent change	-75%
Site 1 (2006)	Raspberry	25	25	100%
Site 1 (2007)	Raspberry	6	6	100%
			Percent change	0%
Site 2 (2006)	Raspberry	28	26	92.8%
Site 2 (2007)	Raspberry	12	8	67%
			Percent change	-25.8%
Site 1 (2006)	Combined	43	43	100%
Site 1 (2007)	Combined	44	29	65.9%
			Percent change	-34.1%
Site 2 (2006)	Combined	52	50	96.1%
Site 2 (2007)	Combined	68	21	30.8%
			Percent change	- 65.3%

Table 2. Bee collections made with colored bowls, Site 1, Moreland, Ohio 2007.

Bowl color	No. of bowls	Mean no. bees collected
Blue	12	2.24a
White	12	1.03b
Yellow	12	0.74b

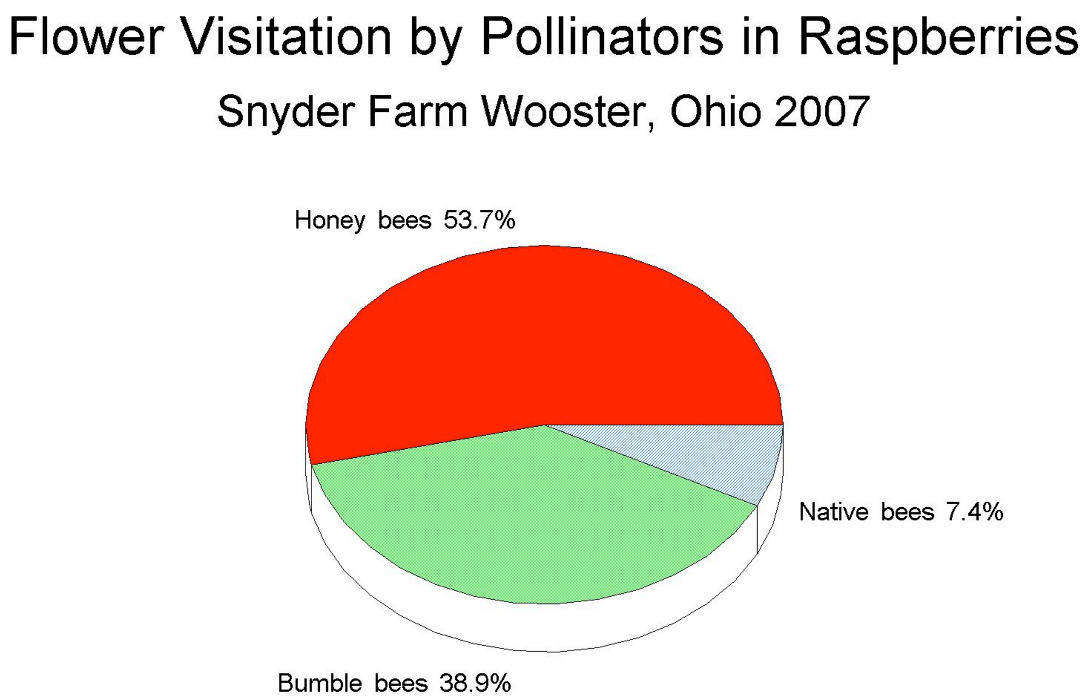
Means within the same column followed by the same letter are not significant (LSD test, P=0.05).

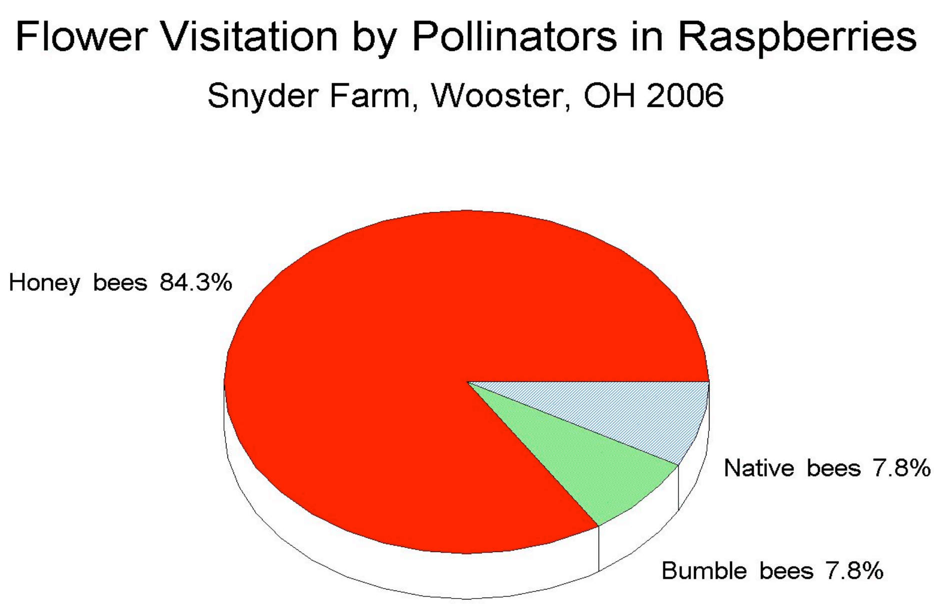
Table 3. Hymenopterous Pollinators Identified from Fruits and Vegetables, Wooster and Moreland, Ohio 2006-07.

Family	Genus	Species
Andrenidae	Adrena	vicina
	Adrena	nuda
	Adrena	imitatrix
	Adrena	nasonii
	Adrena	crataegi
	Pseudopanurgus	andrenoides
	Pseudopanurgus	sp.
Apidae	Apis	mellifera
	Bombus	impatiens
	Bombus	bimaculatus
	Ceratina	calcarata
	Xylocopa	virginica
	Melissodes	bimaculata
	Peponapis	pruinosa
Halictidae	Agapostemon	sericeus
	Agapostemon	virescens
	Augochlora	pura
	Augochlorella	aurata
	Halictus	rubicundus
	Halictus	ligatus
	Halictus	parallelus
	Halictus	confusus
	Lasioglossum	pilosum
	Lasioglossum	lineatulum

Representative samples of voucher specimens were determined by Sam Droege of the U. S. Geological Survey, Beltsville, MD and Karen Goodell of The Ohio State University, Newark, Ohio.

Fig 2


Flower Visitation by Pollinators in Raspberries
Snyder Farm Wooster, Ohio 2007
Honey bees 53.7%
Native bees 7.4%
Bumble bees 38.9%


Flower Visitation by Pollinators in Raspberries
Snyder Farm, Wooster, OH 2006
Honey bees 84.3%
Native bees 7.8%
Bumble bees 7.8%

Flower Visitation by Pollinators in Raspberries

Moreland, Ohio 2007

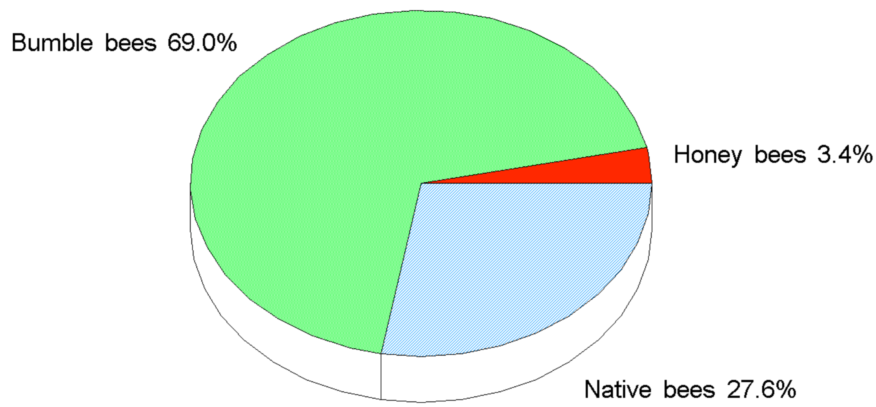


Fig 3

Flower Visitation by Pollinators in Raspberries

Moreland, OH 2006

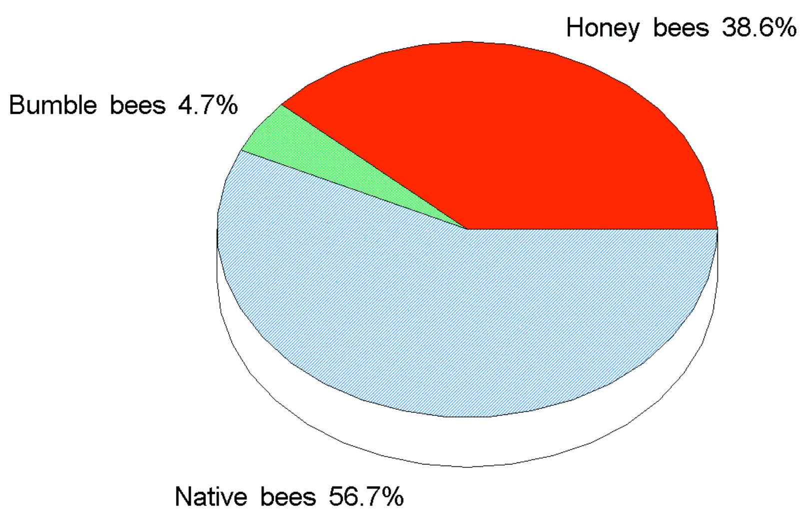


Fig 4

Fig 5

Flower Visitation by Pollinators in Blueberries

Snyder Farm Wooster, Ohio 2007

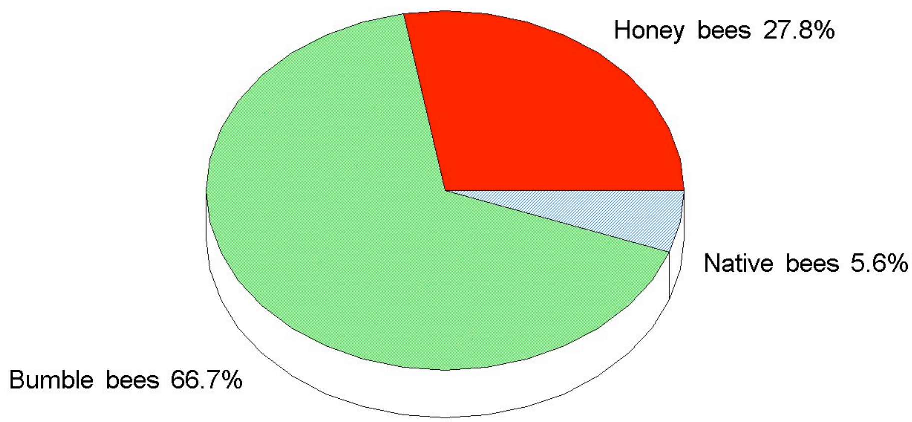


Fig 6

Flower Visitation by Pollinators in Blueberries

Snyder Farm, Wooster, OH 2006

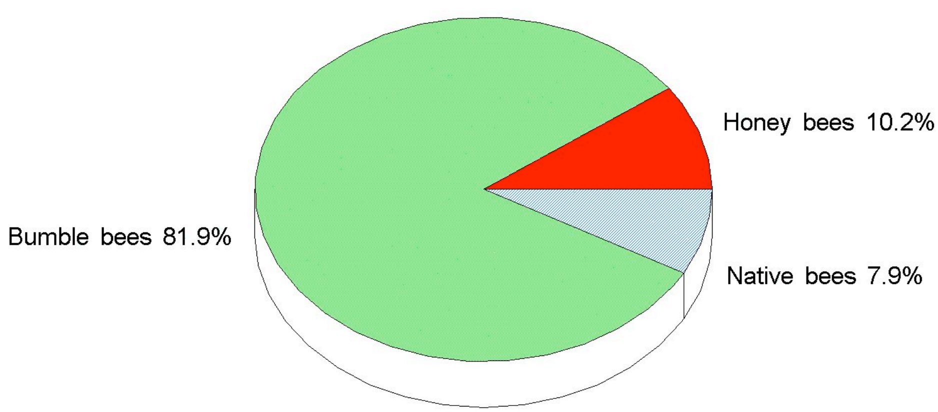


Fig 7

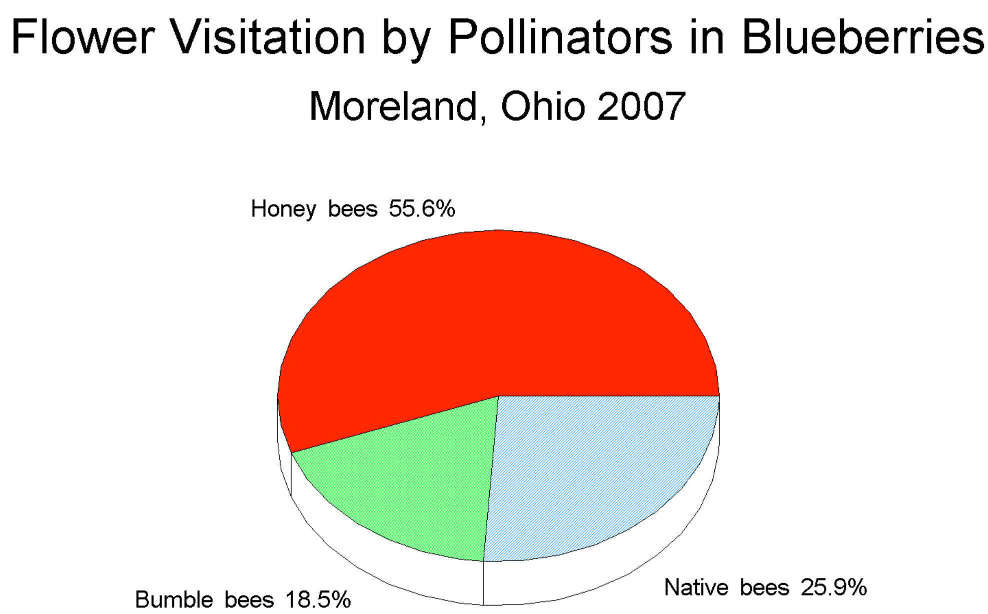

Flower Visitation by Pollinators in Blueberries
Moreland, Ohio 2007
Honey bees 55.6%
Bumble bees 18.5%
Native bees 25.9%

Fig 8

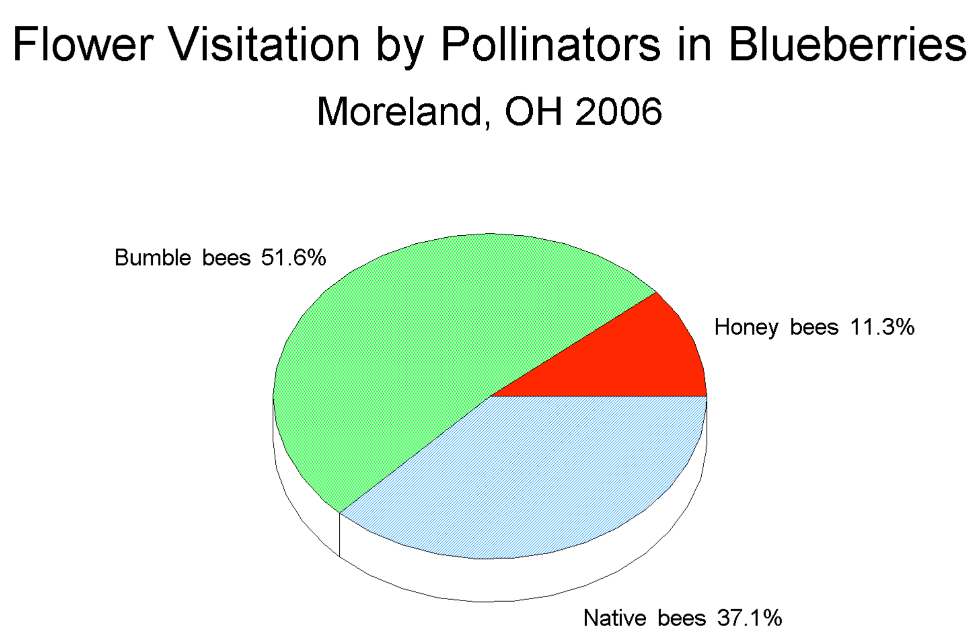

Flower Visitation by Pollinators in Blueberries
Moreland, OH 2006
Bumble bees 51.6%
Honey bees 11.3%
Native bees 37.1%

Fig 9

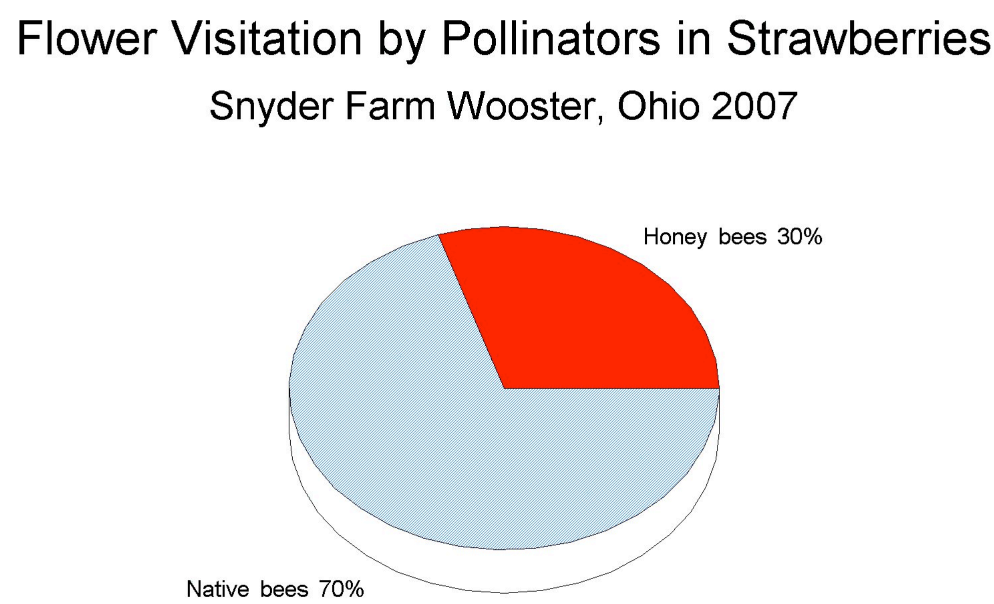

Flower Visitation by Pollinators in Strawberries
Snyder Farm Wooster, Ohio 2007
Honey bees 30%
Native bees 70%

Fig 10

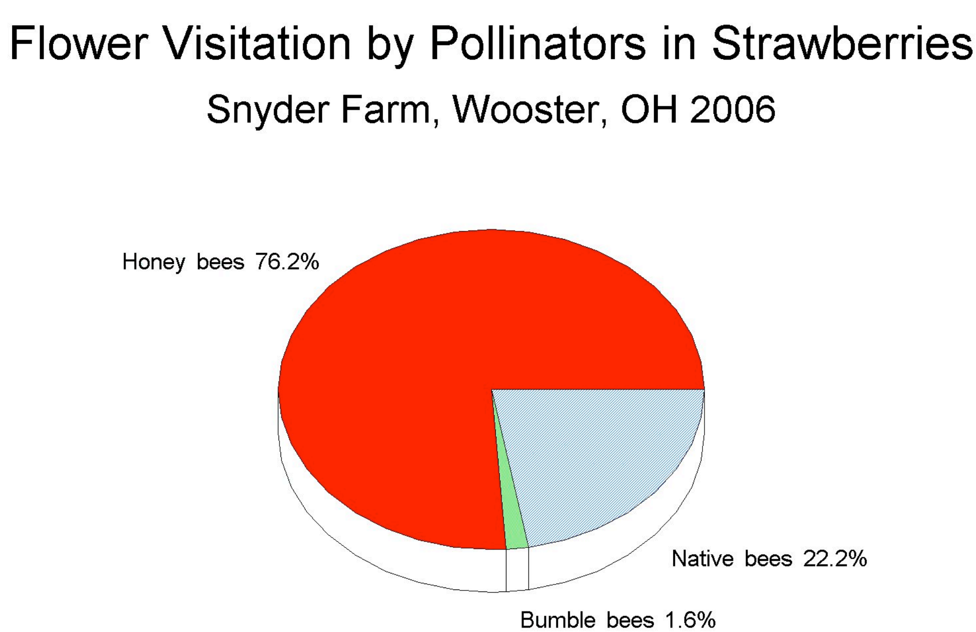

Flower Visitation by Pollinators in Strawberries
Snyder Farm, Wooster, OH 2006
Honey bees 76.2%
Native bees 22.2%
Bumble bees 1.6%

Fig 11

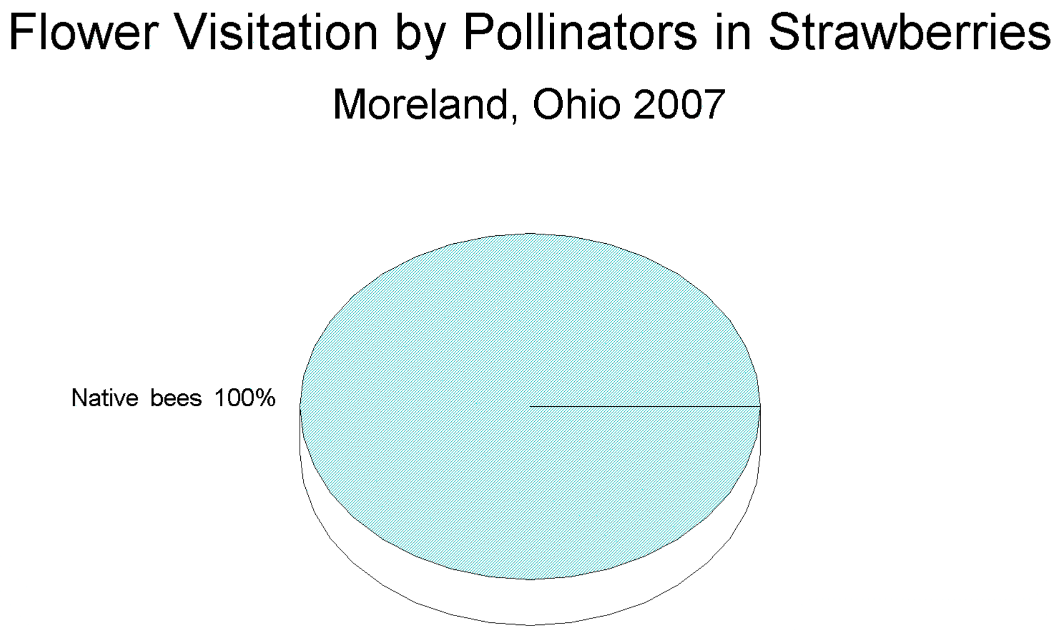

Flower Visitation by Pollinators in Strawberries
Moreland, Ohio 2007
Native bees 100%

Fig 12

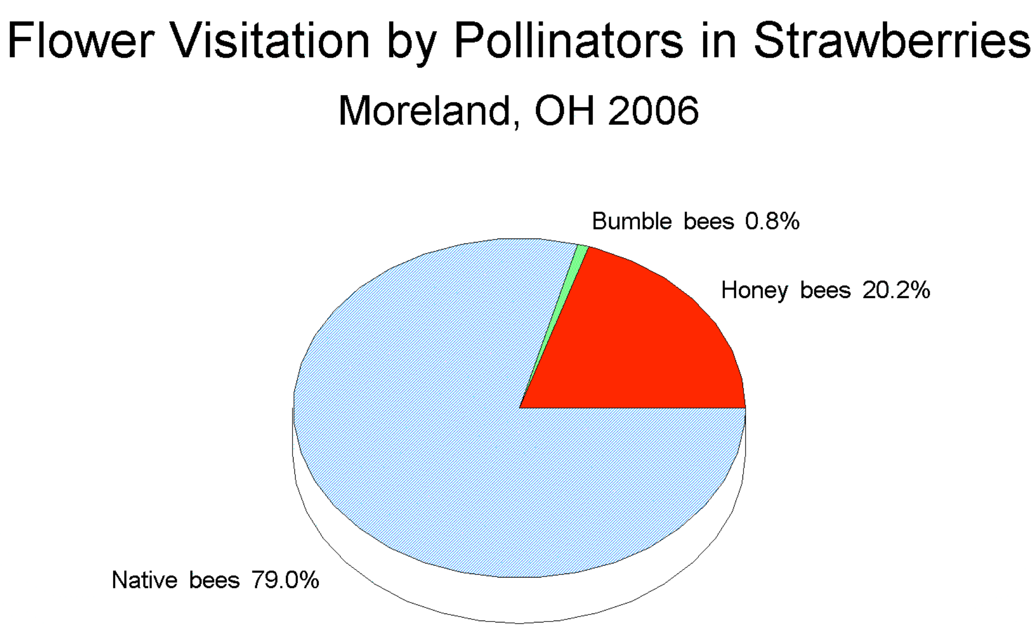

Flower Visitation by Pollinators in Strawberries
Moreland, OH 2006
Bumble bees 0.8%
Honey bees 20.2%
Native bees 79.0%

Fig 13

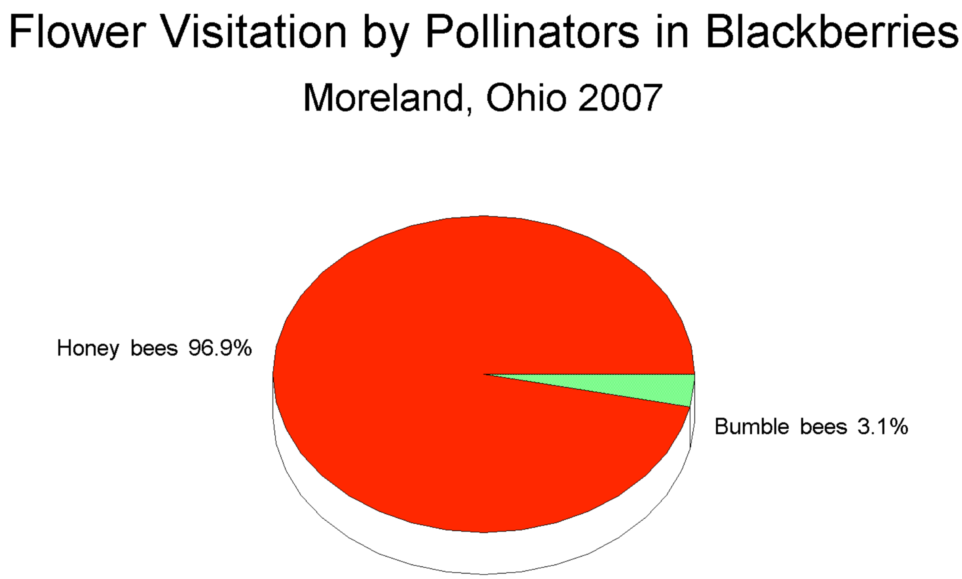

Flower Visitation by Pollinators in Blackberries
Moreland, Ohio 2007
Honey bees 96.9%
Bumble bees 3.1%

Fig 14

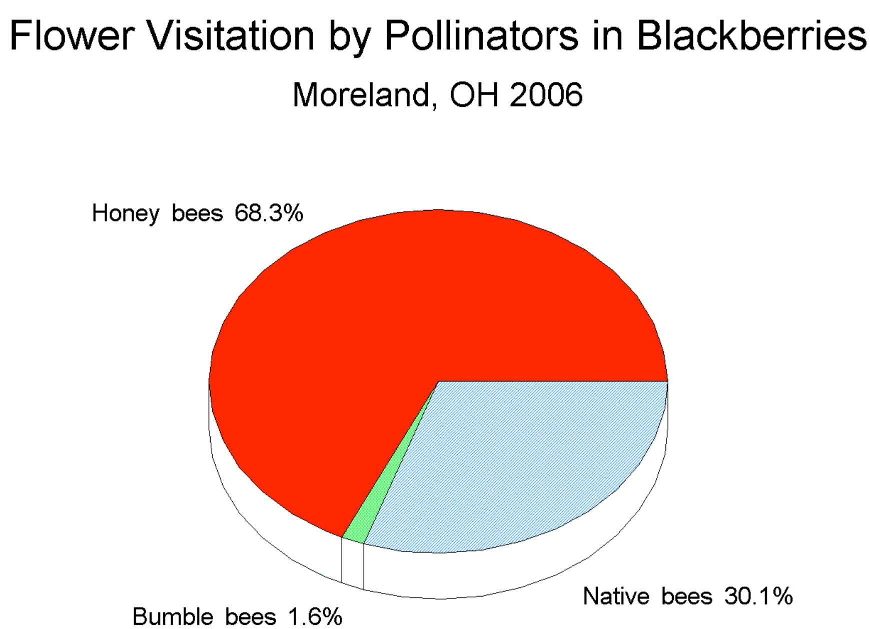

Flower Visitation by Pollinators in Blackberries
Moreland, OH 2006
Honey bees 68.3%
Bumble bees 1.6%
Native bees 30.1%

Fig 15

Flower Visitation by Pollinators Under Plastic Culture
Snyder Farm, Wooster, Ohio 2007

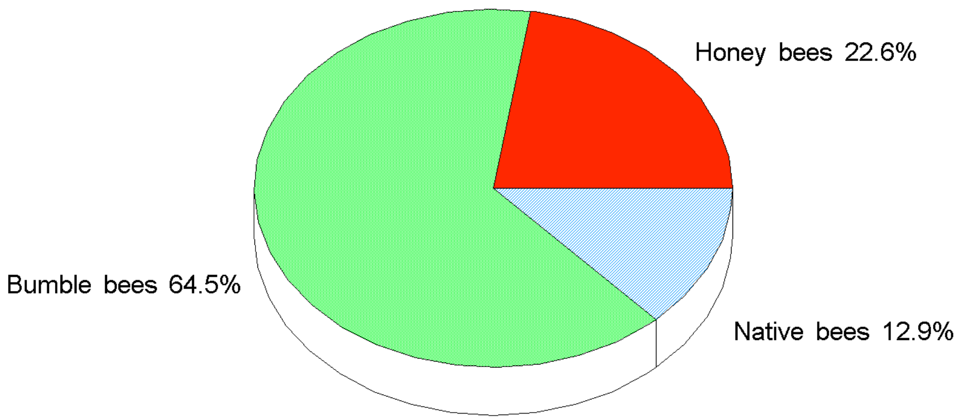


Fig 16

Flower Visitation by Pollinators Outside Plastic Culture, 2007
Snyder Farm, Wooster, Ohio

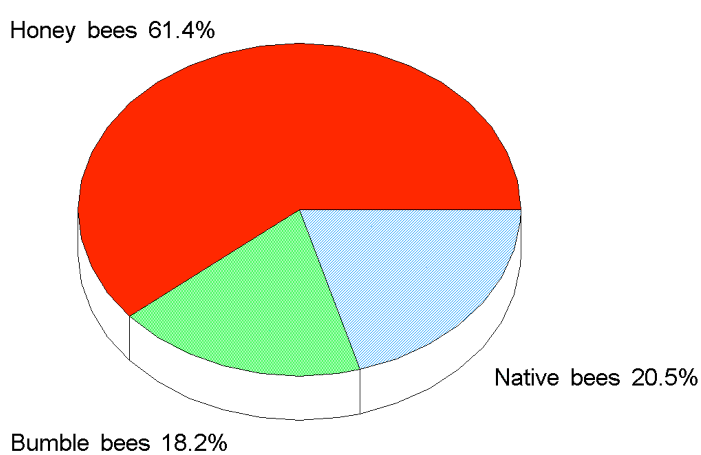
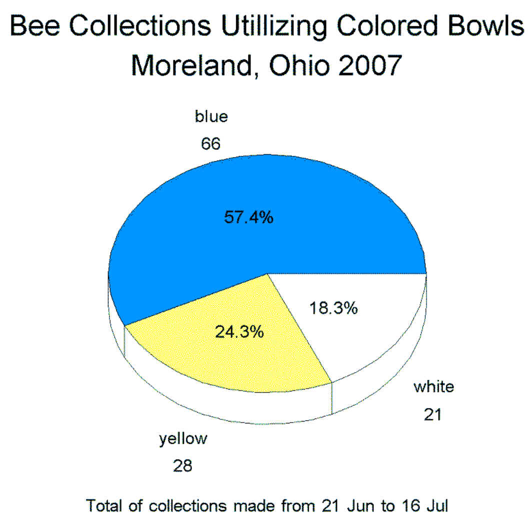


Fig 17


Bee Collections Utillizing Colored Bowls
Moreland, Ohio 2007
blue
66
57.4%
18.3%
24.3%
white
21
yellow
28
Total of collections made from 21 Jun to 16 Jul

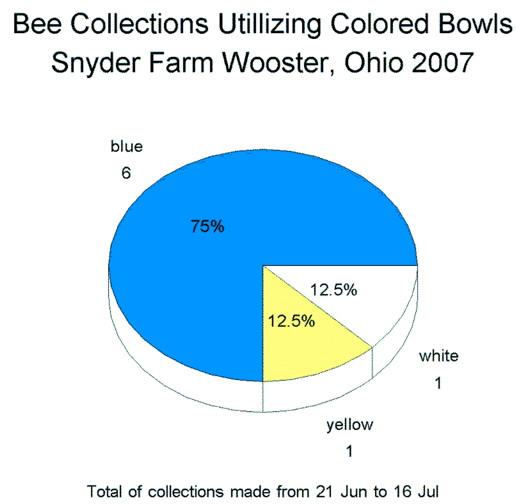
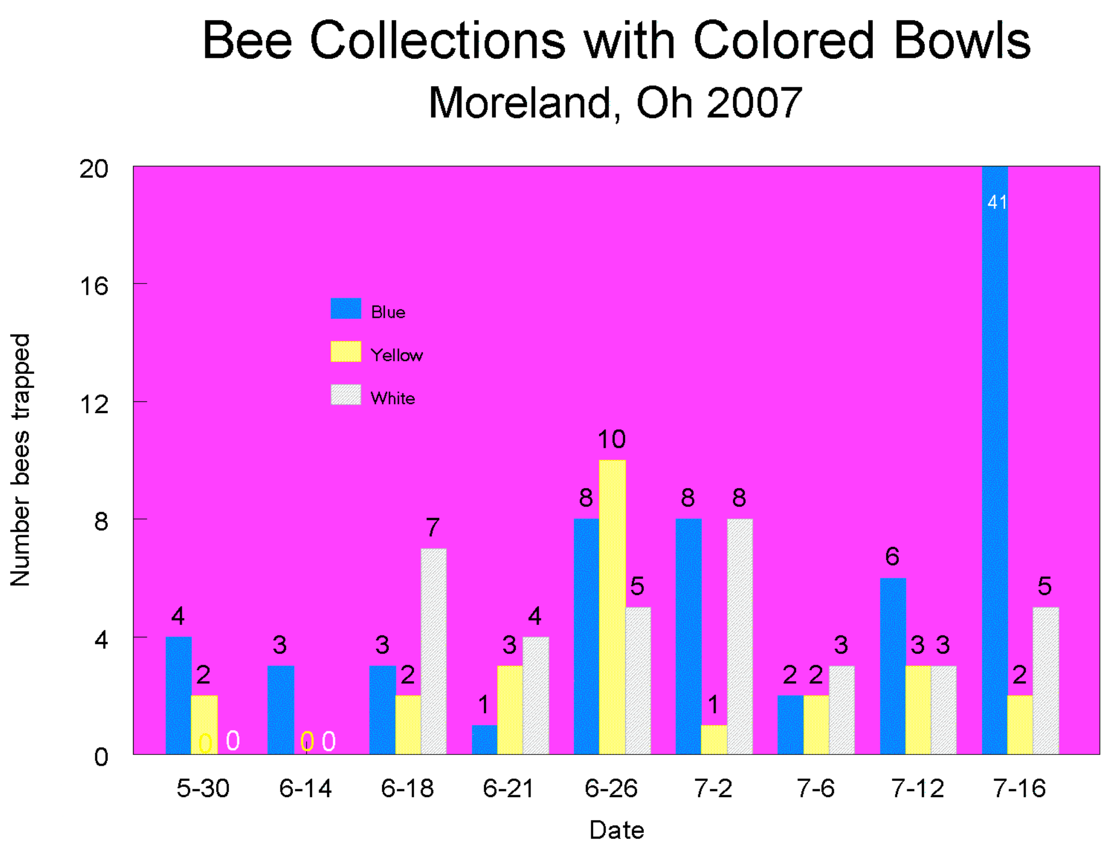

Bee Collections Utillizing Colored Bowls
Snyder Farm Wooster, Ohio 2007
blue
6
75%
12.5%
12.5%
white
1
yellow
1
Total of collections made from 21 Jun to 16 Jul

Fig 18


Bee Collections with Colored Bowls
Moreland, Oh 2007
Blue
Yellow
White
Number bees trapped
Date
5-30
6-14
6-18
6-21
6-26
7-2
7-6
7-12
7-16
41

Thornless Blackberry Production Systems for Control of Winter Injury and Cane Canker Disease 2007 Report

submitted to the 2007 Ohio IPM Grants Program
by the OSU Fruit Team, as represented by
Shawn Wright, Mike Ellis, Brad Bergefurd, Maurus Brown,
Gary Gao, Steve Prohaska and Celeste Welty
(Co-Principal Investigators for this project)

EXECUTIVE SUMMARY

We initially proposed developing thornless blackberry plantings at two locations that would evaluate the efficacy of various production systems in reducing winter injury, and blackberry cane blight disease that is associated with winter injury. Due to reduced funding from our initial proposal we have chosen to focus the work at the OSU South Centers in Piketon. We still have the potential in the future of establishing another location when funding and staffing issues allow. Production systems will include the current standard of open field planting and planting in high tunnels. Our hypothesis is that if we can reduce winter injury, blackberry cane blight can be prevented; thus, eliminating the use of fungicide for disease control. This may also allow us to diversify our recommend varieties to additional ones that we do not currently recommend due to winter injury potential. These plantings will also be available as demonstration plots, for variety evaluations, and other integrated crop management studies for a period of 8-12 years. This study will provide researchers and Extension Educators with information that will enable them to make sound, economically-based recommendations for the successful production of thornless blackberries in Ohio. These plantings will also be useful in providing high tunnel fruit production workshops.

In 2007 we received our funding. Major tasks for this year included soil sampling, field preparation, construction of the high tunnel, and ordering plants.

BACKGROUND AND JUSTIFICATION

There is more market demand for fresh, locally grown blackberries in Ohio than can currently be supplied because the Eastern thornless blackberry (*Rubus* subgenus *Rubus* Watson) is one of the least winter hardy small fruits in Ohio. 'Chester Thornless' is the standard variety grown throughout Ohio because it is more winter hardy than other commercially viable thornless varieties; however, it is not the preferred variety by consumers for fresh consumption. Other less winter hardy eastern thornless cultivars such as 'Triple Crown' are typically more preferred by consumers for fresh consumption because they have superior flavor compared to 'Chester Thornless'. At present, growers are forced to select varieties that are less preferred by consumers, but more reliable due to greater winter hardiness. Even the most winter hardy varieties may suffer from cold injury however. Spring of 2007 illustrated the difficulty in producing blackberries in Ohio. Because blackberries are a low-chilling requirement plant, we had plants that had emerged from dormancy by Easter weekend when we had a hard freeze for 5 days.

Virtually all blackberries south of Interstate 70 were froze to the ground with no production for the year. North of I-70 where the plants were not as advanced, there was still major damage and limited production.

One way to minimize winter injury and development of cane blight is to encourage the adoption of effective crop protection strategies, such as high tunnels, row covers and wind barriers. These strategies are all low cost compared to greenhouse production and there are many anecdotal reports suggesting that these practices are highly effective. Strong, research-based data is very limited. Growers, Extension Educators, and researchers have all stressed the need for sound research-based information that will enable the growers to make informed decisions on the economic viability of various production strategies. Over 60 individuals attended the high tunnel workshop held in Wooster last year. When the post workshop evaluation was completed, one of the main topic that individuals requested more information on was fruit production including brambles.

This project will meet the national IPM roadmap focus in the following areas:

1) Improve benefit/cost ratios when adopting IPM practices in production agriculture by developing new more cost effective production systems.
2) Reduce potential human health risks from pests and related management strategies in production agriculture by reducing the pesticides required for optimum fruit production
3) To minimize adverse environmental effects from pests and related management strategies in production agriculture by reducing the potential for pesticide run-off associated with mixing, application, spraying, and rinsing.

Expenditures - unaudited

Onset Corp. (Hobo microstations, data loggers, sensors, shuttle) -	$2123
FarmTek (Growers Supply High Tunnel, plastic lumber) -	$2139.47
Total	$4262.47
Awarded	$4500.00
Unspent	$ 237.53

Labor requirements -

Soil sampling 1@ 0.5 hours	= 0.5 man-hours
Field preparation 2@ 1.5 hours	= 3 man-hours
Construction of the high tunnel 4@ 16 hours	= 64 man hours

Tasks to be completed - Plant blackberries, cover high tunnel, continue funding search

High tunnel looking and field looking north.

High tunnel and field looking northeast

Codling Moth Monitoring in Northern Ohio Orchards
Ohio IPM Grant Report

Principal Investigator: Zachary Rinkes, OSU Extension, Erie County

Scouts: Ted Gastier, Extension Program Assistant
James Mutchler, Extension Program Assistant

Resource People: Dr. Celeste Welty, OSU Extension Entomology
Dr. Michael Ellis, OSU Extension Pathology

Introduction and Methods:

The North Central Tree Fruit Integrated Pest Management Program is designed to educate fruit growers on insect identification and proper pesticide use in northern Ohio. This program has now completed seventeen successful years and is still providing recommendations to growers in regards to pesticide application timing and insect population levels. This program encompasses and embraces the aspects of being environmentally friendly, economically feasible and socially aware.

Sixteen apple growers enrolled twenty-four apple blocks (one block is approximately 10 acres) in the 2007 North Central Tree Fruit Integrated Pest Management Program. Counties involved in the program were Erie and Lorain (East District) and Ottawa, Huron, Richland and Sandusky (West District). Inputs into the program included two program scouts, which incurred compensation for travel and wages, traps, equipment and data collation technical assistance. Scouts monitored orchards from the beginning part of April through early October. They worked approximately 25-30 total hours per week combined. Growers were charged a fee to help support the program.

Codling moth continues to be the major apple pest in northern Ohio. The larvae of this non-native insect will tunnel to the core of the apple. They feed on the seeds of the fruit, which lowers market value and renders the fruit unfit to eat. Codling moth "stings" also lower the value and marketability of apples.

Producers in northern Ohio have been investigating management techniques, such as how to better time insecticide applications and the effectiveness of microbial products, to help keep populations below threshold. Scouts monitored traps placed in all orchards for codling moth and extended their monitoring through September to see if a third generation was present. This helps determine times of first flight and of peak flight for the insect. The first moths usually appear as blossoms drop from trees. The summer brood emerges in July, peaking around August. Occasionally, there is a partial summer brood in September.

Apple pests, including codling moth, lesser appleworm, Oriental fruit moth and redbanded leafroller populations were monitored with "Multipher 3" pheromone traps. Three traps were placed at each site and an average number was calculated for codling moth on each weekly visit.

Results and Discussion:

Traps were monitored weekly from April through September. Trap report summaries are available online at http://erie.osu.edu/north-central-fruit-integrated-pest-management-program.

Codling moth averages (3 trap average for each site) can be found in Figure 1. Peaks were found in (1.) late May to early June and (2.) mid-August. Data provide evidence that no third brood was present this year. Table 1 shows the average codling moth trap counts from late August through October.

Northern Ohio escaped widespread damage from the April freeze in 2007. Northern Ohio growers had 80-100% of a full apple crop this year. Peach crops ranged from 50-80% of a full crop. However, several growers have noted trees displaying unusual rebloom and fruiting through November.

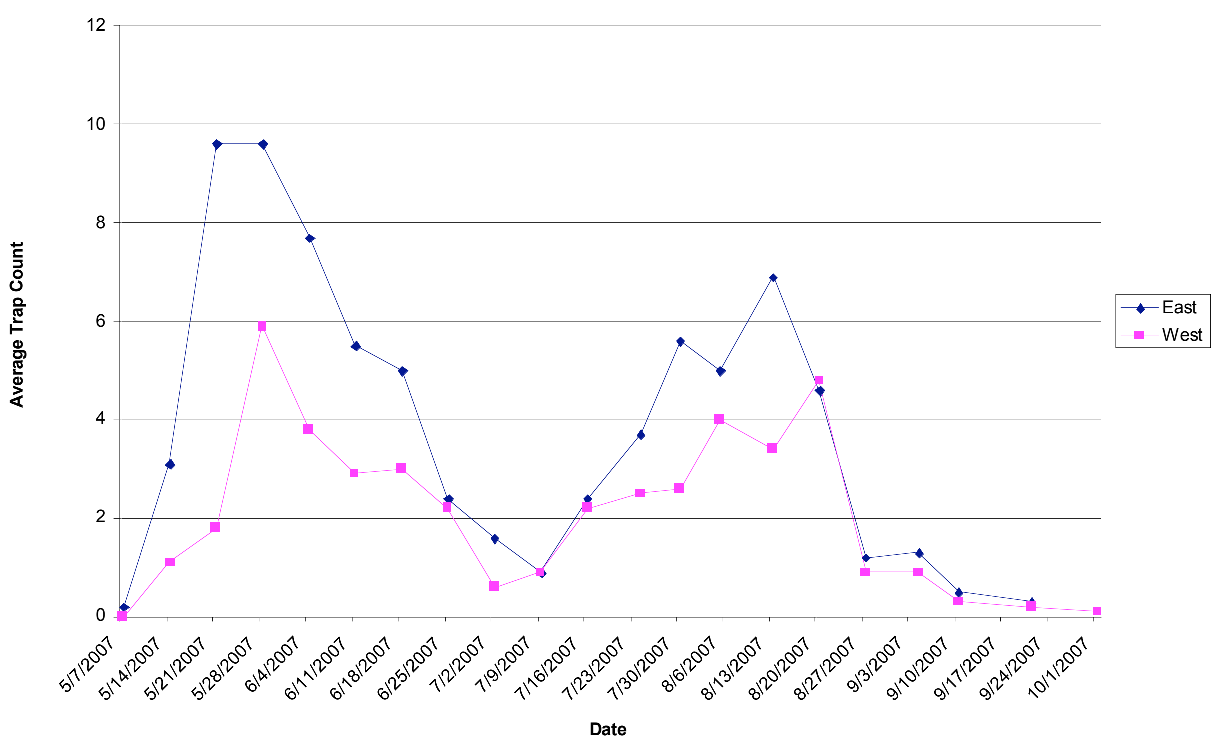
Several growers commented on the many ways the scouts helped them with pest control from an economical as well as environmental viewpoint. During post-harvest reports, which were conducted with each grower, several positive comments about the program were mentioned. These included scouts helping improve orchard insect control and providing the information needed to adjust spray materials and schedules according to data found in the scouting reports. The program was also reported to give growers the confidence that they have an appropriate pest management program that is protecting the quality of their apple and peach crop. New producers enrolled in the program this year noted that they learned the importance of scouting for insects and realized how this can help them increase yield and quality in their orchard. The program helped growers manage blocks appropriately with light crops and provided sound pest control techniques to growers in a reasonable time frame.

Codling moth will likely continue to be a major pest of apples in the northern region of Ohio. Research is needed to fine tune timing of pesticides and help producers learn more about flight patterns. The North Central Tree Fruit IPM program will continue to monitor for codling moth as well as lesser appleworm, redbanded leafroller, spotted tentiform leafminer, san jose scale and apple maggot in apples as well as redbanded leaf roller, oriental fruit moth, lesser peachtree borer and greater peachtree borer in peaches. Beneficial insects are also noted and this program is expected to continue in the future.

Table 1. Codling moth averages (3 trap average per site) for East and West District (Late August through October 1).

	East District (Erie and Lorain)	**West District (Sandusky, Ottawa, Richland and Huron)**
August 27	1.2	0.9
September 4	1.3	0.9
September 10	0.5	0.3
September 21	0.3	0.2
October 1	N/A	0.1

Figure 1. Codling moth averages (3 trap average) for East and West District



Developing integrated control tactics for cole crop pests

Final report to the Ohio IPM Block Grant Program, January 2008

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Background: Broccoli and other cole crops are attacked by numerous insect pests, whether the crops are grown on commercial farms or in home gardens. The key pest is a complex of three species of caterpillars: imported cabbageworm, diamondback moth, and cabbage looper. Although most commercial farmers use conventional insecticides for caterpillar management, most market gardeners prefer to not use conventional insecticides, yet alternative tactics are not well demonstrated or understood. All three species of caterpillars have several parasitoid wasp species that attack them if these natural enemies are not killed by insecticides. This project was done to see if some reduced-risk chemicals could be successfully combined with biological and mechanical tactics to form a truly integrated management program.

Trial 1: Parasitoid enhancement

Objective: Determine whether or not parasitism of diamondback moth and imported cabbageworm can be significantly increased by provision of a flowering border that can provide nectar to native parasitoid wasps.

Methods: A field trial on parasitoid enhancement by provision of a flowering border of sweet alyssum ('Carpet of Snow', W. Atlee Burpee & Co., Warminster PA) was conducted at OSU's Waterman Farm at Columbus. A randomized complete block design was used with two treatments and four blocked replicates. The broccoli cultivar used was 'Flash Hybrid' (W. Atlee Burpee & Co.). The two treatments were broccoli with flowering borders and broccoli without flowering borders. Within a blocked replicate, the two treatments were separated by 50 meters of soybeans to avoid potential movement of parasitoids between treatments, and blocks were separated by 300 meters. Plots were established on 23 April by transplanting 12 plants per plot. The with-flower plots had one row of sweet alyssum on each side. Plants were inspected once per week for pests. During each week in June, all pupae were collected and held to determine whether they were parasitized. Broccoli heads were harvested and evaluated on 27 June and 5 July. Density of the three caterpillar species was converted to Larval Units by multiplying the number of small (<13 mm) imported cabbageworm larvae by 0.1, multiplying the number of large (≥13 mm) imported cabbageworm larvae by 0.67, multiplying the number of diamondback larvae by 0.1, multiplying the number of small (<13 mm) cabbage looper larvae by 0.67, and multiplying the number of large (>13 mm) cabbage looper larvae by 1.0, then summing those components. Data were subjected to analysis of variance and mean comparisons were made by least significant difference (LSD) tests in the SAS 9.1 microcomputer statistics program.

Results: Parasitization of diamondback was high in both the flower border and the no flower border treatments during June, and there was no significant difference between treatments (P>0.05; Table 1). The parasitoids recovered were ichneumonids, braconids, and chalcids. Parasitization of imported cabbageworm was lower but also not significantly different between treatments. Caterpillars were detected during scouting but the average number of larval units per plant did not differ significantly between treatments (Table 2). At harvest, the head weight, head diameter, and the number of caterpillars in the head did not differ between treatments (P>0.05).

Table 1. Percentage of diamondback moth parasitized on broccoli in flowering border trial.

Treatment	*% of DBM parasitized before collection on each date*				
	9 June	*13 June*	*20 June*	*27 June*	*all samples*
With flowering border	41% (N=38)	52% (N=27)	52% (N=42)	78% (N=34)	59% (N=141)
No flower border	36% (N=19)	27% (N=17)	52% (N=26)	90% (N=13)	52% (N=75)
Probability value (treatment effect)	*0.42*	*0.39*	*0.99*	*0.99*	*0.51*

Table 2. Caterpillar pest density on broccoli, detected by scouting in flowering border trial.

Treatment	*Number of larval units per broccoli plant on 8 sampling dates*							
	4/30	*5/7*	*5/21*	*5/31*	*6/8*	*6/15*	*6/20*	*6/27*
With flowering border	0	0	0.01	0.24	0.17	0.16	0.51	0.69
No flowering border	0	0	0	0.06	0.28	0.09	0.31	0.59
P value (treatment effect)	-	-	*0.39*	*0.10*	*0.72*	*0.47*	*0.12*	*0.81*

Trial 2: Integrated control.

Objective: Compare caterpillar control by microbial insecticides, conventional insecticides, row covers, and hand-picking, all in conjunction with a flowering border for enhanced biological control.

Methods: A field trial was conducted to evaluate efficacy of insecticides and mechanical controls for caterpillar and flea beetle control, all in the presence of a flowering border that was used to enhance parasitoid activity. A randomized complete block design was used with ten treatments and four blocked replicates. Treatments were sprays of B.t. (Bonide's Thuricide), spinosad (Fertilome's Borer Bagworm Spray), methoxyfenozide (Dow AgroScience's Intrepid), azadirachtin (Gowan's Aza-Direct), esfenvalerate (Ortho's Bug-B-Gon Max), and pyrethrins + PBO (Spectracide's BugStop), as well as B.t. dust (Fertilome's Dipel Dust), row covers, hand-picking, and an untreated check. Plots were established on 20 April with three plants per plot. Each broccoli row had a row of sweet alyssum on each side. Row covers used were 'Super-Light Insect Barrier' (Gardens Alive! Inc., Lawrenceburg IN), anchored by metal garden staples. For weed suppression, the ground between rows was covered with newspaper mulch topped by straw. Plots were scouted once per week for insect pests. In the hand-picking treatment, insects were removed during each scouting as soon as they were counted. Row cover plots were not scouted. Insecticide treatments were applied by hand with 1-liter spray bottles, seven times from late April until mid-June. Broccoli heads were harvested and evaluated on 20 June.

Results: The number of larval units per harvested broccoli head differed significantly among the integrated control treatments, with the most larval units in the hand-pick treatment and the least in row cover, esfenvalerate, methoxyfenozide, spinosad, and B.t. dust treatments (Table 3). The weight of harvested broccoli heads was significantly higher in the row cover treatment than in all other treatments (Table 3). Scouting data showed that the number of larval units per plant differed significantly among treatments on two dates: on 30 May when infestation was higher in azadirachtin than other treatments (P=0.0028), and on 6 June when esfenvalerate and spinosad were significantly less infested than untreated, azadirachtin, hand-picking, or pyrehrins + PBO (P=0.0096). The ranking of treatments according to larval units found during weekly scouting was similar to harvest rankings (Table 3).

Table 3. Caterpillar infestation and yield at harvest in broccoli integrated control trial.

Treatment	*Sum of ranks of Larval Units on 8 scouting dates*	*Larval Units per harvested broccoli head*	*Weight of broccoli head harvested (grams)*
row cover	-	0 C	725 A
esfenvalerate	61.5	0 C	195 BC
methoxyfenozide	46.5	0 C	246 BC
spinosad	44.0	0 C	277 BC
B.t. spray	42.5	0.11 BC	270 BC
pyrethrins + PBO	41.0	0.16 ABC	112 C
B.t. dust	38.5	0 C	317 B
hand picking	35.5	0.28 A	290 BC
azadirachtin	25.5	0.14 ABC	310 B
untreated	25.0	0.22 AB	149 BC
P value from ANOVA (trtmt effect)	-	*0.0047*	*0.0001*

Trial 3: Predator augmentation

Objective: Evaluate predator augmentation for suppression of caterpillar and aphid pests.

Methods: A field trial was conducted to evaluate whether a release of lacewing eggs and lady beetle larvae could adequately suppress caterpillars on broccoli. A randomized complete block design was used with two treatments and four replicates. The two treatments were predator release and no predator release. Each plot was four adjacent plants. Plants were scouted once per week. Once aphids were detected, lacewing eggs on cards were purchased from Rincon-Vitova Insectaries Inc. (Ventura, CA). Lacewing eggs were released on 11 May by placing one card, holding approximately 167 lacewing eggs, on top of a leaf in the middle canopy on each plant. Lady beetle larvae were collected from a local apple orchard and released on 9 June, using six larvae per plot. Broccoli heads were harvested and evaluated on 5 July.

Results: Weekly scouting data showed that the number of caterpillars per plant and aphids per plant did not differ between the predator-release and no-release treatments on any sampling date (P>0.05). At harvest, there was no significant treatment effect on the number of caterpillars found in the heads, or the weight or diameter of the broccoli heads (P>0.05).

Discussion & conclusions:

Because parasitism of diamondback moth was high in plots without flowering borders, it is possible that the separation of plots by 50 m of soybeans was inadequate to prevent movement of parasitoids between plots; the beneficial effect of the flowers was extended to both treatments. Predator augmentation had no documented benefit, probably because the prey density was too low to support the predators. Tactics that seem worthy of further testing are flowering borders of sweet alyssum, row covers, and sprays of methoxyfenozide, spinosad, and B.t., which are reduced-risk insecticides. Sweet alyssum was much more satisfactory than cilantro, Phacelia, or nasturtium used for the same purpose in previous trials, due to sweet alyssum's fast growth, early flowering, and tolerance of cool weather.

Annual Report for Small Industry Matching Grant – OHOA1307

Mike Ellis
Department of Plant Pathology

Evaluation of dormant applications of phosphite fungicides combined with the bark penetrating adjuvant Pentra-Bark for early season control of apple scab, 2007

A trial was conducted to evaluate the efficacy of dormant applications of several treatments for control of apple scab. Treatments were applied to four single-tree replicates on mark rootstock arranged in a complete randomized block design. The 21-year old trees were spaced 10 ft apart with 30 ft between rows. Soil type was Wooster silt loam. Treatments were applied to the bark of dormant trees at the silver tip stage of development on 30 March. Bud break (green tip) occurred on 1 April. Treatments were applied using a 3-gallon, CO2 pressurized hand sprayer at 40 psi. The bark on the main trunk of the tree and the first 1 to 2 feet on the main scaffold limbs was spayed until bark was wet. Treatments were applied once or twice. For treatments that were applied twice, the spray was applied again approximately 15 minutes later. No other fungicide was applied in any of the treatments until 10 May (petal fall). On 10 May, Captec 4L was applied in the first foliar spray to all treatments except one and an untreated control. One treatment received an additional bark spray of Agri Fos plus Penta bark at petal fall and the first cover spray with captan was made at first cover on 18 May. One treatment remained an untreated control and received no fungicide sprays all season long. For all foliar sprays, trees were sprayed to runoff in 300 gallons of water per A with a handgun at 450 psi. All treatments received addition summer cover sprays of Captec 4L at 3 qt/A starting at first cover on the following dates: 18 and 29May: 13 and 27 June; 9 and 24 July and 7 and 24 August. Percentage of leaves (disease incidence) with primary scab (at least one lesion/leave) was determined for all cluster leaves and the first five terminal leaves on 10 shoots per tree on 4 June. Disease severity for primary scab was determined simultaneously on the same leaves by visual estimation of diseased leaf area. Percentage of leaves (disease incidence) with secondary scab (at least one lesion/leaf) was determined on the 10 most fully expanded terminal leaves on 10 shoots per tree on 18 July. Disease severity was simultaneously determined on the same leaves as previously described. Percentage of fruit (disease incidence) with at least one scab lesion/fruit was determined on 25 fruits per tree on 4 September.

On 4 April, when McIntosh (Mac) trees were at the half-inch green stage of development, we experienced very low temperatures. In fact, it was the worst freeze affecting the Ohio apple industry in over 50 years. Daily minimum air temperatures from 4 April through 10 April were: 25, 23, 24, 20, 23, 28 and 24F, respectively. All green tissues were severely damaged. Between half-inch green and the first fungicide application at petal fall (10 May) we only had three scab infection periods; however, incidence and severity of primary scab was high in the untreated Mac control, 100 and 29%, respectively. All treatments had significantly less primary scab incidence and severity than the untreated control; however, most treatments were not significantly different from the control that was treated with captan at petal fall. Golden Delicious (GD) trees were not as developed as Mac when the freeze hit, and appeared to have less visible freeze damage than Mac. Most treatments appeared to perform better on GD than on Mac. On GD, the Agri-Fos plus Peta-Bark sprayed twice and the foliar treatment of Agri-Fos had significantly less primary scab incidence than the control sprayed with captan at petal fall. There were no significant differences in disease severity. The treatment that received the additional bark application at petal fall in place of captan had significantly more incidence and severity of primary scab than most other treatments. The second bark application during the season had no apparent effect on scab control.

Due to dry conditions in June and July, relatively little secondary scab developed in any of the treatments, except for the treatment that received the second bark application and the untreated control.

For fruit scab all treatments had significantly less fruit scab than the untreated control on both cultivars. Fruit scab on Mac was generally more severe than on GD. Except for the foliar treatment of Agri-Fos at 2qt. per 100 gallons , none of the treatments were significantly better than the check treated with captan at petal fall, and some treatments were significantly worse than the check treated at petal fall. Although the level of fruit scab control was significant in all treatments, none of the treatments (with one exception) provided a commercially acceptable level of scab control. The level of control that was obtained from the foliar spray of Agri-Fos was unexpected and was commercially acceptable on GD.

In summary, all treatments provided significantly better scab control than the untreated control. However, most treatments were not significantly different from the control treated at petal fall with captan. Therefore, in most cases, we did not see a significant effect from the dormant bark treatments that can be separated from the petal fall captan treatment. In all cases except for the foliar application of Agri-fos on GD, none of the treatments provided a commercially acceptable level of disease control. The dormant applications in 2007 did not perform as they did in 2006. We observed development of scab in all treatments prior to the petal fall captan spray in 2007. In 2006, we observed no scab in several treatments prior to the first cover spray, while scab incidence in the control was 100%. We can not explain the differences between treatments in 2006 and 2007. Several other researchers in the U.S. and Canada reported no control from the bark treatments in 2007, yet some researchers reported various levels of scab control. We plan to continue evaluation of the dormant treatments in 2008 as well as the efficacy of foliar applications of Agri-Fos for control of apple scab.

Dormant Applications of Agri-Fos and Pentra-Bark for Controll of Apple Scab, OARDC, 2007

#	Treatment and Rate Product/A		Comments	Primary Scab Leaves Incidence Mac	Primary Scab Leaves Incidence GD	Primary Scab Leaves Severity Mac	Primary Scab Leaves Severity GD	Secondary Scab Leaves Incidence Mac	Secondary Scab Leaves Incidence GD	Secondary Scab Leaves Severity Mac	Secondary Scab Leaves Severity GD	Fruit Scab Incidence Mac	Fruit Scab Incidence GD
1	Agri-Fos	1 qt	Spray entire trunk once										
	Water	3 qt	Start fungicide at petal fall										
	Pentra-Bark	3 oz		18cd	29bcd	1.3c	2.3bcd	6.5cd	6.0c	0.4c	0.4c	65.8bc	36.0c
2	Agri-Fos	1 qt	Spray entire trunk twice										
	Water	3 qt	Start fungicide at petal fall										
	Pentra-Bark	3 oz		17cd	28bcd	1.3c	2.2bcd	4.0cde	3.0c	0.2c	0.2c	35.6ed	21.0cd
3	Agri-Fos	2 qt	Spray entire trunk twice										
	Water	2 qt	Start fungicide at petal fall										
	Pentra-Bark	3 oz		13cd	15cd	0.7c	1.6cd	0e	1.0c	0c	0.1c	58.9bc	26.4c
4	Agri-Fos	2 qt	Spray entire trunk once										
	Water	2 qt	Start fungicide at petal fall										
	Pentra-Bark	3 oz		7d	29bcd	0.5c	3.1bcd	0.3de	2.0c	0.1c	0.1c	45.3cde	25.0c
5	Agri-Fos	2 qt	Applied bark treatment again at petal fall										
	Water	2 qt	Started fungicide at first cover										
	Pentra-Bark	3 oz		65b	41b	10.9b	5.0bc	41.6b	36.5b	5.3b	6.9b	74.7b	62.8b
6	Agri-Fos	2 qt	Spray entire trunk once										
	Water	2 qt	Start fungicide at petal fall	20c	33bc	1.3c	3.0bcd	2.0cde	1.5c	0.5c	0.5c	54.0bcd	31.0c
7	Water	4 qt	Spray entire trunk once										
	Pentra-Bark	3 oz	Start fungicide at petal fall	25c	30bcd	2.0c	3.2bcd	8.0c	7.5c	0.5c	0.5c	68.5b	34.5c
8	Agri-Fos 2 qt per 100 gal water		Applied in a protectant fungicide program on a 7-day Schedule	8d	10d	0.4c	0.8d	0e	0c	0c	0c	33.0e	4.0d
9	Untreated Control		Start fungicide at petal fall	17cd	38b	1.0c	5.1b	2.5cde	6.0c	0.2c	0.4c	60.0bc	26.0c
10	Untreated Control		No fungicide full season	100a	100a	28.9c	24.7a	100a	100a	32.9a	28.6a	100a	100a

NOTES:

1.) Bark applications were made using a 3-gallon CO2 hand sprayer at 40 PSI.
The entire trunk and the first foot of major scaffold limbs was sprayed until bark is wet.
For treatments sprayed twice, the applications were repeated on wet bark approximately 15 minutes later.

2.) Treatments were made close to silver tip (30 March).

3.) The first fungicide application was Captan at 3 lbs A.I./A (3 qts of Captec 4L).
The first application of fungicide was made at petal fall for all treatments except one that was made at first cover
The treatment that did not get treated until petal fall received an additional bark application of Agri Fos plus Penta Bark at petal fall.
After the first fungicide application, all treatments will receive cover sprays of Captec 4L at 3 qt per acre for the duration of the growing season.

4.) Scab ratings for disease incidence and severity were taken for primary and secondary scab on foliage and disease incidence on fruit beginning when scab is first observed on control trees.

5.) All treatments were replicated four times in a completely randomized design.

Project Title

Development of Biological Disease Management Approaches For High Tunnel Tomatoes

Principal Investigator

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INTRODUCTION

Interest in using high tunnels for vegetable production has increased significantly in the past several years. High tunnels offer the opportunity to extend the growing season for many vegetable crops, allowing growers to capture off-peak production prices. While high tunnels decrease the incidence of some diseases, such as early blight and Septoria blight due to protection of plants from rain splash, other diseases that are not a problem in open fields can be serious in high tunnels. Growers have reported that leaf mold, a fungal disease, is a serious late season problem in high tunnels; however it is almost never observed in the open field. Botrytis is also a significantly greater problem in greenhouse and high tunnel tomatoes than in field tomatoes. Timber rot can be a problem in high tunnels and our previous results showed that high tunnel tomatoes planted in compost-amended soils had significantly less timber rot than those in non-amended soils.

The objective of this study was to determine the effects of compost on development of timber rot and other diseases in high tunnel tomatoes. The second objective was to evaluate the effectiveness of several biorational products (*Muscodor* biofumigant (QRD 300), *Trichoderma hamatum* 382, Kocide 2000 and hydrogen peroxide) in reducing tomato diseases under high tunnel conditions. Timber rot did not develop in this study in 2007, and results are reported for other diseases, including Botrytis gray mold, leaf mold, Septoria blight and early blight.

METHODS

The experiment was conducted at the Ohio Agricultural Research and Development Center, Snyder Farm in Wooster, OH on Wooster silt loam. On 3 April, the test field was plowed and cultivated, and composted dairy manure (N-P-K, 4-5-14, 15 ton/A dry weight) was applied to the appropriate plots before beds were prepared. On 23 April, a seedling mix was prepared containing 70% Sunterra Peat Moss (Conrad Fafard, Inc., MA) and 30% peat-perlite mixture plus amendments (150 g dolomitic lime, 50 g mississippi lime, 31 g potassium nitrate, 31 g triple super phosphate, and 31 g gypsum). Seedling mix, for *Trichoderma* treatments, was inoculated with approximately 1 X 10^6 conidia/fl oz (1 X 10^5 conidia/ml) *T. hamatum* 382 seven days before seeding. 'Mountain Spring' tomato seeds were hot water-treated (10 min pre-soak at 100ºF, then treatment for 25 min at 122ºF) and sown on 30 Apr into 50-cell plug trays containing *T. hamatum* 382 inoculated mix or non-inoculated mix. On 18 May, black plastic mulch and black nursery shade cloth were laid for weed control over a single drip irrigation tape (flow 0.5 GPM/100 ft at 12 PSI, drip emitters space every 12 in (Chapin Watermatics Inc.)). The biopesticide QRD 300 (*Muscodor albus*) was broadcast and incorporated as a band application at the rate of 7.75 lb/50 ft row, 16 in. wide, and 4 in. depth on 4 Jun. Drip irrigation was turned on at the time of Muscodor application to maintain moisture. The high tunnel was moved onto the plots and anchored before transplanting. Tomato seedlings were transplanted on 13 Jun; fertilizer (N-P-K 5-3-3; 1.6 lb/10 gal water) was applied. Plots were arranged in a randomized split block design with four replications. Each plot consisted of eight plants spaced 1.5 ft apart with 4 ft between rows. M-Trak (3qt /A) and Diatect V (6 lb/A) were applied on 20 Aug and 3 Sep; and 27 Aug and 10 Sep, respectively to control insect pests. Kocide 2000 (2 lb/A) and peroxide (1 qt/20 gal water) were applied using a backpack CO_2-pressurized sprayer (40 psi, 92.4 gal/A, 0.5 mph) on a 7-10 day schedule beginning on 9 Jul and ending 26 Oct for a total of nine applications. Plants were drip irrigated three times per week for one hour each interval (173 gallons water) beginning on 13 Jun and ending 26 Oct. Severity of Botrytis gray mold, early blight, Septoria leaf spot and leaf mold on foliage was evaluated on 21 and 29 Aug, 5, 12, 20, and 28 Sep, 3 and 22 Oct, and 2 Nov; 29 Aug, 5, 12, 20, and 28 Sep, 3 and 22 Oct, and 2 Nov; 5, 12, 20, and 28 Sep, 3 and 22 Oct, and 2 Nov; and 3 and 22 Oct, and 2 Nov, respectively using a scale of 0-100 percent foliage affected. Fruits were harvested from all plants of each treatment row on 10, 19, and 27 Sep and 10 Oct and weights of marketable fruit, healthy cull fruit, fruit with anthracnose, Botrytis, “other” rots (minor fungal and oomycete fruit rots), blossom end rot, and fruit damaged by insects were determined. Average maximum temperatures for 28-30 Jun, Jul, Aug, Sep, Oct, and 1-2 Nov were 92.5, 97.4, 98.8, 94.2, 92.1, and 90.2 ºF and average minimum temperatures were 58.7, 58.3, 63.4, 53.6, 49.5, and 33.7 ºF Data were analyzed by ANOVA using SAS statistical software. Means were separated using Fisher’s protected least significant difference test.

RESULTS

Natural disease pressure was low under high tunnel conditions until high humidity and cool temperatures resulted in increased leaf mold and Botrytis gray mold at the end of the season. All of the treatments reduced the severity of leaf mold; the most effective treatment was Kocide 2000 (Table 1). Plants grown in compost-amended soil had significantly less leaf mold than those grown in non-amended soil. None of the treatments were effective against Botrytis gray mold, and plants grown in compost-amended soil had significantly more Botrytis gray mold than those grown in non-amended soil (Table 2). The severity of early blight and Septoria leaf spot was very low (<3%) and there were no significant differences among treatments and the untreated control (data not shown).

Tomato plants treated before transplanting with Trichoderma and grown on soil biofumigated with Muscodor (QRD 300) yielded a significantly higher proportion of healthy and marketable fruit than those treated with Kocide 2000 (Table 3). Overall, compost amendment significantly increased the percentage of healthy and marketable fruits and decreased the incidence of minor fruit rots (data not shown). The incidence of Botrytis ghost spot/rot and anthracnose was low and there were no significant differences among treatments and the untreated control (data not shown).

Table 1. Effect of compost and biorational treatments on severity of leaf mold (% leaf area affected on 2 Nov 2007 and the Area Under the Disease Progress Curve (AUDPC, a measure of whole season disease severity).

Source	*df*	Levels (application timing[z])	% leaf mold[y] (2 Nov)	AUDPC leaf mold[yx]
Treatment	5		*P*=0.0001 *F*=22.51	*P* =0.0001 *F*=34.00
		Untreated control	16.6 a[w]	454.8 a
		QRD 300 3.75 oz/ft^3	10.6 bc	309.8 bc
		Trichoderma	10.0 c	284.7 cd
		QRD 300 3.75 oz/ft^3 + Trichoderma	12.5 b	340.2 b
		Kocide 2000 2 lb/A (1-9)	7.5 d	197.8 e
		Peroxide 1 qt/20 gal (1-9)	9.1 cd	244.7 d
Compost amendment	1		*P*=0.0043 *F*=61.36	*P*= 0.0027 *F*=84.43
		Yes	9.5 b	257.2 b
		No	12.6 a	353.5 a
Treatment X Compost amendment	5		*P*=0.0001 *F*=29.57	*P*=0.0001 *F*=31.92

[z]Application dates for peroxide and Kocide 2000 were: 1= 21 Aug; 2= 29 Aug; 3= 5 Sep; 4= 14 Sep; 5= 24 Sep; 6= 2 Oct; 7= 12 Oct, 8= 19 Oct, 9= 26 Oct.
[y]Disease rating and area under the disease progress curve (AUDPC) were based on the values of the scale of 0-100 percent foliage affected.
[x]Area under the disease progress curve calculated according to the formula: $\sum([(x_i+x_{i-1})/2](t_i-t_{i-1}))$ where x_i is the rating at each evaluation time and (t_i-t_{i-1}) is the time between evaluations.
[w]Values are the means of four replicate plots; treatments followed by the same letter within a column are not significantly different at $P \leq 0.05$.

Table 2. Effect of compost and biorational treatments on severity of Botrytis gray mold (% leaf area affected on 22 Oct 2007 and the Area Under the Disease Progress Curve (AUDPC, a measure of whole season disease severity).

Source	*df*	Treatment and rate (application timing[z])	% botrytis gray mold[y] (22 Oct)	AUDPC botrytis gray mold[yx]
Treatment	5		*P*=0.3458 *F*=1.22	*P* =0.1546 *F*=1.90
		Untreated control	16.9 a[w]	884.6 a
		QRD 300 3.75 oz/ft^3	14.7 a	747.6 a
		Trichoderma	12.8 a	648.5 a
		QRD 300 3.75 oz/ft^3 + Trichoderma	15.6 a	838.0 a
		Kocide 2000 2 lb/A (1-9)	16.3 a	919.9 a
		Peroxide 1 qt/20 gal (1-9)	14.4 a	766.2 a
Compost amendment	1		*P*=0.0833 *F*=6.55	*P*=0.0062 *F*=47.57
		Yes	16.4 a	916.9 a
		No	13.9 b	684.6 b
Treatment X Compost amendment	5		*P*=0.5842 *F*=0.77	*P*=0.7207 *F*=0.57

[z]Application dates for Kocide 2000 and peroxide were: 1= 21 Aug; 2= 29 Aug; 3= 5 Sep; 4= 14 Sep; 5= 24 Sep; 6= 2 Oct; 7= 12 Oct, 8= 19 Oct, 9= 26 Oct.
[w, x, y]See footnotes, Table 1

Table 3. Effect of compost soil amendment and biorational treatments on yield of healthy and marketable tomato fruit grown under high tunnels

Source	*df*	Treatment and rate (application timing[z])	% Healthy fruit	% Marketable fruit
Treatment	5		*P*=0.1125 *F*=2.17	*P* =0.0806 *F*=2.46
		Untreated control	68.1 ab[y]	66.1 a
		QRD 300 3.75 oz/ft^3	68.1 ab	66.5 a
		Trichoderma	67.3 ab	65.1 ab
		QRD 300 3.75 oz/ft^3 + Trichoderma	71.4 a	69.5 a
		Kocide 2000 2 lb/A (1-9)	61.9 b	59.4 b
		Peroxide 1 qt/20 gal (1-9)	67.1 ab	64.4 ab
Compost amendment	1		*P*=0.0359 *F*=13.19	*P*=0.0228 *F*=18.67
		Yes	69.0 a	66.9 a
		No	66.0 b	63.4 b
Treatment X Compost amendment	5		*P*=0.9704 *F*=0.17	*P*=0.9463 *F*=0.22

[z]Application dates were: 1= 21 Aug; 2= 29 Aug; 3= 5 Sep; 4= 14 Sep; 5= 24 Sep; 6= 2 Oct; 7= 12 Oct, 8= 19 Oct, 9= 26 Oct.
[y]Values are the means of four replicate plots; treatments followed by the same letter within a column are not significantly different at $P \leq 0.1125$.

CONCLUSIONS

Compost amendment of soils prior to producing tomatoes in high tunnels reduced the severity of leaf mold and minor fruit rots, but increased the severity of Botrytis gray mold. However, in this study disease severity was low for most of the season and only moderate at the end of the season. Nonetheless, compost amendment increased the percentage of healthy fruit and percentage of marketable fruit in this study. Yield effects may be partially the result of increased fertility in compost-amended compared to non-amended plots, but reduction in incidence of leaf mold may be related to compost effects on plant health. The increase in Botrytis gray mold severity in plants grown in compost-amended soil was small but significant. Plants were larger and produced more foliage when growing in soil with higher fertility, and thus likely had higher humidity within the leaf canopy, which would favor Botrytis development, compared to control plants.

All of the biorational treatments reduced leaf mold at the end of the season compared with the untreated control. The differences were relatively small, and it remains to be seen how these treatments will perform under conditions of high disease pressure. However, proper ventilation of the high tunnel, pruning to improve air flow through the canopy and use of biorational products can be effective in an integrated disease management program to reduce the incidence and severity of tomato foliar and fruit diseases.

This project was completed with funding from the Ohio Vegetable and Small Fruit Research and Development Program ($2,500) and gifts to the OSU Vegetable Pathology program, in addition to IPM funding.

The project was demonstrated to about 40 farmers and others during the OSU Organic Food and Farming Education and Research (OFFER) field day on 30 August, 2007.

REDUCING PESTICIDE CONSUMPTION THROUGH TARGETED APPLICATIONS IN ORCHARDS AND VINEYARD

Final Report

Submitted by:
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Food Agricultural and Biological Engineering Dept.
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Current chemical application in orchards and vineyards is not target-oriented. Chemicals are always applied with the same flow rate for the entire orchard regardless of tree intervals, sizes, and foliage densities. This results in excessive chemical waste and potential environmental contamination. Smart spraying systems are needed to improve pesticide application efficiency with minimum human involvement.

The objective of this research was to develop a system that could a) measure the gaps between trees and turn the sprayer on and off depending on the presence of trees (target) aligned with the spray nozzles; and b)measure the tree canopy height, width, volume and foliage density and make adjustments in the spray application rate accordingly.

With the funding provided from IPM program at Ohio State University, we were able to accomplish the first objective (objective a) above. A sprayer was equipped with CAPSTAN nozzles which can be turned on and off depending on presence of targets. We used a fast-response, high resolution SICK LMS200 laser scanner to measure the distances between the scanner and different points on trees.

We are working on accomplishing the second objective above. The data of distances generated by the laser will be reconstructed and converted to the tree height, width, and outside shape profile. A pattern classification algorithm will be developed to establish the relationship between the smoothness of the tree profile and the foliage density. A user-friendly, human-machine communication interface will be constructed using a LabVIEW programming language. The system will be compared and calibrated with manual measurements of different tree canopy characteristics.

Once this project is completed, it will offer fruit and grape growers an opportunity to reduce their pesticide consumption significantly, and it will reduce the pesticide waste that may eventually lead to environmental contamination problems.

SOIL QUALITY WORKSHOP

Managing Pests by Linking Plant Health to Soil Health

Principle Investigator – Alan Sundermeier, Wood County Extension Educator

This hands on workshop instructed 106 farmers, crop consultants, NRCS, SWCD, and Extension staff on the benefits of achieving healthy soils. The locations at Bowling Green and Wooster, Ohio allowed participants to examine soils managed under sustainable farming practices and compare to conventional soils. Instructors: Dr. Rafiq Islam, Alan Sundermeier, Bruce Clevenger, OSU Extension.

Topics included: Fundamentals of soil quality properties, carbon sequestration, soil quality tests ,interpretation, and recommendations.

Hands on exercises: Fixed wavelength field colorimeter, Ohio Soil Health Card for self-assessment of soils, soil quality color chart.

In-field demonstrations: Soil compaction comparison with penetrometer, water infiltration, earthworm inventory, soil aggregate sizing.

Bring your own soil for quality analysis: Participants brought 2 samples of poor and 2 samples of good quality soil from their own fields. A total of 92 soil samples were submitted. Analysis results are below.

A workbook was provided to each participant which included powerpoint handouts, copies of journal articles, factsheets, and Ohio research data. The OSU Extension Sustainable Ag team provided each participant with a copy of the Sustainable Ag Network book - Building Soils for Better Crops, 2nd Edition.

A Field Test to estimate soil quality was included as a hands on exercise. Soil solution was mixed with reactant. Then, participants matched the color of the solution (top part in the tube) with the color chart, and estimated soil quality (excellent, good, fair and poor), active C and available N content.

A survey was conducted with participants. Knowledge was gained in every measured topic of learning. Written responses confirmed knowledge gained was significant with participants.

Participants submitted samples for soil quality testing. An assumed soil quality rating before testing was compared to the measured rating after analysis. This exercise gave participants an understanding of soil quality on their own farm.

25 samples assumed = measured soil quality
28 samples assumed < measured soil quality
39 samples assumed > measured soil quality

SURVEY RESULTS FROM PARTICIPANTS

1 = no understanding / experience
2 = little understanding / experience
3 = moderate understanding / experience
4 = quite a bit of understanding / experience
5 = great deal of understanding / experience

	My Understanding and Involvement						
	After the Workshop			Before Training			Knowledge Gained
	Bowling Green	Wooster	Both	Bowling Green	Wooster	Both	
How would you describe your understanding of the following:							
1. The fundamentals of soil quality	3.94	3.94	3.94	2.97	2.73	2.84	1.10
2. Gypsum & soil amendments	3.65	3.73	3.69	2.36	2.33	2.34	1.34
3. Tillage, compaction, cover crops effects on soil quality	4.32	3.73	4.02	3.36	3.09	3.23	0.78
4. Soil Health Card	3.90	3.66	3.78	2.10	2.03	2.06	1.72
5. Water infiltration, earthworm inventory, penetrometer	4.10	3.97	4.03	3.03	2.73	2.88	1.16
6. Instant soil quality color chart	3.97	3.88	3.92	1.84	1.79	1.81	2.11
7. Interpreting soil quality test results	3.87	3.79	3.83	2.23	2.30	2.27	1.56
8. Recommendations for improving soil quality	4.00	3.90	3.95	2.87	2.71	2.79	1.16

Soil Quality Rating

Good > 1500 ppm Active Organic Matter
Fair 1500 - 1100 ppm Active Organic Matter
Poor <1100 ppm Active Organic Matter

Bowling Green Soil Quality Workshop Participant Soil Samples, August 28, 2007

Soil Code		**Assumed Soil Quality**	**Active OM (ppm)**	**Measured soil quality**
21 A		Good	1125.5	Fair
21 B		Good	1173.5	Fair
33 A		Poor	910.5	Poor
33 B		Poor	943.9	Poor
Na Goyner		Poor	1261.2	Fair
HV GC		Good	1359.3	Fair
Sharpe South-Milsdale		Good	1286.2	Fair
Ramsey-Hoytville		Poor	1518.0	Good
N-25-07 A		Good	1403.1	Fair
N-25-07 B		Good	1365.6	Fair

NHG-07 A		Poor	1119.2	Poor
NHG-07 B		Poor	1142.2	Poor
Millgrove / Deerborn rdg		Good	1131.7	Poor
LTW		Poor	1380.2	Fair
Mermill		Good	1277.9	Fair
Hoytville		Poor	1505.4	Good
Nappanee		Poor	1296.7	Fair
Digby		Good	1309.2	Fair
B 1		Poor	1363.5	Fair
Y 2		Poor	1394.8	Fair
G 3		Good	1574.3	Good
F 4		Good	1309.2	Fair
AdA		Fair	1382.3	Fair
GAR		Good	1591.0	Good
L.M.		Fair	1202.7	Fair
VAL		Poor	1158.9	Fair
BoA		Good	1440.7	Fair
A		Good	1242.4	Fair
B		Good	1317.6	Fair
c		Good	831.1	Poor
1		Good	1574.3	Good
2		Poor	1540.9	Good
Chile-NE Ohio		Good	1480.4	Fair
Elsworth-NE Ohio		Good	1620.3	Good
Wolf		Good	1399.0	Fair
Minier		Poor	1430.3	Fair
Lieske Conv		Poor	1344.7	Fair
A		Poor	920.9	Poor
B		Good	1073.3	Poor
C		Good	1280.0	Fair
d		Good	1004.4	Poor
House		Poor	1367.7	Fair
Sign		Poor	1492.9	Good
Garden		Good	1622.3	Good
School		Good	1449.1	Fair
Mermill		Good	1192.3	Fair
Rimer Les		Poor	950.1	Poor
1		Good	1129.7	Poor
2		Good	1388.5	Fair
3		Poor	1183.9	Fair
4		Poor	1288.3	Fair
Chet		Poor	1282.1	Fair
Lieske NT		Poor	1277.9	Fair
Skinner		Poor	1520.1	Good
RaA		Good	1144.3	Fair

Wooster Soil Quality Workshop Participant Soil Samples, Sept. 27, 2007

Soil Code	Assumed Soil Quality	Active OM (ppm)	Measured soil quality
K - C	Fair	929.2	Poor
K - N	Fair	1006.5	Poor
1	Poor	1106.7	Fair
2	Poor	1144.3	Fair
3	Good	1438.6	Fair
4	Good	1568.1	Good
ME	Good	1150.5	Fair
NA	Poor	1054.5	Poor
1 L.N.E.	Poor	1100.4	Fair
2 L.S.W.	Poor	1125.5	Fair
3 N.3	Fair	1131.7	Fair
4 I	Good	1607.7	Good
1 Creek	Fair	1509.6	Good
2 Far East	Fair	1497.1	Fair
3 West	Fair	1482.5	Fair
3 Middle West	Fair	1438.6	Fair
1 Home Garden	Good	1461.6	Fair
2 Lab Yard	Fair	1421.9	Fair
3 Home Yard	Fair	1503.4	Good
4 Lab Lawn-slop	Poor	1495.0	Fair
R - 1	Fair	1311.3	Fair
1	Good	1518.0	Good
2	Poor	1336.3	Fair
4	Good	1421.9	Fair
1 A	Good	1367.7	Fair
2	Fair	1238.2	Fair
3	Poor	1158.9	Fair
4	Poor	1219.4	Fair
5	Good	1407.3	Fair
FRONT	Good	1553.5	Good
BACK	Poor	1557.6	Good
1 (sol, field)	Good	1135.9	Fair
2 (pepper field)	Good	1150.5	Fair
3 (mustard field)	Fair	998.1	Poor
4 (cucumber fld)	Fair	1071.2	Poor
OC	Good	1244.5	Fair
DC - CC	Good	1244.5	Fair

The OSU Vegetable Team – Adapting to Grower Needs in a Digital World

Lead PI's: Jim Jasinski, IPM Program & Bob Precheur, Dept. of Horticulture and Crop Science
Co PI's: Celeste Welty, Brad Bergefurd, Mark Bennett, Sally Miller, Doug Doohan,
Matt Kleinhenz, Hal Kneen, David Francis, Matt Hofelich & Ron Becker

Introduction

The OSU Extension Vegetable Team has existed formally since the implementation of the team concept in the late 1990's, though it had existed informally for year's prior. The mission of the team is to serve the vegetable industry and growers in Ohio through highly integrated programs of research, instruction, and Extension. Traditionally, the delivery of programs has been through field days, vegetable schools & workshops, presentations at the annual Vegetable Grower's Congress, articles in trade magazines, and newsletters. The VegTeam is looking to expand its sphere of influence into the digital world by upgrading the VegNet website to provide production and management information in several new formats to growers.

IPM surveys conducted by the Great Lakes Vegetable Working Group revealed that 43-86% of growers occasionally or usually search for information on the Internet. To acknowledge this trend we need to take steps to proactively organize the existing and future VegNet content in an effort to retain and recruit grower traffic to the website.

The two objectives in our original proposal have been addressed as follows:

1. Creation of a revamped VegNet website.

Upon grant award notification, a series of three meetings were held April 5th, May 10th, and July 13th, between key members of the Vegetable team and staff at Communications and Technology. The substance of these meetings was to exchange ideas on the visual appearance, format, and content organization of the new VegNet website.

During these meetings, we clearly outlined two new key features of the new VegNet website, a digital library and an audio podcast archive. The digital library will be a collection of thumbnail images of pests and crop injury to support content referenced in the VegNet newsletter. It will also contain video clips generated and submitted by Veg Team members for the purpose of bolstering pest identification and illustrating pest management practices. Podcast content would initially be based on articles submitted to the VegNet newsletter. The podcasts will be posted in either all audio or audio plus images format. Currently 8 podcasts have been created based on newsletter content. Traditional content areas of the new website will include an online version of the VegNet newsletter, faculty web pages, current and archived research reports, presentations, trap reports, insect trap reports, weather links, and highlights of the vegetable production guide.

The maintenance of the new website will be distributed across members of the Veg Team so that updates can be more timely and frequent. A four hour PLONE training session was given to five VegTeam members and staff on December 7th in Columbus. Content is now being actively uploaded into the new website with an anticipated go live launch date of April 1, 2008. A mock up image of the new website is shown below (Figure 1).

Figure 1. Screen shot of new VegNet website.

2. Creation of Rapid Alert System for Growers.

The second objective in our original proposal included the development of a cell phone based rapid alert system using Simple Message System (SMS) protocol to deliver small messages (ca. <150 characters) to text capable phones. These alerts would be issued based on significant pest discoveries throughout the state during the growing season. This objective had to be abandoned when it was discovered that broadcasting messages to several cell phones simultaneously skirted the boundary of cell phone telemarketing, an illegal practice. This objective was not carried out.

Evaluating the effectiveness of the Pherocon® AM yellow sticky traps to predict the potential of developing problems with the western corn rootworm in first year corn following soybeans.

Curtis E. Young (Allen County), Harold Watters (Champaign County), Steve Foster (Darke County), W. Bruce Clevenger (Defiance County), Greg LaBarge (Fulton County), Gary Wilson (Hancock County), Wes Haun (Logan County), Glen Arnold (Putnam County) and Andy Kleinschmidt (Van Wert County)

Market pressure is on corn producers to plant transgenic hybrid corn with inserted genes for insect control (Bt-European Corn Borer (ECB) and Bt-Corn Rootworm (CR)) and/or herbicide resistance (RR-Roundup Ready and Liberty Link). These transgenic corn hybrids have both positive and negative aspects. On the positive side, the transferred genes for insect protection perform well as designed to either manage ECB damage or CR damage or both should they occur together in the same field. The current transgenic hybrids also yield very well (see OSU Corn Hybrid Performance Trial data at: http://oardc.osu.edu/corntrials/). Thus, from these points of view, the Bt transgenic corn hybrids are very attractive.

The negative aspects include the cost of the transgenic hybrid corn seed being higher than that of non-transgenic hybrid corn seed. The use of the transgenic hybrid corn seed does not completely fit into an IPM philosophy since the insect protection that the transferred genes produce is always present whether it is needed or not. Although the first year corn WCR variant has become well established in a number of western and north central Ohio counties, there are many Ohio counties that do not have the variant present in them as of yet and even in the counties where the variant is established, it is not at economically damaging levels in all fields throughout those counties. Thus, standard rotational practices are adequate for rootworm management in these areas. However an argument could be made that if economically significant WCR variant infestation did occur in a field planted to the transgenic corn, then there would be no need for additional insecticides to be inputted into the cost of production because the protection is already present in the corn plant. Another drawback to the extensive usage of the transgenic CR hybrid corn is producers may not be adhering to the label that requires a 20% non-transgenic hybrid corn be planted at the same time and in the same area for insecticide resistance management. This lack of compliance could result in the development of Bt-CR resistant WCR variants that would result in the loss of this tool for future rootworm management when the WCR variant becomes more wide-spread than it is currently.

To use these transgenic Bt-CR hybrids in the most IPM judicious manner, it is imperative to know where the first-year WCR variant is located within Ohio and whether it is present at economically significant levels. The most proficient method to monitor populations of the first-year WCR variant is by the use of Pherocon AM unbaited, yellow, sticky traps. Pherocon AM unbaited, yellow, sticky traps are and were the standard insect monitoring traps used by several states to track migrations and distributions of corn rootworms within and between corn fields (northern and western corn rootworms), and from corn fields to soybean fields (WCR variant also referred to as the rotation-resistant WCR). States that have used these traps include: Illinois, Indiana, Iowa, Kansas, Michigan, Ohio and Wisconsin. An economic threshold and scouting procedures have been developed for the WCR variant using the Pherocon AM sticky traps (see: http://ipm.uiuc.edu/fieldcrops/insects/western_corn_rootworm/index.html). Unfortunately, the utility and effectiveness of these traps has been called into question. It has been noted that CR beetles can and do escape from the traps before they are collected from soybean fields potentially resulting in lower population estimates than what is truly in a field. Others have noted the lack of sufficient glue on the surface of the traps to capture and hold insects. Thus, it has become necessary to evaluate the effectiveness of these traps for continued use as an appropriate monitoring tool for the first-year WCR variant in Ohio.

The research in this project focused on two issues pertaining to the first year western corn rootworm variant in 2008:

1) Is the Pherocon AM unbaited, yellow, sticky trap a reliable trap for monitoring WCRs migrating to soybean fields?
2) How does the Pherocon AM unbaited, yellow, sticky trap compare to other sticky traps on the market?

Materials and Methods:

Four trap types were employed in this study: 1) Pherocon® AM unbaited, yellow, sticky traps (Ph); 2) IPM yellow, corn rootworm traps (IPM); 3) Scentry Multigard corn rootworm yellow sticky traps (MY); and 4) Scentry Multigard corn rootworm green sticky traps (MG). A fifth treatment of the study was altered Pherocon® AM unbaited, yellow, sticky traps (Ph+) with 15-20 ml of Tangle Trap glue added to each trap to increase their consistency of stickiness across the entire trap surface.

Twenty soybean fields in 10 Ohio counties (Allen, Champaign, Darke, Defiance, Fulton, Hancock, Hardin, Logan, Putnam and Van Wert Counties) were monitored with combinations of the five treatments. Seventeen fields were monitored by two trap treatments and 3 fields were monitored by three trap treatments. The treatments were combined in the following manner and locations: Field 1 (Ph, Ph+ & MG, Allen Co.); Field 2 (Ph, Ph+ & MG, Allen Co.); Field 3 (Ph, Ph+ & MY, Hardin Co.); Field 4 (Ph & Ph+, Fulton Co.); Field 5 (Ph & Ph+, Defiance Co.); Field 6 (Ph & IPM, Allen Co.); Field 7 (Ph & IPM, Allen Co.); Field 8 (Ph & IPM, Putnam Co.); Field 9 (Ph & IPM, Hancock Co.); Field 10 (Ph & IPM, Van Wert Co.); Field 11 (Ph & MY, Logan Co.); Field 12 (Ph & MY, Allen Co.); Field 13 (Ph & MY, Allen Co.); Field 14 (Ph & MY, Van Wert Co.); Field 15 (Ph & MY, Putnam Co.); Field 16 (Ph & MG, Champaign Co.); Field 17 (Ph & MG, Darke Co.); Field 18 (Ph & MG, Hancock Co.); Field 19 (Ph & MG, Hancock Co.); and Field 20 (Ph & MG, Putnam Co.). Traps were placed in soybean fields affixed to 5' metal fence posts with twist-ties or cable zip ties at 6-8" above the soybean canopy, and changed weekly from mid-July 2007 through mid-September 2007. Traps were distributed within a soybean field in 2 or 3 lines of 6 traps per line. Distance from field edges, neighboring corn fields, and between individual traps was a minimum of 100'. Area covered by traps was 4.8 acres to 6.4 acres for 2 and 3 trap treatment fields, respectively. Traps were alternated in their positions within the field so as not to favor any one type of trap due their position relative to adjacent corn fields and to evenly distribute the traps within the field. Thus, in a field with 2 trap types, there were 3 of each type in each line (Figure 1). When 3 trap types were distributed into a single field there were 2 of each trap type per line (Figure 2).

Figure 1. Distribution of sticky trap within a field monitored by 2 trap types (Type A and Type B) with a minimum of 100' between traps and from edges of field.

```
A---B---A---B---A---B
|   |   |   |   |   |
B---A---B---A---B---A
```

Figure 2. Distribution of sticky trap within a field monitored by 3 trap types (Type A, Type B and Type C) with a minimum of 100' between traps and from edges of field.

```
A---B---C---A---B---C
|   |   |   |   |   |
B---C---A---B---C---A
|   |   |   |   |   |
C---A---B---C---A---B
```

To evaluate the ability of Pherocon AM traps to capture and hold captured beetles, new

Pherocon AM traps and traps altered with extra glue had live beetles placed on the traps at a rate of one per square on the grid printed on each trap (Figure 3). On one set of traps, the beetles were placed on their feet. On a second set of traps the beetles were placed on their backs. Traps with beetles were then hung on 5' metal fence posts for one week, taken down at the end of the week and remaining beetles counted.

Figure 3. Corn rootworm beetles distributed on Pherocon AM trap for evaluating the effectiveness of the trap to capture and hold captured beetles.

Results

Throughout the study, the Pherocon AM unbaited yellow sticky trap (Ph) captured and held less adult WCR beetles than three of the four alternative traps evaluated. The Pherocon AM unbaited yellow sticky trap with added Tangle Trap glue (Ph+), the Scentry Multigard yellow sticky trap (MY) and the Scentry Multigard green sticky trap (MG) captured 1.25-3.59 times the number of beetles/trap/day (B/T/D), 0.88-14.00 times the number of B/T/D, and 1.79-17.75 times the number of B/T/D than the standard Ph traps that were paired with them in the same soybean fields, respectively. For these three trap types (Ph+, MY and MG), the majority of the data points showed captures that were 10% or more greater than captures by the Ph traps (Tables 1, 3 and 4). The IPM yellow sticky trap (IPM) was less effective to nearly equivalent to the Ph trap showing captures that were 0.28-1.48 times the number of B/T/D of the Ph captures (Table 2). Weekly capture comparisons for all twenty soybean fields monitored are represented in Figures 4-29.

Table 1. Ratio of the number of adult WCR beetles/trap/day captured by the Pherocon AM yellow sticky traps with additional Tangle Trap glue (Ph+) compared to the Pherocon AM yellow sticky traps (Ph) in the same soybean field. Ratio is Ph+ captures/Ph captures. 1 = equal captures, <1 = fewer captures on the alternative trap, and >1 = greater captures on the alternative trap.

	Week in the Field					
Field#	1	2	3	4	5	6
1	2.51	2.94	1.88	2.61	2.43	1.60
2	1.69	3.22	3.48	1.98	1.78	2.29
3	2.69	3.32	2.29	1.37	3.59	1.82
4	2.27	2.79	3.07	2.05	1.31	n/a
5	1.25	1.67	2.00	2.73	1.48	2.82

Table 2. Ratio of the number of adult WCR beetles/trap/day captured by the IPM traps (IPM) compared to the Pherocon AM yellow sticky traps (Ph) in the same soybean field. Ratio is IPM captures/Ph captures. 1 = equal captures, <1 = fewer captures on the alternative trap, and >1 = greater captures on the alternative trap.

	Week in the Field					
Field#	1	2	3	4	5	6
6	1.03	0.83	1.31	0.77	0.28	n/a
7	0.82	0.68	1.06	1.15	1.10	0.56
8	1.12	1.40	0.99	1.34	1.48	1.35
9	0.80	0.80	0.76	1.17	0.52	0.70
10	0.81	0.73	0.56	0.59	0.95	0.83

When adult corn rootworms were systematically placed on the Ph and Ph+ traps to observe their ability to escape, position on the trap, orientation of the beetles, and amount of glue all influence how many beetles remained on the traps after a week's time in the field. Beetles toward the edges of the trap more easily escaped off of the traps than those toward the center of the trap. Beetles that remained on their feet had a better chance of escaping than those on their backs, 64.8% and 75.4% respectively. The Ph+ traps with the extra glue had a better mean percent beetle retention than the Ph, 86.5% and 53.7% respectively.

Table 3. Ratio of the number of adult WCR beetles/trap/day captured by the Scentry Multigard yellow sticky traps (MY) compared to the Pherocon AM yellow sticky traps (Ph) in the same soybean field. Ratio is MY captures/Ph captures. 1 = equal captures, <1 = fewer captures on the alternative trap, and >1 = greater captures on the alternative trap.

	Week in the Field					
Field #	1	2	3	4	5	6
11	2.23	1.96	2.19	2.15	2.88	4.53
12	2.93	2.44	3.38	1.67	0.88	1.68
13	3.41	5.53	2.28	2.18	3.10	4.12
3	3.91	4.01	2.66	2.20	5.43	2.49
14	10.64	2.07	1.73	5.83	0.41	14.00
15	1.23	2.30	3.38	3.26	1.31	4.33

Table 4. Ratio of the number of adult WCR beetles/trap/day captured by the Scentry Multigard green sticky traps (MG) compared to the Pherocon AM yellow sticky traps (Ph) in the same soybean field. Ratio is MG captures/Ph captures. 1 = equal captures, <1 = fewer captures on the alternative trap, and >1 = greater captures on the alternative trap.

	Week in the Field					
Field #	1	2	3	4	5	6
1	3.05	4.99	2.81	4.67	6.32	4.15
2	4.10	5.16	5.44	5.05	8.75	10.34
16	5.07	5.57	2.72	16.00	17.75	n/a
17	2.30	2.57	2.27	2.16	2.60	3.00
18	3.39	1.75	2.49	n/a	3.91	n/a
19	3.01	2.12	2.93	n/a	4.53	n/a
20	4.62	4.93	6.61	4.49	4.34	4.29

Trap Type Observations and Pros and Cons

Ph - Pros

1) An economic threshold has been determined for this trap type.
2) Trap has been used by numerous states in monitoring CRW beetle populations.
3) Trap does not capture large numbers of beetles making counting relatively quick and easy.

Figure 4. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Pherocon AM unbaited yellow sticky traps altered with additional Tangle Trap glue in SB Field 1, Allen County, OH, 2007.

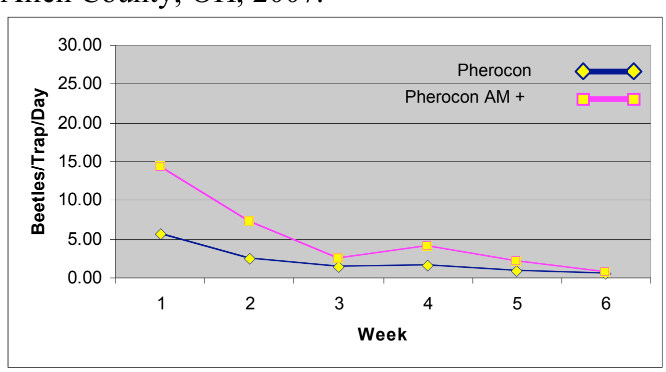
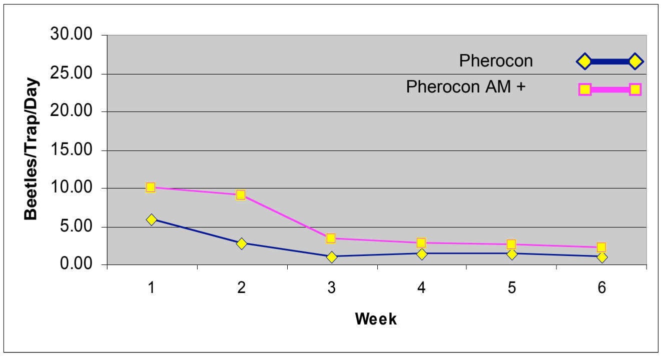


Figure 5. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Pherocon AM unbaited yellow sticky traps altered with additional Tangle Trap glue in SB Field 2, Allen County, OH, 2007.



Ph - Cons

1) Inconsistency in the quantity and distribution of the glue on the traps. Quantity varies to the extent that some have very little glue on the surface allowing most insects that encounter the trap to escape their entanglement. This results in poor performance of the traps for the purpose intended.

2) May not be the most sensitive trap in areas where variant WCR populations are low and newly established.

Figure 6. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Pherocon AM unbaited yellow sticky traps altered with additional Tangle Trap glue in SB Field 3, Hardin County, OH, 2007.

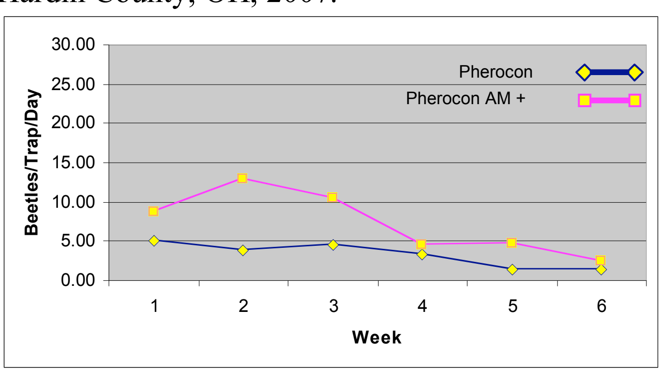


Figure 7. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Pherocon AM unbaited yellow sticky traps altered with additional Tangle Trap glue in SB Field 4, Fulton County, OH, 2007.

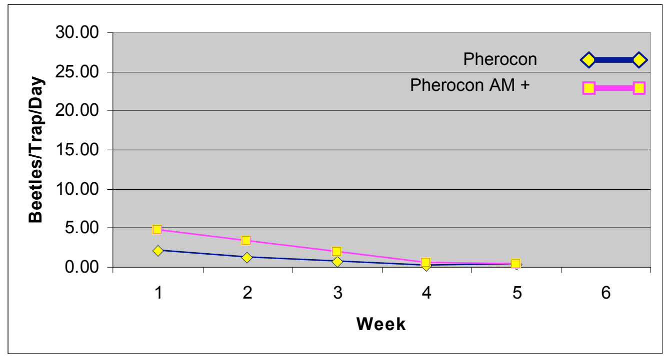
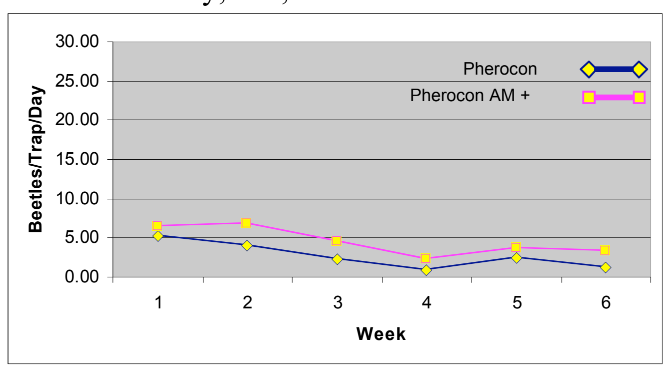


Figure 8. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Pherocon AM unbaited yellow sticky traps altered with additional Tangle Trap glue in SB Field 5, Defiance County, OH, 2007.



Ph+ - Pros

1) The addition of extra glue to the Pherocon AM traps improved their performance 2 to 3 times better than the standard unaltered Pherocon AM traps.

2) Assures complete coverage of grid on the trap.

3) Does not change the attractiveness of the trap.

Ph+ - Cons

1) Heavier glue can make counting more challenging by totally engulfing insects in glue, a minor inconvenience.
2) Traps are more costly (materials, time and labor to augment the glue).
3) Traps with extra glue may over estimate the beetle population compared to the standard Ph trap type.

IPM - Pros

1) Similar to Ph trap is appearance and performance in the field.
2) Glue evenly distributed across surface of the trap.

IPM- Cons

1) Quantity of glue same as or less than that present on Ph traps. In field comparisons, these traps captured fewer beetles than the Ph traps through the majority of the field experiment.
2) No economic threshold has been determined for this trap type.

Figure 9. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six IPM (Generic) yellow sticky traps in SB Field 6, Allen County, OH, 2007.

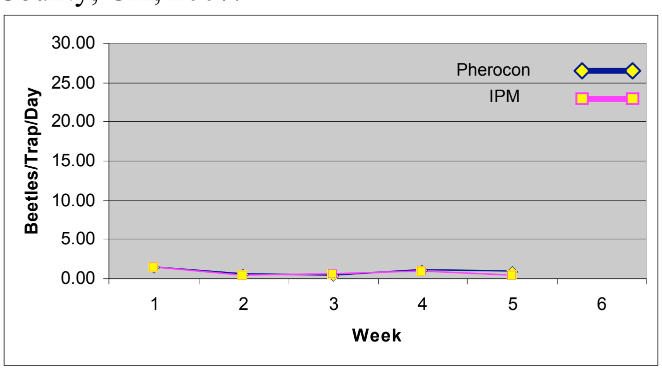


Figure 10. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six IPM (Generic) yellow sticky traps in SB Field 7, Allen County, OH, 2007.

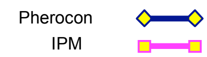


Figure 11. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six IPM (Generic) yellow sticky traps in SB Field 8, Putnam County, OH, 2007.

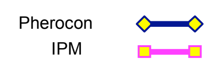


Figure 12. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six IPM (Generic) yellow sticky traps in SB Field 9, Hancock County, OH, 2007.

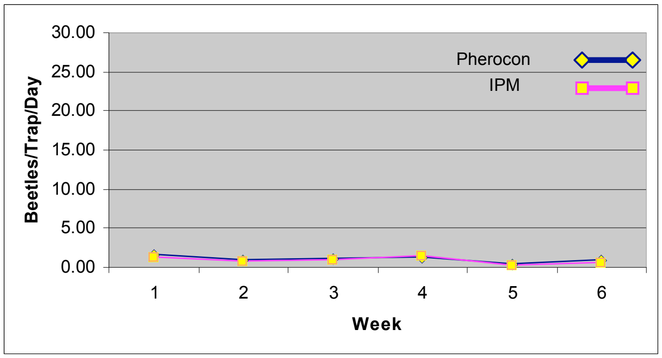
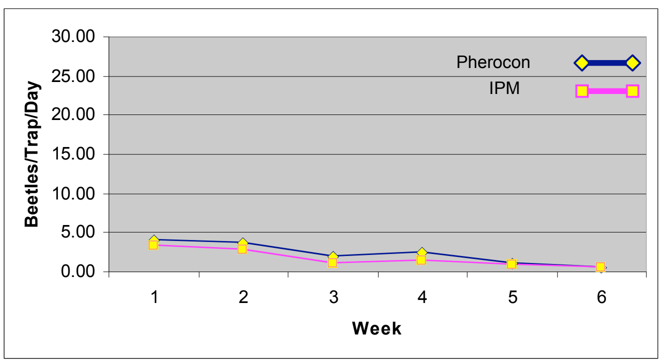


Figure 13. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six IPM (Generic) yellow sticky traps in SB Field 10, Van Wert County, OH, 2007.



MY - Pros

1) Adequate glue.
2) Glue dispersed across most of trap grid.
3) Color of trap is very attractive to CRW adult beetles.
4) Trap captures large numbers of beetles.

MY -Cons

1) Exposed glue on trap does not hold up under field conditions in open soybean fields.

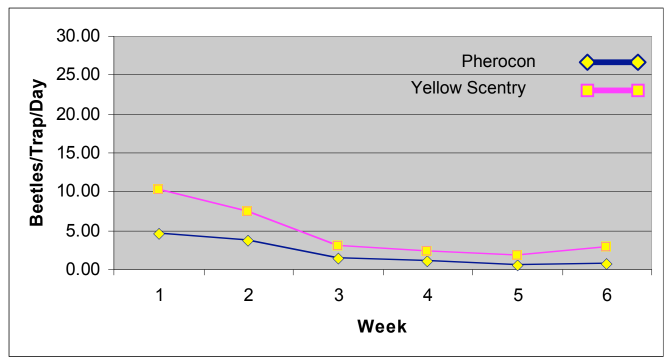
a) Glue appears to melt and run off the bottom edge of the trap taking most of the captured beetles with the glue. Numerous beetles could be observed on the ground or foliage of soybeans under the trap.

2) Glue not always dispersed evenly over the surface of the trap.
3) Received two different styles of this trap.

a) Style 1 was shipped in the first order placed in 2008. These traps came as a pair of traps that shared a common perforated edge and were folded onto one another glued to glued surface.

b) Style 2 was shipped in a second, smaller order late in 2008. These traps came as a single trap folded onto itself. Glue was heaviest on these traps toward the edges of the grid and lightest toward the center fold of the trap.

Figure 14. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard yellow sticky traps in SB Field 11, Logan County, OH, 2007.



c) The glue on the two styles appeared to be of different formulas, glue on the paired traps melted more readily than that on the single trap.

4) Trap captures large numbers of beetles, takes long periods of time to count.
5) No economic threshold has been determined for this trap type.

Figure 15. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard yellow sticky traps in SB Field 12, Allen County, OH, 2007.

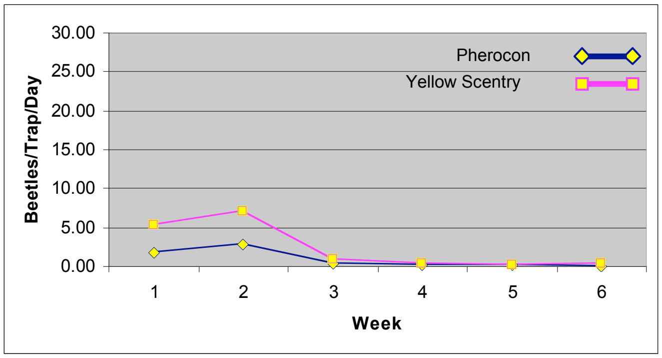


Figure 16. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard yellow sticky traps in SB Field 11, Allen County, OH, 2007.

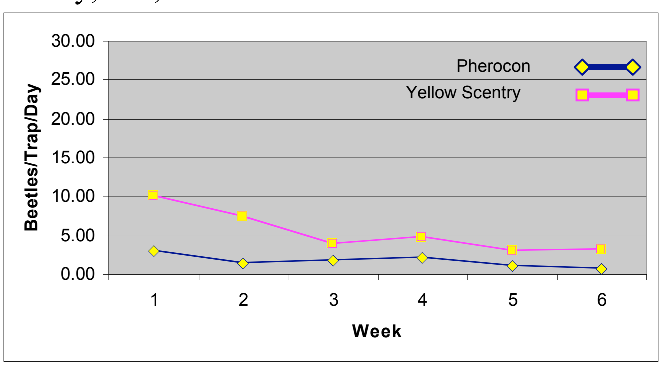


Figure 17. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard yellow sticky traps in SB Field 3, Hardin County, OH, 2007.

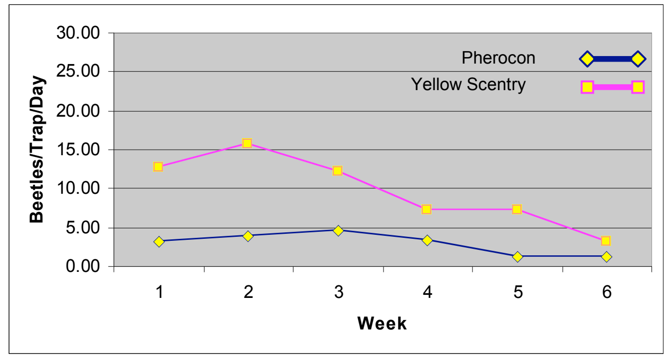


Figure 18. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard yellow sticky traps in SB Field 14, Van Wert County, OH, 2007.

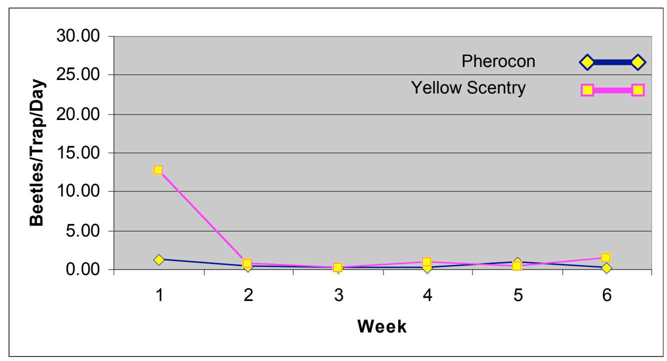
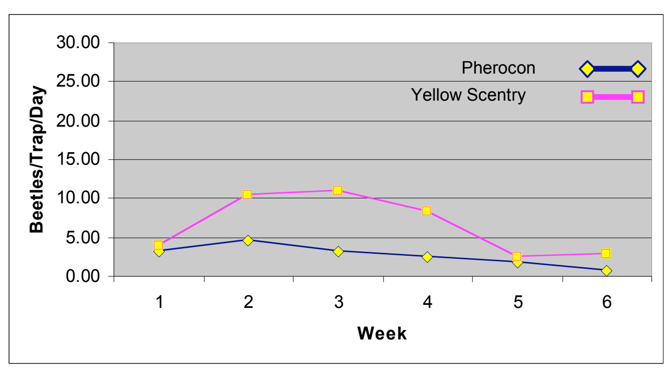


Figure 19. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard yellow sticky traps in SB Field 15, Putnam County, OH, 2007.



MG - Pros

1) Adequate glue
2) Glue dispersed across most of trap grid
3) Trap is very attractive to CRW adult beetles
4) Color of trap is very attractive to CRW adult beetles
5) Trap captures large numbers of beetles.

MG- Cons

1) Green paint can peal off of the cardboard backing. Traps left for to long a period in storage before counting of captured beetles may be difficult to count.
2) Glue not always dispersed evenly over the surface of the trap.
3) Trap captures large numbers of beetles, takes long periods of time to count.
4) No economic threshold has been determined for this trap type.

Figure 20. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard green sticky traps in SB Field 1, Allen County, OH, 2007.

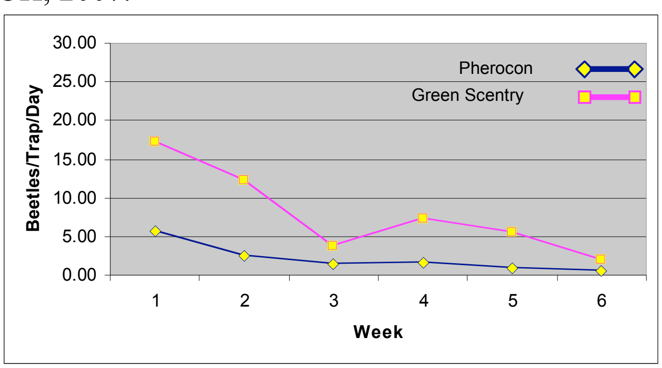


Figure 21. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard green sticky traps in SB Field 2, Allen County, OH, 2007.

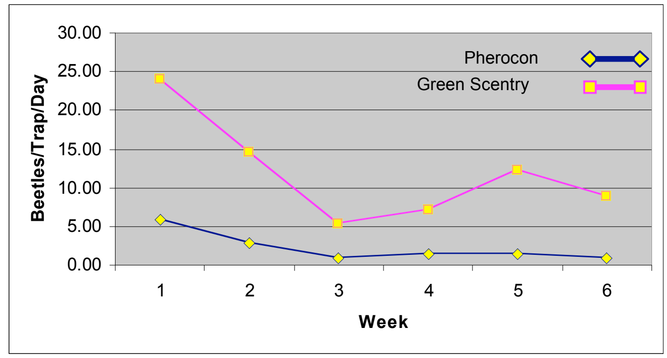


Figure 22. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard green sticky traps in SB Field 16, Champaign County, OH, 2007.

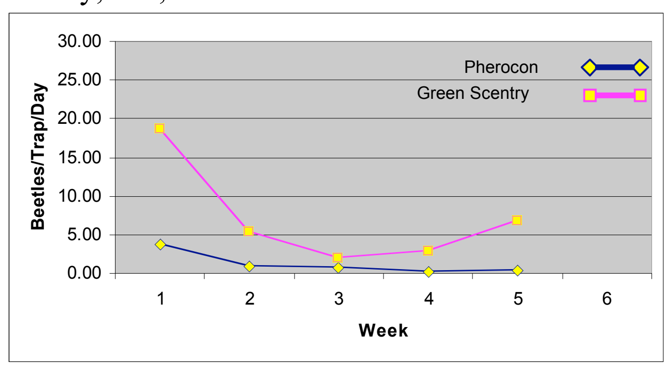


Figure 23. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard green sticky traps in SB Field 17, Darke County, OH, 2007.

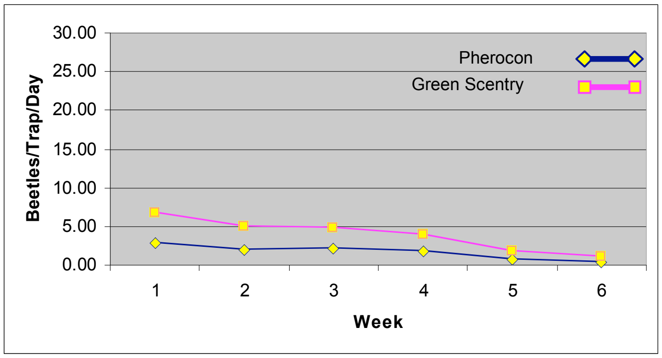


Figure 24. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard green sticky traps in SB Field 18, Hancock County, OH, 2007.

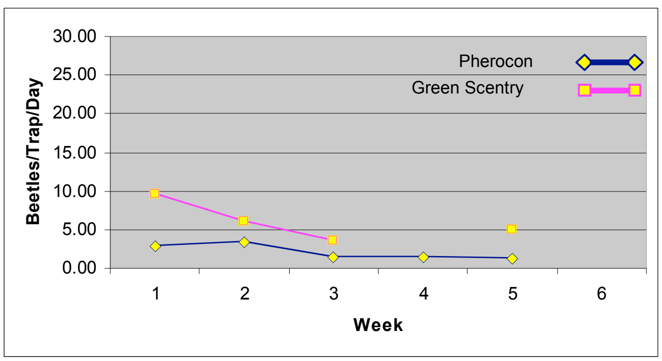


Figure 25. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard green sticky traps in SB Field 19, Hancock County, OH, 2007.

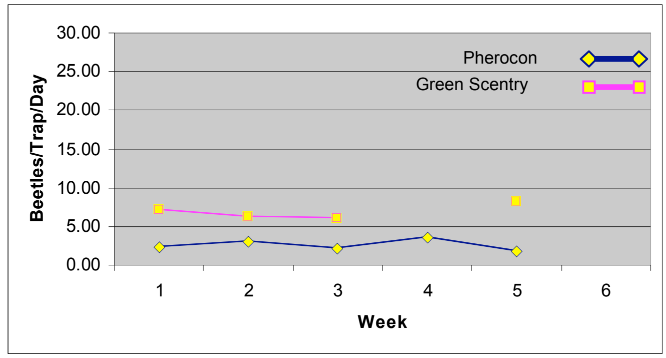
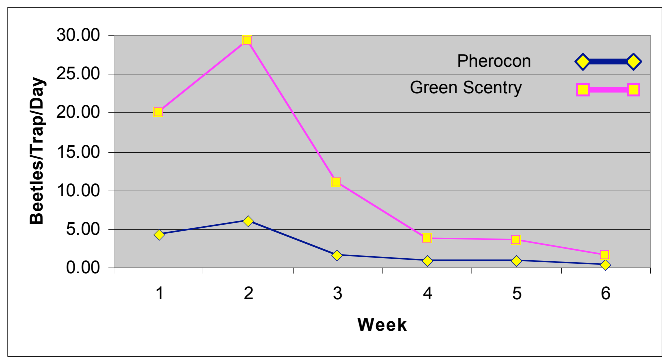


Figure 26. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps and six Scentry Multigard green sticky traps in SB Field 20, Putnam County, OH, 2007.



All traps can be influenced by:

1) Their proximity to corn fields:

a) The type of corn (transgenic or non-transgenic) produced in the field.

b) Whether the corn is first year corn or continuous corn.

2) Direction to nearest corn field:

a) Flight of rootworm beetles may be influenced by line of sight to traps

3) Direction of prevailing winds:

a) Prevailing winds may push beetles in direction of the wind

b) Winds may influence the distribution of rootworm beetles into soybean fields.

4) Presence of weeds in soybean fields shedding pollen:

a) Corn rootworm adults are pollen feeders and can become abundant on and around heavy pollen producing plants such as ragweed and lambsquarter.

5) Insect management actions taken in corn or soybeans:

a) Corn treated for silk clipping by corn rootworm beetles.

b) Soybeans treated for defoliators or soybean aphids.

6) Weather:

a) Heavy rains reduce flights of rootworm beetles.

b) Temperature:

1. Low temperatures may reduce activity of rootworm beetles.

2. High temperatures can result in glue becoming too thin and cause it to run off the bottom of the traps.

7) Timing of trap placement in the field:

a) Peak flights to soybean fields could be missed if weather conditions accelerate beetle development.

Figure 27. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps, six Pherocon AM unbaited yellow sticky traps altered with additional Tangle Trap glue, and six Scentry Multigard green sticky traps in soybean field 1, Allen County, OH, 2007.

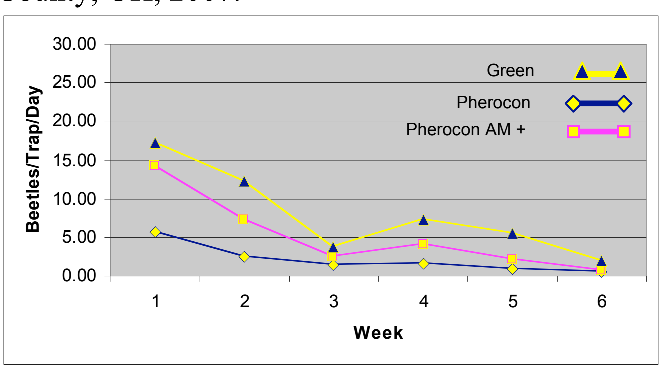


Figure 28. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps, six Pherocon AM unbaited yellow sticky traps altered with additional Tangle Trap glue, and six Scentry Multigard green sticky traps in soybean field 2, Allen County, OH, 2007.

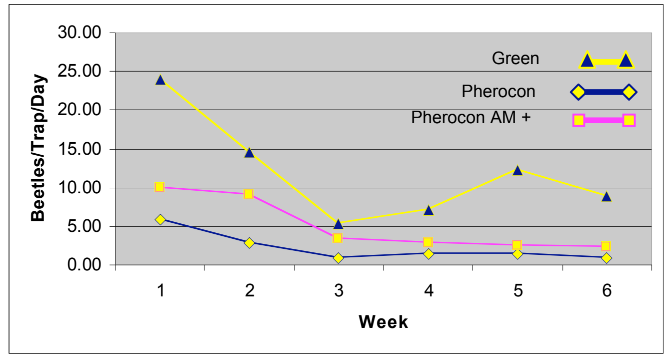
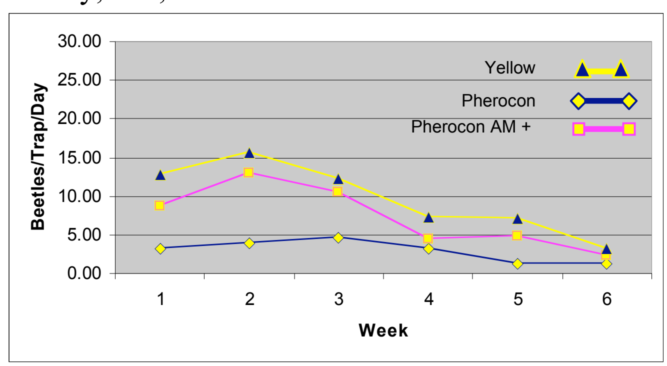


Figure 29. Mean adult *D. v. virgifera* (WCR) captures per trap per day by sampling week as measured with six Pherocon AM unbaited yellow sticky traps, six Pherocon AM unbaited yellow sticky traps altered with additional Tangle Trap glue, and six Scentry Multigard yellow sticky traps in soybean field 3, Hardin County, OH, 2007.



Conclusions and Recommendations

1) None of the traps was perfect. All of the traps had flaws of one sort or another. However, the use of traps to monitor insect populations still remains one of the most cost effective means to measure migration and distribution, especially for lengthy surveys that collect data over weeks to months.

2) Pherocon AM unbaited, yellow sticky traps still need to be the standard trap used to measure economic threshold in soybean fields

that will be followed by first year corn in the following planting season. Data collected using these traps should be used to help determine the management practices that will be needed to manage the CRW populations that may be present.

3) Carefully check traps for adequate glue coverage before placing them into soybean fields for monitoring purposes.

4) Do not use traps that are short on glue.

5) Traps short on glue could be improved by adding Tangle Trap glue to the traps (approximately 10 ml or less for a pair).

6) Redistribute glue on traps by unfolding two traps, press the two together face to face (glue side to glue side) and slide traps over one another while applying pressure. This action will move glue from heavy areas to areas with less glue. Peal traps apart and distribute into field.

7) In surveys to determine distribution of the first year corn rootworm variant into areas of Ohio where its distribution is unknown or may be at very low levels, the Scentry Multigard Green trap may be a very useful tool because of its extreme attractiveness to CRW and its apparent ability to stand up under field conditions.

8) Scentry Multigard yellow traps will not be of any use in soybean fields, but has been shown in past corn field surveys to be a very functional tool for monitoring CRW inside of a corn field where it is not directly exposed to sun and other weather conditions.

9) The IPM trap is a marginal trap that could be made better with the addition of extra glue.

How Monies were spent from the IPM Mini-grant:

Supplies:

Traps -	$3,200.00
Posts -	$ 173.62
Glue -	$ 21.25
Zip-Loc Bags -	$ 13.96
Postage:	$ 215.55
Mileage:	$ 753.69
Total:	$4,377.29