1994 Ohio IPM Block Grant Reports

1994 North Central Ohio Tree Fruit IPM Program

Principal Investigator:

Ted W. Gastier, Extension Agent, Huron County

Abstract:

Sixteen apple producers, representing Erie, Huron, Lorain, Ottawa, and Sandusky Counties, enrolled 24 blocks of commercial production. Insect pests monitored weekly by traps included spotted tentiform leafminer (STLM), codling moth (CM), apple maggot (AM), and San Jose scale (SJS). Other fruit pests monitored by scouting included various aphids, leafhoppers, and European red mites. In addition, the following beneficials were identified at various locations and times during the growing season: syrphid fly, lacewing, *Stethorus punctum*, Cecidomyiid larvae, phytoseiid mite ('fallacis'), and ladybird beetle. Their presence was noted to allow for their protection (whenever possible), thus providing for natural control of tree fruit pests.

The following project objectives served as grant reporting guidelines:
1. To test the Penn State guidelines for sampling ERM and *Stethorus punctum* populations for application in Ohio.
2. To calculate the predator/prey ratios on a weekly basis and report to growers.
3. To transfer predator mites from blocks where they are abundant to other blocks without adequate populations.
4. To evaluate the benefit of biological control by comparing miticide use records and leaf quality.

The Penn State guidelines suggested initiating ERM monitoring at 65-75% infestation which was considered to be too late for the comfort of Ohio producers. We started on June 1st with the knowledge that *Stethorus punctum* would not be evident until later in June. Penn State used a timed method of observation which was modified to correspond with our 25-leaf sample. The predator-to-mite ratio of 2.5, as suggested in the Penn State Tree Fruit Production Guide, was used.

Our results indicated that the Penn State guidelines were reasonable during the period of mid-July through August when we would expect the greatest ERM pressures. However, our Ohio system based on Joe Kovach's work at Cornell was more user friendly. The following charts indicate the *Stethorus punctum* populations observed and the populations suggested as needed for ERM control based on Penn State guidelines. The observed populations of predatory mites and lacewings, as well as the ERM infested leaves per 25-leaf sample, are reported on the charts for the East and West districts of our production area.

We experienced difficulty in making timely identifications of predatory mites. As this information became available, we were already detecting levels of *Stethorus punctum* sufficient for consideration of biological ERM control. Therefore, no transfers of predatory mite were attempted. One transfer of *Stethorus punctum* was done successfully in a non-program orchard.

Grant funds made possible the purchase of two additional trap sets for each of twenty-two blocks of apples. These additional traps were used to monitor codling moth and provided greater assurance that we were observing actual orchard conditions. This was important, since we were testing the validity of a level of three moths per trap per week as an action threshold.

Examination of the range of trap counts during a given week in each of the blocks supported the theory that one trap per block is not adequate. In forty-one situations interpretation of one trap per block would have indicated that the action threshold had been reached. Control measures would have been called for, even though an average of three traps indicated otherwise. If the twenty-two blocks included in this program represented 250 acres, then approximately $5,000 was saved in economic terms. Damage to beneficials was prevented forty-one times. In addition, the three trap average protected fruit in thirty-five situations where one trap would not have indicated that an action threshold had been reached.

The confidence gained by growers through the use of three traps enabled us to recommend skipping a scheduled codling moth spray in mid-July. As an added bonus to cost savings, this recommendation enabled predators of European red mites to reach population levels sufficient for control. In some blocks control continued up to harvest without the application of miticides. Previously, our control measures for codling moth had a deleterious effect on European red mite predators. This concept will be studied further in 1994 with the growers indicating strong support for encouragement of lacewings and *Stethorus punctum*.

It had been our intention to study mating disruption in at least one commercial block of apples. However, we were unable to find a participant. This study would have required a commitment to leave an unsprayed area of three to five acres. Growers were unwilling to sacrifice potential profits because of damage from other pests left uncontrolled. Further studies using insect growth regulators for spotted tentiform leafminer control, plus allowing beneficials to control European red mite might provide a future opportunity for a mating disruption trial.

Twenty-two issues of a newsletter covering timely fruit notes based on scouting and trapping reports were mailed to cooperating growers, District and State Specialists, and all Agricultural Agents in the NE District. A majority of growers used the IPM generated recommendations throughout their orchards, whether the blocks were enrolled or not. Generally, growers made fewer applications of pesticides than would be expected when using a calendar spray schedule. An average of two cover sprays and one miticide application were eliminated. This cost savings of materials and operator/machinery time covered or exceeded the grower program cost of $27.50 per acre. According to harvest surveys and grower evaluations, excellent quality fruit which was free of pest damage was harvested. Growers were satisfied with leaf appearance as season's end.

Extension Program Implementation:

Participants desire a continuation of some type of IPM program, with some growers indicating a desire to add more blocks to the program. Additional growers have been contacted and are interested in enrolling in 1995. Our goal of having growers commit to more time involvement with orchard scouting has not been met, due to their time restraints. Therefore, hired technicians are necessary for the continuation of this type of program. Expansion into other production areas in Ohio will provide additional data for testing tentative thresholds for use as IPM guidelines for the state. Winter meetings are planned to share our experiences with other agents and producers to increase the use of IPM.

1994 IPM Trap and Survey Report

DATE	DD's	STLM	CM	AM	SJS	ERM	SP	PA/SP	PM	OM	LW	WM	LB	BT
EAST						/25 lv		Need						
May 3	156	455												
May 10	175	305									0.13	0.38		
May 10	218	298	0.27											
May 24	290	463	2.15		22									
May 31	400	235	2.73		4					0.50				
June 7	503	150	3.79		0							0.38		
June 14	623	304	2.79		0	0.1				3.13	0.13	0.50		
June 21	850	825	3.98		0	0.8	0.13	0.12		0.94	1.13	0.75	0.75	2.1
June 28	982	920	1.56		0	0.4	0.19	0.06		0.13	4.38	1.31	0.31	0.3
July 5	1146	1186	1.15		0	3.3	0.13	1.03		1.38	24.44	2.44	0.25	0.6
July 12	1131	1276	1.29	0.1	4	2.7	0.13	0.85		1.68	20.00	0.25		0.2
July 19	1506	1060	2.07	14.6	150	5.1	1.13	1.58		14.88	31.50	2.00		0.1
July 26	1676	899	3.86	19.0	111	6.9	3.50	2.15		10.19	33.19		0.25	
Aug 2	1839	1049	3.36	21.7	148	5.8	14.56	2.70	0.13		27.69			
Aug 9	1968	1222	4.10	12.1	85	4.6	15.31	2.16	0.54		20.19			
Aug 16	2090	1170	5.09	16.6	88	4.5	13.94	2.09	1.13	0.56	17.00		0.19	
Aug 23	2228	1277	5.93	10.1	69	2.2	15.06	1.02	1.88		10.88		0.19	0.8
Aug 30	2382	1273	4.57	7.3	83	0.9	8.50	0.40	0.75		8.13			0.2
Sep 6	2457	1069	1.48	2.4	0									
Sep 13	2559													

DATE	DD's	STLM	CM	AM	SJS	ERM	SP	PA/SP	PM	OM	LW	WM	LB	BT
WEST						/20 lv		Need						
May 3	156	126												
May 10	175	117												
May 10	218	96	0.10											
May 24	290	82	0.33		60									
May 31	400	27	1.14		1						0.29			
June 7	503	12	1.38		1	0.4					0.14			
June 14	623	191	1.52		0	3.4					0.14			
June 21	850	767	2.48		0	2.4		0.38		1.71	1.57			0.9
June 28	982	792	1.10		0	4.0	0.57	0.63			1.71			1.3
July 5	1146	822	0.57		0	8.4	1.71	2.63		0.86	6.14			0.6
July 12	1331	918	0.43		0	8.8	5.71	2.74	0.86		4.00			3.9
July 19	1506	190	0.61		27	11.5	7.71	3.59		1.14	3.29		0.14	2.1
July 26	1676	442	0.48	11.1	15	14.7	11.00	4.60	0.86		1.71			0.3

Aug 2	**1839**	**1345**	**1.38**	**8.9**	**27**	**13.6**	**10.71**	**6.36**	**0.86**		**0.57**			**0.4**
Aug 9	**1968**	**1530**	**1.14**	**7.2**	**29**	**11.3**	**6.71**	**5.31**	**0.86**		**1.14**			**0.9**
Aug 16	**2090**	**1488**	**2.43**	**4.1**	**26**	**9.4**	**7.29**	**4.42**	**0.86**	**0.71**	**1.43**			**0.9**
Aug 23	**2228**	**1436**	**2.33**	**3.6**	**15**	**2.3**	**7.57**	**1.07**	**1.71**		**0.43**			**2.1**
Aug 30	**2382**	**1356**	**2.10**	**1.0**	**19**	**4.3**	**3.14**	**2.01**	**3.14**		**0.43**			**0.3**
Sep 6	**2457**	**785**	**1.00**	**0.4**	**3**	**4.4**	**0.57**	**2.08**	**3.00**					**1.3**
Sep 13	**2559**	**689**	**0.71**	**0.4**	**3**	**4.0**	**0.43**	**1.88**	**3.86**				**0.14**	**0.6**

KEY: DD50=degree days, base 50 degrees F; STLM=spotted tentiform leafminer; CM=codling moth (3 trap average); AM=apple maggot (3 trap total); SJS=San Jose scale; ERM=European red mite (number of infested leaves per 25 leaf sample); SP=*Stethorus punctum*; SP Need (Penn State guideline number based on ERM populations); PM=predatory mites; OM=orange maggot (cecidomyiid fly); LW=lacewing; WM=white maggot (syrphid fly); LB=lady beetle Beneficial numbers are populations observed on a sample size of 25 leaves

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For further information contact Ted W. Gastier , Extension Agent, Ohio State University Extension, Huron County or the Ohio IPM Office.

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Alfalfa/Grass Mixtures vs. Alfalfa: Profitable Alternatives to Deter the Potato Leafhopper

Principal Investigators:

Roger Bender, Shelby Co.
Mark Sulc, Horticulture & Crop Science
Jim Jasinski, SWD, IPM Specialist
Harold Willson, Entomology

Abstract:

A field research project, to compare the effect of alfalfa/grass mixtures with pure alfalfa stands, on potato leafhopper populations, was planted August 16, 1993. Comparisons included a standard alfalfa variety (Provico) with 1 lb. of orchardgrass and with 2 lbs. of orchardgrass, standard alfalfa alone (control), and a reputed potato leafhopper resistant alfalfa variety (ABI 9045). These 4 plantings were randomly replicated 4 times for a total of 16 plots. The soil was tilled twice to level the seedbed, kill existing weeds and volunteer wheat, and to incorporate fertilizer. An excellent stand was established, despite very dry conditions 2 weeks after the planting date. The alfalfa stand survived the winter and comparison of the plots with PLH populations, yield and palatability records gathered for 2nd and 3rd cuttings. The research project is planned for a 3- to 5-year period, depending on the vitality of the stand. The orchardgrass seedings did not survive, so timothy was planted in September following the original grass plot layout. Thus, comparative mixtures could not be analyzed in 1994. The plots are on land involved in the Lake Loramie Water Quality Incentive Project (WQIP) and could result in reduced insecticide use. One acre replicated plots to compare infestations of PLH have been planted. Large plots are critical to accurately assess the impact of control strategies on PLH populations because of their mobility.

To evaluate potential PLH tolerance or resistance in variety ABI 9045, half of the plots of each variety were treated with an insecticide during the 2nd and 3rd cuttings and half remained untreated on the assumption that any differences in PLH impact between treated and untreated plots would be less in the tolerant variety than a susceptible variety. Following treatments, relative PLH abundance was monitored, pre-harvest stand height was measured, yields were determined, and harvest samples were evaluated for differences in forage quality.

Significant reductions in leafhopper activity and associated impact on stand height were observed between treated and untreated plots of both varieties (see Table 1). However, no significant differences were observed between varieties. If variety ABI 9045 was tolerant or resistant to leafhopper, the untreated plots of ABI 9045 should have demonstrated relatively less reduction in stand height compared to that of the Provico variety which is presumed to be susceptible to leafhopper impact. No significant differences were observed among yields and differences in forage quality were minimal (see Tables 2 & 3).

For further information contact Roger Bender , Extension Agent, Ohio State University Extension, Shelby County or the Ohio IPM Office.

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Alternatives to Insecticides for Control of Garden Pests

Principal Investigators:

Richard C. Funt, Professor, Horticulture & Crop Science
Mike McCullough, Graduate Student, Horticulture & Crop Science
Celeste Welty, Assistant Professor, Entomology
Mark Bennett, Associate Professor, Horticulture & Crop Science

Abstract:

The traditional recommendation for controlling pests that injure plants in home gardens is to protect plants by treating with insecticide. Gardeners and extension agents are often frustrated by the lack of research-based information about efficacy of non-chemical alternatives for garden pest management. The objective of this project was to evaluate non-chemical strategies of interest to gardeners, specifically the effect of repellents and row covers on pests that attack snap beans. In this first year of the two-year project, evaluations were done in plots on campus at the Lane Avenue Horticulture Farm; the plan to conduct experiments in private gardens was postponed until the second year.

This project focused on evaluating efficacy of garlic and hot pepper repellents on pod and leaf feeding by the bean leaf beetle, Mexican bean beetle, and potato leafhopper on snap beans. Treatments included low, moderate, and high rates of garlic and hot pepper, each applied on a high intensity schedule (sprayed five times) and a low intensity schedule (sprayed weekly). These repellents were compared with conventional insecticide, with lightweight row covers that excluded pests, and with untreated controls. There were four replicates per treatment. Beans were planted on 8 June and harvested on 3 August. Plots were scouted weekly for pests. At harvest, six plants per plot were evaluated for quality and yield. Harvest results are summarized in Table 1. Analysis of harvest and scouting data will be completed by January 1995.

Extension Program Implementation:

Results of the 1994 trial will be shared with extension agents and Master Gardeners via the Ohio Master Gardener Newsletter. After the second season in 1995, conclusions will be incorporated into a new Extension FactSheet on management of snap bean pests.

Harvest Results -- Mean of Four REPS					
	Number of beans per plant		Bean Yield (grams)		Plant Dry Weight
Treatment	Marketable	Unmarketable	Marketable	Unmarketable	(Grams)
Plain Water	7	3	33	13	152

Insecticidal Dust	**19**	**3**	**98**	**13**	**158**
Rowcover	**6**	**1**	**33**	**3**	**63**
Control	**11**	**7**	**57**	**30**	**145**
Garlic 1/3x	**9**	**5**	**41**	**26**	**135**
Garlic x weekly	**12**	**5**	**59**	**22**	**140**
Garlic 3x weekly	**12**	**6**	**58**	**32**	**148**
Garlic 1/3x twice	**11**	**6**	**58**	**28**	**146**
Garlic x twice	**11**	**4**	**57**	**19**	**138**
Garlic 3x twice	**10**	**5**	**52**	**25**	**131**
Pepper 1/3x	**9**	**5**	**44**	**24**	**127**
Pepper x weekly	**10**	**5**	**49**	**22**	**118**
Pepper 3x	**10**	**4**	**53**	**18**	**134**
Pepper 1/3x	**11**	**5**	**56**	**22**	**129**
Pepper x twice	**11**	**5**	**56**	**22**	**139**
Pepper 3x twice	**9**	**5**	**44**	**25**	**132**

	% of Foliage	**% of foliage with beetle feeding**			
	with Leafhopper				
Treatment	**damage**	**0%**	**1-10%**	**10-50%**	**>50%**
Plain Water	**23**	**13**	**43**	**30**	**14**
Insecticidal Dust	**23**	**30**	**64**	**5**	**1**
Rowcover	**1**	**52**	**42**	**5**	**1**
Control	**30**	**13**	**51**	**31**	**5**
Garlic 1/3x	**34**	**13**	**49**	**28**	**10**
Garlic x weekly	**29**	**19**	**49**	**22**	**11**
Garlic 3x weekly	**24**	**14**	**51**	**25**	**11**
Garlic 1/3x twice	**31**	**11**	**62**	**22**	**5**
Garlic x twice	**29**	**13**	**60**	**22**	**5**
Garlic 3 twice	**31**	**12**	**53**	**27**	**8**
Pepper 1/3x	**32**	**11**	**57**	**26**	**6**
Pepper x weekly	**28**	**12**	**57**	**25**	**6**
Pepper 3x	**27**	**15**	**60**	**20**	**6**
Pepper 1/3x	**31**	**12**	**58**	**24**	**7**
Pepper x twice	**23**	**15**	**60**	**19**	**7**
Pepper 3x twice	**28**	**13**	**54**	**24**	**10**

For further information contact Richard C. Funt , Professor, Dept. of Horticulture & Crop Science, The Ohio State University or the Ohio IPM Office.

Crop Diagnostic and IPM Training

Principal Investigators:

Larry Lotz, Fayette Co. Extension Agriculture Agent
Troy Putnam, Highland Co. Extension Agriculture Agent

Abstract:

This project was designed to:

1.) Provide farmers and agribusiness personnel hands on experience in crop pest detection and management, IPM principles, & problems related to plant health via a series of field days held throughout the growing season highlighted by three diagnostic field days scheduled during the month of June.

2.) Expand and improve comparisons between the existing high, typical, and low input plots including evaluation between cultural/mechanical pest control measures versus chemical control.

3.) Teach farmers and agribusiness personnel the principles and use of prescription farming technology including the refinement and interpretive techniques concerning the use of infra-red photography to detect crop growth problems and to relate this technology to IPM principles.

4.) Provide accurate, relevant data to farm managers to aid in arriving at those decisions that yield the most optimum combination of economics, increase in yield, and environmental quality.

5.) Teach farm decision makers those principles of crop pest management that will effectively control pests with the least amount of chemical application as possible, therefore protecting the quality of the environment.

Extension Program Implementation:

Three major diagnostic field days held during the month of June included the following:

1.) June 21 - Pioneer Seed Diagnostic Field Day.

Eighty-five Pioneer dealers and guests attended sessions on corn and soybean growth and development, crop insects, disease, scouting, and herbicide performance. Following is an evaluation summary from those attending done by Pioneer.

** PIONEER CROP DIAGNOSTIC TRAINING **
Washington Court House, Ohio -- June 21, 1994

A. TOPICS: PLEASE RATE THE VALUE OF THE PROGRAM CONTENT.....

Techniques	POOR	AVERAGE	GOOD	EXCELLENT
Corn Development		4	20	32
Soybean Development		2	23	31
Herbicide Performance/Injury	1	8	17	30
Current Crop Insects		9	21	26
Scouting & Service Call		6	24	26

B. SPEAKERS: PLEASE RATE OVERALL SPEAKER EFFECTIVENESS....

Techniques	POOR	AVERAGE	GOOD	EXCELLENT
Corn Development			18	38
Soybean Development			20	36
Herbicide Performance/Injury		5	18	33
Current Crop Insects		5	22	32
Scouting & Service Call		2	22	32

C. PLEASE RATE YOUR EXPERIENCE AT THIS OUTDOOR LABORATORY.....

POOR	AVERAGE	GOOD	EXCELLENT
	1	22	31

2.) June 22 - Southern Ohio Crop Diagnostic Field Day:

One hundred thirty-five producers and agribusiness people attended sessions on: Corn Growth and Development by Dr. Peter Thomison, OSU Extension Agronomy Specialist; Soybean Growth and Development by Dr. Jim Beuerlein, OSU Extension Agronomy Specialist; Herbicide Performance Properties & Weed Control by Dr. Mark Loux, OSU Extension Weed Science Specialist; Crop Insects Including Soybean Cyst Nematode by Dr. Hal Willson, OSU Extension Entomologist and Troy Putnam, Highland Co. Agriculture; Field Crop Diseases by Dr. Wayne Ellett, OSU Professor Emeritus in Plant Pathology; Principles of Effective Field Scouting by John Gruber, Ag. consultants, Inc.; Evaluating Sprayer Performance by Tony Nye, Clinton Co. Agriculture Agent; Site Specific Farming by Larry Lotz, Fayette Co. Agriculture Agent.

3.) June 23 - Countrymark Diagnostic Field Day:

Forty-five Countrymark personnel attended sessions on precision farming, corn and soybean growth and development, insects and disease, and fertility.

On August 18 the Southwest Ohio Corn Growers and Fayette Agronomy Field Day was held at the Fayette Co. plot site. Approximately 450 people attended. Wagon tour stops included:

Corn Fertility Plots
Herbicide Adjuvant & Rate Demonstration Plots
27 Corn and Soybean Herbicide Plots

Insect Identification and Sweeping
Effects of Seasons Weather on Corn Growth
Watershed Quality
Roundup Resistant and STS Soybeans
Corn & Soybean Planting Date & Population Plots
110 Corn Hybrids

The site was also used by a number of individuals and groups for tours and informal teaching activities during the year. A five year summary including many data charts is printed for distribution in December, In addition, 120 aerial infrared photographs were taken of the plots and farm fields around the county, which were used to diagnose crop problems.

For further information contact Larry Lotz , Extension Agent, Ohio State University Extension, Fayette County or the Ohio IPM Office.

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Effects of Row Width and Plant Population on Herbicide Requirements in Corn

Principal Investigators:

Mark Loux, Horticulture & Crop Science
Peter Thomison, Horticulture & Crop Science

Abstract:

The objective of this study was to determine the potential for integrating reduced herbicide inputs with narrow row spacing to improve weed control in corn. Crops grown in narrow rows (row spacings of 20 inches or less) shade weed seedlings more than those grown in traditional wide rows (row spacings of 30 inches or more). Corn grown in narrow rows may require less herbicide than corn grown in wide rows for equally effective weed control. Grain yields have been increased by as much as 5 to 10% by switching from 30-inch to 20-inch and 15-inch row spacings. Reduced herbicide rates in conjunction with narrow row corn production may have significant economic and environmental benefits.

A field experiment was planted 12 May 1994 at the Farm Science Review site near London, Ohio. Treatments were arranged as a split-split plot in a randomized complete block design with three replications. Row widths were whole plots, plant populations were subplots, and herbicide treatments were sub-subplots. Two row widths (15 vs. 30-inch row spacings) and two seeding rates (24,000 vs. 30,000 plants/A) were used. Seven herbicide treatments were evaluated (Table 1). Labeled and reduced rates of a broadcast preemergence herbicide treatment (atrazine and metolachlor) and a postemergence herbicide treatment (nicosulfuron and dicamba) were compared to a control which received no herbicide inputs. Reduced herbicide rates were equivalent to 1/2 and 1/4 labeled rates.

Weed pressure was heavy throughout the experimental area. Giant foxtail and velvetleaf were the predominant weed species. Row width and plant population effects on weed control were either not significant ($p=0.05$) or not consistent on the different sampling dates. Any potential weed control provided by narrow rows and high plant population may have been limited by early season moisture stress which slowed vegetative growth and resulted in uneven canopy development. Lack of rainfall in late May and June also reduced the efficacy of the preemergence herbicide treatments (table 1). Above-ground weed dry matter (biomass) accumulation and visual ratings of weed control (for foxtail and velvetleaf) indicated that the postemergence herbicide treatments provided consistently better weed control compared to the preemergence herbicide. Above-ground weed biomass in the reduced rate preemergence herbicide treatment was not significantly different from the control; whereas in the reduced rate postemergence treatments it was less than 1/3 that of the control. Weed control provided by the reduced rates of the postemergence herbicides was not significantly different from that provided by the labeled rate. However, the weed control provided by the

preemergence herbicides was significantly reduced at the 1/4 labeled rate.

Differences in grain yield were closely associated with the varying levels of weed control (Table 2). Yields, averaged over application rates, were greater for the postemergence herbicide treatments compared to the preemergence herbicide (123 vs. 86 bu/A). Reduced rates of postemergence herbicides did not significantly affect yield. Yields for the two reduced rate preemergence treatments were not significantly different from the control. The lower yields of the control and reduced rate preemergence herbicide treatments were associated with a greater percentage of barren plants and reduced plant stands. Row width did not influence yield, but the higher plant population, averaged across row width and the herbicide treatments increased yield (111 vs. 88 bu/A).

Extension Program Implementation

Results of this study will be reported at 1994 grower meetings, field days, and crop tours. Data collected will also be summarized in the Ohio ICM Newsletter and Extension bulletins. Economic evaluations will be performed on data to determine costs associated with different reduced herbicide and control options. Additional research is needed before narrow row corn production can be recommended by OSU Extension.

For further information contact Mark Loux , Associate Professor, Dept. of Horticulture & Crop Science, The Ohio State University or the Ohio IPM Office.

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Implementing IPM for Codling Moth and Red-Banded Leafrollers in Commercial Apple Orchards in East Central Ohio

Principal Investigators:

Mark Mechling, Extension Agent, Muskingum County
Celeste Welty, Extension Entomology

Abstract:

Eight cooperating orchards in East Central Ohio utilized traps and pheromone lures in monitoring the levels of three important insect pests of apples - codling moth (CM), red-banded leafroller (RBLR), and apple maggot (AM). Cooperators measured activity levels every week from June to September and reported the results to the Muskingum County Extension Service via a weekly postcard.

Growers used established guidelines to determine if insect activity was at a high enough level to justify treatment. Growers received assistance and support from Extension personnel through a newsletter, personal consultations, a field meeting and educational materials. As a result of this project, growers gained more confidence and skill in determining insect activity levels through the use of these traps.

The three pests (CM, RBLR, and AM) being monitored are similar in appearance to some harmless insects found in the region and can be misidentified by growers. The cooperators received specimens of these insect pests provided by the Extension Entomologist so that the insects in the traps would be correctly identified.

Extension Program Implementation:

A ten issue newsletter produced by the East District Extension Agents in 1994 was sent to the cooperators as well as about fifty other fruit producers in the region. Sources for this periodical included articles from the OSU ICM newsletter and from other universities' fruit updates (Purdue, Kentucky, Cornell, and Penn State). Producers were kept up-to-date on topics such as label changes, current activity levels of fruit pests, proper application of pesticides, and recommended cultural practices.

A grower's meeting was held in July with about thirty in attendance. The Fruit Extension Entomologist and Pathologist both updated growers on the current pest activity levels. Demonstrations on insect identification and proper use of traps were included in this meeting.

Integrated pest management (IPM) served as the topic of a television show conducted by the agent on WHIZ in Zanesville. Topics included the principles of IPM, the different methods and instruments used to measure pest activity levels, and ways that IPM benefits both the consumer and producer. This IPM project has also been discussed with a variety of audiences, including area Master Gardeners, Extension advisory committee members, licensed pesticide applicators, and school children. Results will also be shared with fruit growers at the Eastern Ohio Fruit and Vegetable School in January, 1995.

For further information contact Mark Mechling , Extension Agent, Ohio State University Extension, Muskingum County or the Ohio IPM Office.

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Improved Detection and Management of Aster Yellows in Vegetable Crops

Principal Investigators:

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Lowell R. Nault, Dept. of Entomology
Casey W. Hoy, Dept. of Entomology

Abstract:

Aster yellows (AY) is caused by a mycoplasmalike organism (AY MLO) obligately transmitted by the aster leafhopper, *Macrosteles quadrilineatus* Forbes. It is a disease that occurs erratically in the midwest, often resulting in inefficient use of insecticides by growers. Leafhoppers migrating into Ohio vegetable production areas can be tested for the presence of the AY MLO by using a bioassay, and the results incorporated into an AY Index that can be used by growers to determine if insecticide applications are indicated. However, the bioassay is time consuming and relatively inefficient in that results of leafhopper infectivity are not know until 2-3 wk after collection. In addition, an important part of the AY Index is the susceptibility of crops to the pathogen. There is very little information available regarding the relative susceptibility of lettuce and related crops to AY, and variety trials are needed to measure difference between cultivars in response to inoculation with AY MLO.

During this study, we focused on 1) improving and validating a rapid assay for detection of AY MLO based on DNA hybridization (the polymerase chain reaction technique, PCR) and 2) gathering preliminary data on susceptibility of lettuce varieties to AY MLO in the field.

Two sets of DNA primers (oligonucleotides of known sequence) designed for general detection of MLOs (primers r16F2/r16R2) or for specific detection of AY MLO (primers r16F4/r16R1) were tested. The primers were obtained from R. E. Davis, USDA-ARS, Beltsville, MD. The general primer proved to give inconsistent results in the assay, so all results reported are based on use of the AY MLO-specific primer r16F4/r16R1. A rapid DNA extraction method was developed, allowing the preparation of insect samples for analysis in a few minutes. We were also able to improve the sensitivity of the assay at least 8-fold by including a second polymerase enzyme. The assays could be completed in one day, although typically the PCR reaction was run overnight, and products were detected the next day. This represents a significant improvement over the bioassay.

The PCR assay was tested and compared with the bioassay using insects collected in commercial lettuce fields in Celeryville and Hartville, Ohio biweekly throughout the summer, for a total of six collections (Table 1). Whenever possible (when populations permitted), at least 100 leafhoppers were collected from each

location, then brought to the laboratory in Wooster where they were placed on individual lettuce seedlings in small cages. After an inoculation access period of 7 days, leafhoppers were removed from their cages, bulked in groups of 8-10, extracted and tested by PCR. The proportion of positive individuals in the bulked samples was estimated using the formula: $z = 1 - (1-x)1/y$, where z = the proportion of positive insects, x = the proportion of positive groups of insects and y = the number of groups of insects. Lettuce plants were held for an additional 2 wk, then scored for the presence of AY symptoms. Results shown in Table 1 indicate that the PCR assay usually resulted in higher proportions of insects infected by AY MLO than the bioassay. Our previous studies have shown that AY MLO can be detected in leafhoppers soon after exposure, before they have completed the latent period and become inoculative. These data may reflect the detection of the MLO in infected but non-inoculative leafhoppers by the PCR technique. Bioassay values may also be lower than expected due to disease escapes. For collections made on July 22 and Aug 8 in Celeryville, all of the bulked insect samples tested by PCR were positive, resulting in an estimated proportion of MLO-positive individuals of 100%. Since our previous studies have shown that only one AY MLO-infected leafhopper in a sample of 10 can be detected by PCR, this estimation is very likely to be too high. We will address this issue in future validation studies by using more samples consisting of fewer insects.

Table 1. Detection of aster yellows (AY MLO) in leafhoppers (Macrosteles quadrilineatus) collected in Celeryville and Hartville, Ohio, in 1994 by bioassay and the PCR technique.

Collection		No. Leafhoppers	% Leafhoppers Positive for AY MLO	
Date	Location	Collected	Bioassay[a]	PCR[b]
June 2	Celeryville	100	0.0	2.2
June 13	Celeryville	100	1.0	11.3
June 24	Celeryville	100	3.0	5.0
July 11	Celeryville	100	7.0	1.8
July 22	Celeryville	100	7.0	100.0[c]
Aug 8	Celeryville	100	8.0	100.0[c]
June 2	Hartville	14	0.0	0.0
June 13	Hartville	100	0.0	1.1
June 24	Hartville	100	3.0	2.2
July 11	Hartville	44	0.0	4.4
July 22	Hartville	100	1.0	2.2
Aug 11	Hartville	67	0.0	0.0

[a]Percent of individual plants with symptoms of aster yellows 3 wk after exposure to leafhoppers collected among lettuce plants in each location.
[b]Percent individuals positive based on testing insects in batches of 8-10 (see text for formula); AY MLO-specific primer pair r16F4/r16R1 was used in the assay.
[c]All batches of insects were positive by PCR.

The relative susceptibility of lettuce and escarole varieties to AY was evaluated in a field trial carried out in Celeryville, OH at the Muck Crops Branch of OSU-OARDC. Lettuce seedlings were raised in the greenhouse at the OARDC facility in Wooster, then exposed to 120 AY MLO-inoculative leafhoppers (bolt or severe strain) per flat of 96 plants. Seventeen varieties of lettuce and one of escarole were tested in a randomized complete block design, with 25 plants per replicate, three replicates per treatment. Plants were rated for disease incidence 31 and 41 days after transplanting. The results of the trial are shown in Table 2. All of the lettuce varieties tested were susceptible to aster yellows, while the escarole was highly resistant or immune. Some of the plants had been exposed to only 50 leafhoppers/flat, and these had much less disease than plants exposed to 120 leafhoppers/flat. Both strains of AY MLO caused high disease incidence on the lettuce varieties.

Table 2. Incidence of aster yellows 31 d after inoculation of lettuce varieties with either the "bolt" or "severe" strain of aster yellows mycoplasma-like organism.

	Mean Disease Incidence (Percent Diseased Plants)	
Variety	**Bolt Strain**	**Severe Strain**
Vanity MTO	**79.6**	**81.6**
Butterhead Boston	**18.2***	**81.1**
Red Butterhead	**36.3***	**93.8**
Red Salad Bowl	**81.2**	**74.9**
Fancy Butterhead Boston	**89.7**	**86.4**
Tall Guzmaine	**85.4**	**92.5**
Esmerelda	**39.9***	**82.3**
Special Ideal Cos Mi	**62.2**	**57.6***
Slobolt	**57.8**	**72.0**
New Fire Red	**70.1**	**82.9**
Pic 318 Romaine	**69.9**	**81.2**
New Red Fire	**68.0**	**90.2**
Summer Bib Mi	**72.3**	**23.4***
Esmerelda Mi	**92.1**	**88.1**
Slo Bolt Mi	**42.4**	**64.0**
Waldman's Green Leaf	**93.6**	**82.5**
Valmaine	**86.7**	**87.4**
Deep Heart Escarole	**0.0**	**0.0***

***Indicates transplants inoculated with 30-50 leafhoppers/flat; 120 leafhoppers/flat used for all other inoculations.**

Extension Program Implementations:

The results of the PCR tests and bioassays were related to growers at the monthly muck crop growers breakfasts. The variety trial at the Muck Crops Branch was open to growers to visit and evaluate. A full report of this project will be presented at the Muck Crops School, which will be held in January, 1995, in Willard, OH.

For further information contact Sally Miller , Assistant Professor, Dept. of Plant Pathology, The Ohio State University or the Ohio IPM Office.

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Integrating Biological and Chemical Control of Sweet Corn Pests

Principal Investigators:

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Abstract:

Sweet corn in the midwestern USA has three key insect pests that have a direct effect on ear quality and thus on the value of the crop: European corn borer, corn earworm, and fall armyworm. Progress has been made in implementing IPM on Ohio sweet corn farms, with emphasis on monitoring moth activity and optimal timing of insecticide applications for control of these key pests. The question remains whether biological control can be incorporated. Previous researchers have shown that naturally occurring predatory insects such as the spotted lady beetle and the insidious flower bug can contribute significantly to control of European corn borer and corn earworm, but the local populations of predators are not usually large enough or timely enough to provide commercially acceptable control. This project was initiated because information is lacking on whether predators can be manipulated to make a greater contribution to pest suppression. We are interested in predator conservation by applying microbial insecticide (B.t.), and predator enhancement by a sprayable sugar-protein product (Pred-Feed) that acts as an attractant and feeding supplement for some predatory insects. This work was initiated in 1993 and continued in 1994.

The objective of the extension component of this project was to provide timely information on pest activity and management suggestions to sweet corn growers, with expansion of monitoring reports from southern Ohio. The objectives of the research component of this project were 1) to compare sweet corn pest management by conventional insecticides with the biological control strategies of predator conservation and predator enhancement, and with combined biological and chemical control, 2) to document the seasonal population abundance of the insidious flower bug and lady beetles in sweet corn fields, and 3) to conduct arena studies of predator-prey relationships. Data obtained in this project is allowing us to evaluate whether a reduction in conventional insecticide use and an increase in biological control is a viable option in commercial sweet corn production during part or all of the season.

Extension Component:

We reported pest activity trends weekly from June to September in the Ohio ICM Newsletter, and on a weekly recorded telephone message from late July to mid-September. Reports were also sent to a small number of growers and industry personnel from late July to mid-September in a pilot project of a weekly VegNet report sent by a computerized fax system. Pest activity trends reported were based on trap reports. For European corn borer, we monitored moths in blacklight traps at three locations: Reedsville in southeastern Ohio, Columbus in central Ohio, and Fremont in northern Ohio; cooperators emptied the traps daily and sent trap contents to us for sorting. For both European corn borer and corn earworm, we reported moth catches in pheromone traps from a few key cooperators at locations across Ohio.

Research experiment 1: Conservation and enhancement of natural enemies for suppression of key sweet corn pests. In an early planting of 'Seneca Horizon' and a late planting of 'Lancelot' at both Fremont and Columbus, main plot treatments were Pred-Feed applied weekly vs. no Pred-Feed; sub-plot treatments were whorl treatments with B.t. granules vs. permethrin granules; silk treatments with B.t. sprays vs. thiodicarb sprays; and an untreated check. There were four replicates per treatment. Plots were monitored weekly for pests and natural enemies, and ear quality was evaluated at harvest. Pest pressure was light and European corn borer was the dominant species in all plantings except the late planting at Columbus, in which corn earworm was dominant. Harvest evaluation (Table 1) showed no significant effect of Pred-Feed except in the late Columbus planting, when PredFeed plots had more damage than plots without PredFeed. Sub-plot treatments differed significantly in the early planting at Fremont and in the late planting at Columbus. When applied as a granular treatment to whorls, B.t. efficacy was equal to conventional insecticide. When applied as a spray treatment to silks, B.t. efficacy was intermediate between untreated checks and conventional insecticides. Analysis of other data is in progress and should be completed by February 1995.

Research experiment 2: Dynamics of three key predators in sequential sweet corn plantings. Seasonal population abundance of the insidious flower bug and two species of lady beetles were monitored in three replicates of eight small sequential plantings of sweet corn at both Fremont and Columbus. Plantings were seeded at two week intervals from early May until early July. Plantings were monitored weekly to determine the seasonal population abundance of the insidious flower bug and lady beetles. Analysis of data is in progress and will be completed by February 1995. Predators and pests found were used as a source of subjects for preliminary arena studies on predator-prey interactions, which will be investigated in more detail in 1995.

Extension Program Implementation:

Pest activity reports were generated and disseminated throughout the growing season. A progress report was made to growers, industry, researchers, and extension personnel who attended the Veg Crops field day at Fremont on 20 July 1994. Results of the 1993 and 1994 research trials will be presented at the Ohio Fruit & Vegetable Growers Congress on 8 February 1995.

For further information contact Celeste Welty , Assistant Professor, Dept. of Entomology, The Ohio State University or the Ohio IPM Office.

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Management of Virus Diseases and Their Vectors on Pumpkins

Principal Investigators:

Mac Riedel, Professor, Plant Pathology
Celeste Welty, Assistant Professor, Entomology
Bob Precheur, Associate Professor, Horticulture & Crop Science

Abstract:

Pumpkin yields have been reduced up to 50% on Ohio farms where severe problems with mosaic virus diseases develop early in the growing season. We have been investigating efficacy of integrated cultural and chemical strategies for virus management, but one impediment to implementation of these strategies is accurate information about which viruses are infecting Ohio pumpkins. The most important virus disease of pumpkins in Ohio is thought to be zucchini yellow mosaic virus because zucchini yellow mosaic symptoms are rather easy to identify visually in the field. Squash mosaic virus also is known to occur on pumpkins in Ohio. It is possible that Ohio pumpkins are infected by three other viruses: watermelon mosaic virus, cucumber mosaic virus, and papaya ringspot virus; these viruses can not be identified accurately by visual inspection of field symptoms, and their importance to pumpkins may be underestimated. Aphids are the vectors of all of these viruses except squash mosaic virus, which is vectored by cucumber beetles. Because aphid management strategies are different than beetle management strategies, it is critical to know the status of squash mosaic virus on Ohio pumpkins.

The first objective of this project was to determine the identity and distribution of five viruses and their insect vectors in Ohio pumpkins. A state-wide survey of pumpkin viruses was conducted on 26 commercial farms in 18 counties from mid-July to mid-August. In each field, 25 leaf samples were collected and frozen. Twenty-one farms were negative for all five viruses. Watermelon mosaic virus was found on four farms, squash mosaic on two farms, and cucumber mosaic on two farms. Zucchini yellow mosaic and papaya ringspot viruses were never detected. Winged aphids were surveyed by yellow water pan traps at two sites where field experiments on virus management were being conducted. Trapped aphids have been preserved in alcohol and will be identified this winter.

The second objective of this project was to train growers and agents on pumpkin pest management with emphasis on virus management. An evening workshop held on 16 August in Pickaway County was attended by about 35 growers and agents. Topics covered were pest and disease recognition and management, followed by a field tour of plots where row covers, reflective mulch, cucurbitacin bait, and conventional insecticides were being tested as virus management strategies. Participants were given a packet of reference materials on insect pests, diseases, weeds, and harvest and storage guidelines.

Extension Program Implementation:

A workshop on pumpkin pest management was held in August, attended by about 35 growers and agents. Results of the virus survey will be presented at the 1995 Ohio Vegetable Growers Congress on 9 February. Results will also be incorporated into a bulletin on pumpkin pest management, which is now in the planning stage.

For further information contact Richard M. Riedel , Professor, Dept. of Horticulture & Crop Science, The Ohio State University or the Ohio IPM Office.

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Slug Monitoring and Control in No-till Row Crop Production

Principal Investigators:

James C. Skeeles, Fairfield and Perry Counties

Abstract:

This project compared the slug damage on soybean plots treated with 4% metaldehyde bait at planting time. Plots were located on five different farms in Perry, Licking and Fairfield Counties. Due to the difficulty of applying the bait, four of the trials compared treated to untreated plots. One plot in Fairfield Co. compared rates of 0, 5, 7.5, and 10 pounds per acre. In one Fairfield Co. corn field, the bait was applied to different sections in the field at rates of 0, 5 and 10 pounds. Also. across the whole field 2 rows out of 6 had residue removed with row sweepers. Stand and slug damage counts were taken to compare the effectiveness of each treatment, and the combination of both treatments.

The results for four Licking Co. soybean fields are in Table 1. Germination and early growth conditions were extremely dry in 1994; therefore, no slug injury was detected in the comparisons on Table 1. Treatment rate on treated plots was approximately 10 pounds of 4% metaldehyde bait per acre, but varied greatly due to the difficulty of getting the material through a grain drill. Due to the dry conditions, no differences were found between the treated and untreated plots.

Table 2 shows results where plots were treated at planting time with rates of 0, 5, 7.5, and 10 pounds of 4% metaldehyde bait, as well as one plot with 10 pounds of 4% metaldehyde granule. Again, due to the dry conditions, no differences were found in plant population between treated and untreated plots. Dead slugs were observed on the treated plots, but before the crop emerged.

Table 3 shows results where two out of 6 corn rows were "swept" with "row sweepers, residue managers", etc. and sections in the field were treated with a 0, 5, or 10 pound rate of 4% metaldehyde bait at planting time. Considering primarily the June 11 data, it appears that removing residue from the rows gave a stand advantage, but that the at planting bait treatment had no effect. In plots on the same farm the previous year (when slug damage was much more prevalent due to the cool wet weather during germination), slug damage was lower, plant height taller, and stand greater on swept rows. This year, the plant stand was higher in swept rows, but plant height was no different. Yield was not compared this year, as it seemed apparent that the stand difference was not enough to influence yield.

Table 1 - Results from four Licking County Soybean Fields.

	Date of Observations		

Observation	2 June	9 June	16 June
	Williams Farm		
Crop Development	emerging	3" or less	4" or less
Prevailing Temp. & Moisture	78 degrees dry	mod dry	80 degrees dry
Stand per 50 row ft. Treated	n.a.	88	90
Stand per 50 row ft. Untreated	n.a.	133	134
Slug Injury	none	none	none
	Lamp Farm		
Crop Development	emerging	3" or less	4" or less
Prevailing Temp. & Moisture	78 degrees dry	mod dry	80 degrees dry
Stand per 50 row ft. Treated	n.a.	141	141
Stand per 50 row ft. Untreated	n.a.	133	137
Slug Injury	none	none	none
	Branstool Farm		
Crop Development	emerging	2.5" or less	3" or less
Prevailing Temp. & Moisture	78 degrees dry	mod dry	85 degrees adequate
Stand per 50 row ft. Treated	n.a.	131	132
Stand per 50 row ft. Untreated	n.a.	108	107
Slug Injury	none	none	none
	Newell Farm		
Crop Development	emerging	3" or less	4" or less
Prevailing Temp. & Moisture	80 degrees dry	mod dry	85 degrees very wet
Stand per 50 row ft. Treated	n.a.	161	155[1]
Stand per 50 row ft. Untreated	n.a.	144	144
Slug Injury	none	none	none
[1] - Storm and standing water may have resulted in inaccurate count.			

Table 2. - Fairfield soybean plot results at Brandt Farm.

	Dates of Observation			
	11 June		28 June	
Treatment	Population	New Leaf Damage	Population	New Leaf Damage
		%		%
No Bait	50,500	93	94,500	79
10 lbs. granule	55,000	91	103,000	88
10 lbs. molasses bait	72,500	97	121,000	87
No bait	74,500	95	116,000	87
7.5 lbs. molasses bait	78,500	100	128,000	87

5 lbs. molasses bait	45,000	100	77,000	91
No bait	32,500	100	70,500	94

Table 3. - Fairfield corn plot results at Brandt Farm.

	Dates of Observations					
Treatment	24 May		11 June		28 June	
lbs. of bait	With Sweep	No Sweep	With Sweep	No Sweep	With Sweep	No Sweep
	Population					
0	23,900	17,400	27,350	23,400	26,700	23,000
5	22,440	19,200	25,100	20,700	25,200	20,700
10	23,100	18,300	26,500	21,250	26,000	21,250
	Percent New Leaf Damage					
0	59	62	68	65	15	8
5	57	51	57	64	12	14
10	55	59	65	59	10	12
	Comments					
	Corn still emerging		Uniform height		Corn 36" tall	
			regardless of		No slug damage	
			Treatment		on new growth	

Related Literature:

Studies in the northern corn belt have shown an advantage in using "row sweepers" to enhance early growth of corn: Iowa (Kaspar, Erbach and Cruse, 1990), removing residue from the row in continuous corn significantly increased plant height, decreased days to 50% emergence and days to 50% tassel, decreased grain moisture at harvest, reduced barrenness, and increased grain yield by 5 bushels/acre. Minnesota (Moncreif, Wagar and Kuznia, 1989-91 and Moncreif, Wagar and Kuznia, 1986-90) concluded that residue cover in the row of more than 20% was likely to lower yields in years with wet springs. Also in MN, Swan, Schneider, Noncreif, Paulson and Peterson, 1987, concluded that in row residue delayed emergence and corn plant development.

However, further south, results form residue removal or strip tillage have been mixed: Kentucky (Murdock, Herbck and Gray, 1992) obtained better plant stands and yields with strip preparation in one out of four years. Indiana (West, Griffith and Hill, 1992) concluded that strip preparation was generally not beneficial where standard no-till planting was previously successful. Ohio (Skeeles, Willson and Brandt, 1993) found that in a cool wet spring where no-till corn was planted into heavy residue with heavy slug populations, that rows with residue removed had better plant stand, were taller, and had less slug damage. However, no yield advantage was demonstrated.

Extension Program Implementation:

Results will be integrated into a summary of similar plots conducted around Ohio to evaluate the effectiveness of the metaldehyde bait. Also, two twilight tours were held on the plots. Results were presented at local summer field days and will be presented at winter meetings. Results were also published in the popular press.

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For further information contact Jim Skeeles , Extension Agent, Ohio State University Extension, Lorain County or the Ohio IPM Office.

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Ohio Integrated Pest Management

THE OHIO STATE UNIVERSITY EXTENSION

Slug Studies in 1994 in Wayne County

Principal Investigators:

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The Ohio State University

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Wayne County Extension Agent
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Summary and Conclusions

Slug Identification:

There are four distinct species of slugs that are found in Ohio fields. Gray garden slugs, *Deroceras reticulatum*, are medium size, grayish colored slugs having breathing pores on the posterior portions of their mantle. This breathing pore is surrounded by a pale area. When irritated, they exude a white slime. These slugs were the most common and numerous in grower fields. Marsh slugs, *Deroceras laeve*, were the next most numerous slug. Marsh slugs are smaller, usually much darker slugs than gray garden slugs. They also have a breathing pore on the posterior portion of the mantle. These slugs are difficult to differentiate from gray garden slugs when both are small. Their slime is clear and watery. *Dusky slugs*, *Arion subfuscus*, are large slugs, the largest slug found in grower's fields. There are 3 distinct color phases commonly found in Ohio fields, a darkish brown-black color slug with lateral bands that are difficult to see, a medium brownish color slug with distinct lateral bands, and light orangish color slug also with distinct lateral bands. All three color forms can be found together. Their foot fringe is well developed with dark vertical markings (often faint in the lighter colored forms). When irritated, these slugs exude yellow to orange slime. Although not as numerous as gray garden slugs and marsh slugs, they were readily found in most fields. Because their size and coloration make them readily detectable, dusky slugs are often considered the most numerous in certain fields. However, based on the fields sampled, dusky slugs were usually third in population size. Banded slugs, *Arion fasciatus*, the fourth species found in Ohio fields, is not as common as the others. This slug is gray in color with distinct black lateral bands. It has a whitish, longitudinal ridge down its back. Its foot fringe and sole is white. While gray garden slugs, marsh slugs and dusky slugs were found in all fields sampled, banded slugs were only found in a few fields. The field where they were most common has only recently been in field crops (within the past 15 years); prior to that it was a swine feedlot.

Life History:

Various observations suggested the following general life cycle for slugs. Numerous adult slugs were sampled in mid-April through mid-May. These slugs would have had to overwinter as there was not enough time for them to have developed to this stage. At this time, numerous egg masses were observed, including many that were being laid. Whether some of the egg masses had overwintered is unknown, but as mentioned, we did observe many eggs being oviposited.

By late May, the number of adult slugs being sampled went down drastically. Our initial thought was that they were going farther into the soil since it was becoming dry and warm. However, we began sampling large numbers of newly hatched "baby" slugs. During the week of May 24, we often found large numbers around single traps (up to 40 baby slugs per trap) suggesting a recent egg hatching. These high numbers were a result of a nearby egg mass having hatched. By early June, these slugs had become juvenile slugs that were slightly larger in size but definitely much smaller than adults. Traps were very inefficient in sampling these juveniles. Field visits in early June in the evening allowed us to observed many of these juvenile slugs feeding on the corn and soybean. In some fields, numbers ranged from 5-7 slugs per individual corn plant and 1-2 per soybean plant (note: plant population of the soybeans is 2X-3X of the corn). The slugs being observed were gray garden slugs, dusky slugs, and some marsh slugs. Because of the difficult in distinguishing young gray garden slugs and marsh slugs, it was often impossible to correctly identify them. Of note, the dusky slugs, being larger and often an orange color, were very noticeable.

Sampling continued throughout the summer. With the exception of the banded slugs, slugs were always captured, with their body size increasing as the summer subsequently progressed. Although numbers were low in July, they went up in August, September and October. Banded slugs did not appear again until September. Depending upon the field, gray garden slugs, marsh slugs, and dusky slugs became quite numerous in the fall based on the trapping. Most of the trapped slugs were larger adults.

Slug Trap Evaluation:

Numerous traps were evaluated for their efficiency in sampling slugs. After examining various trap ideas, we came down to 6 traps that we examined in three fields for 4 weeks. Average slug counts with different letters are significantly different at the 5% level.

	Total Adult Slugs per Plot				
	May		**June**		**Average**
Trap Description	**18**	**24**	**2**	**7**	**Slugs/Trap**
1. Covered shingle + yeast with 1 TBLS sugar	**24**	**12**	**9**	**1**	**0.92 a**
2. Covered shingle + bait	**30**	**14**	**9**	**3**	**1.17 a**
3. Covered shingle + hole w/ cup + beer	**20**	**17**	**4**	**7**	**1.00 a**
4. Covered shingle + hole	**7**	**5**	**0**	**1**	**0.27 b**
5. Covered shingle + cracked corn	**18**	**21**	**12**	**1**	**1.08 a**
6. Covered shingle + cracked corn + sugar	**13**	**21**	**12**	**5**	**1.04 a**

All traps with the exception of aluminum foil-covered shingle + hole were able to capture larger, adult slugs somewhat equally. When newly hatched baby slugs were initially present (around May 18 and 24), the beer traps captured significantly more (data not presented). Because the beer traps were easier to use than mixing up yeast or cracked corn mixtures, we recommend beer traps as the preferred trap for sampling slugs. However, based on these data and the discussion on slug life history, none of the traps were efficient at sampling juvenile slugs which cause most of the damage in early and mid-June.

We attempted to use the defined area trapping (DAT) method, but met with little success. Various problems associated with them limit their usefulness in IPM programs.

Deadline Efficacy: Because of the wetness of the Deadline Granules, their use at planting time through a drill (and insecticide bins) was limited. The material jammed in the hopper or the tube. Even a drier formulation had problems, although it could be used. Of more importance is whether Deadline Granules applied at planting has potential for reducing slug populations. Based on life history and other efficacy tests, if planting is done in early May, Deadline application at that time would not be appropriate because adults had already laid their eggs. If planting is done in late May - early June, there could be a potential benefit because the material would be applied to juvenile slugs.

Numerous studies were done applying Deadline Granules or other formulations as a broadcast application. In a study applying the Granules at different times following planting (0-5 weeks), the best slug control was achieved with material applied at least 1 week, preferable 2 weeks following the May 5 planting date. Injury ratings or slug counts with different letters are significantly different at the 5% level.

Trt#	Date	Treatment	Ratings	Slugs/8 Corn Plants
1		Check	2.8 ab	6.0 a
2	May 5	0 week	3.0 a	6.5 a
3	May 13	1 week	3.0 a	2.5 bc
4	May 19	2 weeks	1.8 bc	3.0 ab
5	May 27	3 weeks	1.0 c	0.8 bc
6	June 2	4 weeks	1.0 c	0.0 c
6	June 9	5 weeks	2.5 ab	0.3 bc

In a study applying various rates of Granules, all rates from 5 to 40 lb. per acres reduced damage and slugs. The best reduction in damage was with the 20 and 40 lb. rate.

			# Slugs/Trap	
Trt#	Treatment	Injury Ratings	June 2	June 8
1	Check	3.5 a	5.4 a	1.0 a

2	5 lb per acre	1.8 b	0.5 b	0.0 b
3	7.5 lb per acre	1.8 b	0.8 b	0.0 b
4	10 lb per acre	1.8 b	0.4 b	0.0 b
5	15 lb per acre	1.5 bc	0.0 b	0.0 b
6	20 lb per acre	1.0 c	0.3 b	0.0 b
7	40 lb per acre	1.0 c	0.4 b	0.0 b

In a study applying various formulations of Deadline, all were able to reduce the number of slugs, with the Granules being the best (at least numerically). Because this test was initiated after feeding had already occurred, injury ratings are high. However, all materials were able to limit further feeding.

Trt#	Treatment	Rate	Injury Ratings	Slugs
1	Check		3.5 a	12.8 a
2	New Material	5 lb per acre	2.5 b	1.8 b
3	New Material	7.5 lb per acre	2.8 ab	1.8 b
4	New Material	10 lb per acre	2.3 b	1.3 b
5	Granules	10 lb per acre	2.3 b	0.3 b
6	Bullets	10 lb per acre	2.3 b	2.0 b

In a final study with Deadline to a heavily infested field, both formulations were able to reduce the number of slugs, with Granules being the most effective. Injury ratings (not presented) also supported the idea that Granules were the best material.

		Slugs Per Corn Plant			
Trt#	Treatment	June 17	June 18	June 24	June 30
1	Check	2.6 a	2.3 a	4.5 a	6.1 a
2	Granules	0.0 b	0.1 c	0.4 b	0.5 c
3	New Material	0.5 b	0.7 b	0.7 b	1.6 b

Many our of findings are a result of the large egg hatch that occurred around May 18-24 in all the fields. Any of the early May applications of Deadline, while killing numerous adult slugs, had no effect on the egg masses that were present at that time. Additionally, these applications had no effect on later juveniles of the

1st generation. Applications made near or after egg hatch were very effective in reducing slugs populations. Damage reduction was related to the time the application was made. If the material was applied prior to the juveniles doing any feeding, damage was averted. If the material was applied later after some feeding had already occurred, continued damage was reduced.

The 1994 Deadline Granules were quite effective in controlling slugs whenever, and wherever, it was applied. This included the test plots as described and other fields where Deadline Granules was made available to growers. Because of the formulation, a larger number of particles are distributed compared with Deadline Bullets. Five (5) grams of each material had approximately 32, 254 or 438 pieces for the Bullets, new material or Granules, respectively. On a ft^2 basis this corresponds to 0.7, 5.3 or 9.1 pieces. However, the wetness of the material was a major problem. Unless the company can come up with a drier formulation that will easily flow through drills, insecticide boxes, and spreaders, it will not be accepted by growers. Although the Granules used this year worked, any new formulations that are drier will need to be tested for their efficacy. Unless a drier formulation can provide the results obtained this year, all this year's conclusions concerning Deadline Granules have to be limited to a very wet, probably unacceptable, material.

Planting Date:

The attempts to determine if varying the time of planting could affect the amount of damage from slugs proved unsuccessful. The areas where these experiments were placed did not have slug infestations sufficient to produce damage differentials. However, based on the information on the history of slugs that was obtained, planting times should have a major impact on slug damage severity.

The damage that we observed this spring occurred in early-mid June from juvenile slugs of the 1st generation. In the corn fields we sampled, the corn was in the 4-7 leaf stage by the time these young slugs began heavy feeding. The corn was too tall to be economically damage. A number of soybean fields that were located in the surrounding areas, and were being economically damaged, had been planted in late May - early June. These soybeans were either emerging from the soil or were in the V1-2 leaf stages when the juvenile slugs began their active feeding. Conversations with Dave Graham about previous problems support this conclusion. It is later planted fields that tend to have problems in June. Fields planted in early May often have sufficient growth to allow them to escape serious problems from slugs. It should be pointed out that early planting does not limit the presence of slugs, only the economic injury. Heavy feeding will occur, but due to the overall size of the plant, economic damage might be prevented.

Recommendations:

The following are recommendations based on this year's data:

1) Some level of tillage will help to reduce the potential of slug damage by eliminating slug shelter and allowing for more vigorous plant growth.

2) Fields with a history of slugs where concern exists should be planted as early as possible to allow crops to get the most growth possible before slugs begin their heavy feeding.

3) Fields, especially those with a history, should be watched most carefully in late May and then during the first 2 weeks of June for the presence of slug activity. This should be determined (1) by examining plants for feeding and (2) by evening field visits an hour before sunset to determine the presence of slug populations.

4) Trapping, while being effective in early spring for the presence of adult slugs and in later summer for the presence of a slug population, is not effective in determining the relative size of a damaging population in

late May and early June. The traps did not capture the large numbers of damaging juveniles very well. However, when traps are used, cups half filled with a heavy beer would be the best choice.

5) When crop damage becomes sufficient, a molluscicide should be applied. Deadline at a rate of 10-12 lb per acre is suggested. Deadline Granules would be the first choice followed by Bullets. At this time, economic thresholds are not available. However, a drier granule material is needed.

Future Needs:

Because this was the first year that we have conducted intensive sampling of slugs in conservation tillage fields (and then, only spring through fall), we need to continue with the sampling program at least into the spring of 1995. This intensive sampling should then be continued for a number of years to determine the life history of all four slug species. Currently, the life cycle of slugs in Ohio is based on limited information gathered during one spring, from other states, and from sites in foreign countries.

Because most of this information was from work done in Wayne County, it should be extended to other parts of Ohio where slugs are of a concern. In the future, similar work should be done in other midwestern states.

The predominant slug appears to be the gray garden slug, followed by the marsh slug and dusky slug, and then last by the banded slug. We should conduct specific sampling studies to determine the geographic range and make-up of these four slugs throughout Ohio.

Little information is known about the comparative damage potential of these four slugs. Gray garden slugs are known to be an economically important species; however, this might not be true for the other slugs. Studies should be initiated to determine feeding rates and damage potential of all the slugs.

We need to continued work on molluscicides, including a better formulation of Deadline Granules (drier and more consistent). New materials should continued to be evaluated.

Planting time studies should be continued. Specific studies should be established in areas of high slug populations to further explore the potential use of planting times as a preventive tactic against slugs. Damage studies should be done where juvenile slugs on placed onto corn and soybeans at different growth stages (as a result of different planting dates). During the next area-wide outbreak of slugs in the state, surveys should be conducted to attempt to correlate fields with economic-damage with planting times. We should not automatically assume that early planted fields, not experiencing noticeable defoliation, do not have large slug populations. This is perhaps the tactic with the greatest potential for preventive management of slug problems in conservation tillage fields (albeit that tillage would be the best preventive tactic).

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