WERA-060, Science and Management of Pesticide Resistance
2004 Report

No meeting was held in the reporting period. However, reports of activities and accomplishments were solicited from members and others who have been involved in the committee in the past. Their reports are below:

1. Submitted by member

Carol Mallory-Smith
Department of Crop and Soil Science
109 Crop Science Building
Oregon State University
Corvallis, OR 97331-3002
carol.mallory-smith@oregonstate.edu

Projects related to herbicide resistance include studies on glyphosate resistant Italian ryegrass (Lolium multiflorum) found in orchards in Oregon. The mechanism of resistance has not been determined but does not appear to be target site. Work is ongoing with weeds with resistance to ACCase herbicides. Studies include mechanism of resistance and resistance patterns among the ACCase herbicides. Studies on gene flow between wheat and jointed goatgrass (Aegilops cylindrica) and hybridization dynamics between the species are continuing. Gene flow through pollen and seed movement from transgenic creeping bentgrass fields is being monitored.

2. Submitted by member

Margaret Tuttle McGrath
Department of Plant Pathology
Cornell University
Long Island Horticultural Research & Extension Center
3059 Sound Avenue
Riverhead, NY 11901-1098
Phone: 631-727-3595 ext 20
Fax: 631-727-3611
mtm3@cornell.edu

Fungicides are an important tool for managing cucurbit powdery mildew (PM) to avoid losses in quantity and/or fruit quality. This is the most common disease of cucurbit crops, which include pumpkin, squash, and melon. Products able to move through leaves are needed to manage PM on lower surfaces, where this disease develops best. Unfortunately they are prone to resistance (R) development because of their single-site mode of action. R to the QoI (quinone outside inhibitor) fungicide group, first documented in the US in 2002 through this project, was monitored using a seedling bioassay in commercial cucurbit crops on Long Island, NY, in 2004. QoI R was detected in all 8 squash and pumpkin fields in late July when PM was starting to develop in pumpkins on Long Island

and when QoIs had only been used in 1 of the squash fields. A high frequency of the pathogen population in these fields was moderately resistant to DMI fungicides and resistant to benzimidazole fungicides. Most QoI-resistant isolates tested in laboratory assays were also moderately resistant to DMIs (92%). With multiple resistance, using either type of fungicide selects for strains resistant to both. Growers rely on results from university evaluations when they select fungicides and varieties. Two new products used in combination programs with DMI and protectant fungicides effectively controlled PM on both leaf surfaces in a fungicide efficacy experiment. Impact: Information was obtained that growers can use immediately to modify their fungicide programs for managing powdery mildew, the most common disease of cucurbit crops. Based on how quickly the pathogen population has shifted to predominantly strains resistant to the QoI group of fungicides in commercial fields, and the impact of resistance on control, QoI fungicides are no longer recommended for PM. This information, combined with demonstrated superior control with a new fungicide provided justification for emergency exemption registration of the new fungicide.

3. Submitted by member

Mark Whalon
Department of Entomology
Michagin State University
B11 Integrated Plant Systems Center
East Lansing, MI 48824-1311
(517) 353-9425
whalon@msu.edu

a. A complete redesign and implementation of the pesticide resistance database. The first stage was focusing on survey submission and reviewing. We also redesigned the database structure and the web interface which incorporate the latest industry standard. The logic and the look of the web interface are significantly better than the previous version. The implementation of the system will be complete in September, 2005.

b. Our web site (http://www.pesticideresistance.org/DB/) averaged about 3200 visits/mo lasting longer than 10min/ visit. We do not score visits less than 10 minutes in duration.

c. The web-based resistance case reporter is up now, but will be synchronized with the new design by December, 2005.

d. We have put on the web (http://www.msstate.edu/Entomology/v7n2/rpmv7n2.html) and sent to 34 libraries around the world 2 issues of the Resistance Pest Management Newsletter. We have over 2,000 subscribers worldwide, most govt. employees, field workers, academics, policy personnel.

e. My laboratory ran a number of discriminating dosage experiments in the field for plum curculio resistance in 2004-5.

4. Submitted by member

Clifford Keil
220 Townsend Hall
Department of Entomology & Wildlife Ecology
University of Delaware
Newark, DE 19716-2160
Telephone: (302) 831-8882
Fax: (302) 831-8889
Email: keil@udel.edu

Pesticide Resistance in *Lycoriella mali* (Diptera:Sciaridae) in Commercial Mushroom Production. Populations of mushroom flies, *L. mali*, have evolved resistance to a wide range of insecticide products including organochlorines, synthetic pyrethroids, organophosphates, and benzylphenyl ureas. Currently the major chemical pesticide used for control in commercial practice is cyromazine incorporated into the compost or casing soil. Resistance management plans have been implemented to retard the development of resistance and still achieve economic levels of control. Growers use temporal refuges to limit exposure to the pesticide. In the fall, applications of cyromazine to compost are stopped after three consecutive frosts and are not reinitiated until March 15 or even as late as April 15. Because there are low levels of flies present throughout the winter, 3-5 generations of flies are not exposed to the pesticide each year. Further on individual farms only one site is treated with cyromazine, either the compost or the casing but not both. This results in 1-2 generations of flies in each crop that do not develop in growing substrate treated with the pesticide. Susceptibility to cyromazine was assessed in farms experiencing higher fly populations than expected. Adult flies were collected by aspiration from mushroom growing facilities in New Castle County, Delaware, Chester County, Pennsylvania and Berks Country Pennsylvania that reported difficulty in pest control. These adult females laid their eggs on water agar where they hatched and began larval development. These first instar larvae were counted and transferred in groups of 10 to agar with cyromazine incorporated at a series of concentrations designed to produce a range of mortalities. The agar plates with larvae were dusted with soy flour to begin mixed cultures of fungi for nutrition of the larvae. Mortality was assessed over 7 days and compared to no-pesticide controls and historical data obtained during the registration process for cyromazine. None of the farms had populations of *L. mali* with LC_{50} values more than 3.5 times higher than the historical data for pre-exposure susceptibility. High fly populations were likely to have resulted from other factors than pesticide resistance although the general trend appears to be toward slightly higher LC_{50} values over time on individual farms.

Detection of Resistance to *Bacillus thuringiensis* Resistance in Gypsy moth, *Lymantria dispar*. A project between the US Forest Service (V. D'Amico) and the University of Delaware (Keil) was initiated to improve detection of incipient resistance to BT toxins in gypsy moth larvae. The approach uses voltage clamp studies of individual larval midguts, concentration-mortality studies using toxin incorporated into diet, and molecular characterization of toxin receptors in the midgut. Populations will be assayed from areas with long-standing Gypsy moth populations that have been exposed to applications of BT formulations, areas with current outbreaks, and areas with low density populations historically.

5. Submitted by (previous) member

Richard A. Weinzierl, Professor and Extension Entomologist
Department of Crop Sciences, University of Illinois
S-522 Turner Hall, 1102 South Goodwin Avenue
Urbana, IL 61801
weinzier@uiuc.edu, Ph. 217-333-6651

Insecticide resistance management work in fruits and vegetables at the University of Illinois has focused on codling moth in apples and corn earworm in sweet corn.

Control failures and high levels of fruit injury have been observed in apples because of codling moth resistance to organophosphate insecticides (azinphos methyl, phosmet, and diazinon) and pyrethroid insecticides (including fenpropathrin and esfenvalerate and possibly others). Resistant populations were first documented in southern Illinois in 2002; control failures have since been observed throughout the state. Management research has focused on evaluation of management alternatives including mating disruption and insecticides with different modes of action. Not surprisingly, mating disruption has not been successful where resistance has already led to high population densities; it has been an effective management alternative where used prior to resistance development and population buildups. Mating disruption used in annual rotations with conventional insecticides as the primary means of codling moth management could slow or prevent development of resistance to those insecticides. Field data indicate that the neonicotinoid insecticides acetamiprid (Assail) and thiacloprid (Calypso) and the growth regulator novaluron (Rimon) are effective against organophosphate- and pyrethroid-resistant codling moth populations. Growers now use Assail and Calypso (in rotation with other insecticides) for codling moth management and will use Rimon upon its registration.

Pyrethroid resistance in the corn earworm has not yet been observed to cause control failures in sweet corn production fields in Illinois or nearby states, but in small-plot evaluations of insecticides for protection of sweet corn, levels of control provided by pyrethroids have declined in recent seasons in Wisconsin and Minnesota. To determine the role of insecticide resistance in this decline, Illinois contributes collections of corn earworm larvae for colony establishment and subsequent bioassays. Bioassays using cypermethrin are conducted by Dr. Roger Leonard of Louisiana State University. Data from 2003 and 2004 indicate increasing LC50s for the Illinois populations, a trend that is paralleled in populations from Minnesota, Wisconsin, and Indiana. Bioassay data from of Midwest populations also resemble data from *H. zea* populations from Louisiana.

Because Midwest populations develop each season from moths that migrate from Gulf states, it is likely that selection for resistance by sprays applied to cotton in the south may account for resistance levels observed here.

6. Submitted by non member

Bob Hollingworth
Department of Entomology
Michagin State University
106 Integrated Plant Systems Center
East Lansing, MI 48824-1311
(517) 432-7718
rmholl@msu.edu

and member

Mark Whalon
Department of Entomology
Michagin State University
B11 Integrated Plant Systems Center
East Lansing, MI 48824-1311
(517) 353-9425
whalon@msu.edu

Development of an Education and Information Program in Arthropod Resistance Management

Justification: Insecticide resistance is a threat to the financial viability of a number of key crop production systems in Michigan with hundreds of millions of dollars at stake. Indicative of the resistance threat is that 55% of all special application or emergency exemption pesticide registrations initiated by the Michigan Department of Agriculture were based partially or completely on the loss of control due to the development of pest resistance (personal communication, R. Rosenbaum, MDA, 1997). Resistant populations of Colorado potato beetle in Michigan alone accounted for potato crop losses amounting to $16 million in 1993 (personal communication, Dr. E. Grafius, Michigan State University). It ranks as one of the more significant threats to food and health protection globally. The economic impact of pesticide resistance has been estimated at $1.4 billion to over $4 billion US annually. The number of documented resistant arthropods stood at 542 species distributed in 168 countries around the World in 2002. A key to predicting, monitoring and managing resistance is the availability of up-to-date information about its occurrence elsewhere, rates of spread, severity, the cross-resistance patterns that lead to resistance to related compounds, and the mechanisms by which resistance has occurred. Resistance considerations are also an increasingly important factor in the decision-making of pesticide regulators in evaluating the need for the registration of new compounds and the maintenance of older ones. In response, we have developed a database of arthropod resistance which can meet these information needs. This will help to prolong the effectiveness of essential chemical controls for producers, thereby permitting the continued efficient and affordable management of key pests.

Objectives:

1. Develop a searchable database of arthropod resistance to pesticides for use by pest managers and regulatory agencies.
2. Develop an expanded web-based input system to the database to allow the entry of up-to-date information on resistance by researchers and pest management practitioners, and to expand the range of relevant information collected.

Results and Accomplishments:

1. We have developed a basic database containing published cases of resistance to pesticides in arthropods. This database now contains 7,215 entries of literature citations of resistance to pesticides among arthropods (primarily insects and mites) searchable by species, compound and region of occurrence. It can be accessed at http://www.pesticideresistance.org/DB/index.html. During the last year (9/2004 through 8/2005) we had nearly 60,000 visits to use the database over the web. A visit is defined as being connected actively and using the database for 15 minutes. The visitors came from 32 countries. To the best of our knowledge, this is the only database of its kind in existence. It has also been supported by the agrochemical industry and, recently, by USDA. We still hope for funding from the World Health Organization to provide a special section on resistance to insecticides among arthropod vectors of human diseases.

2. In addition to developing and populating the basic database, considerable time has been spent to establish a web-based input system for an upgraded database which will allow researchers in Michigan and around the world to enter cases of resistance directly (after editorial review). This will include both published and unpublished results, and it will allow a much more detailed description of resistance including more specific geographical data, impact analysis, mechanisms of resistance, and cross-resistance spectra. When complete, this should allow users to obtain a detailed analysis of the current status, development and impact of resistance on a regional (Michigan, Great Lakes) or national and international basis. An initial web-based input system was developed but was found to be suboptimal during beta-testing and was unexpectedly difficult to correct. Recently this system has been completely redesigned and considerably improved. Beta-testing of this version is now underway. We anticipate making it available to the public by the end of this year. It will be available on the same website as the basic database and on the IRAC (Insecticide Resistance Action Committee of the plant protection industry) website (www.irac-online.org). An example of the use of this system to plot spatial data on the current status of resistance of a major orchard pest, the oblique banded leafroller, to the primary insecticide used for its control, azinphosmethyl, in the Great Lakes region is shown in Fig. 1 (attached).

A collateral accomplishment has been to play a leading role in the on-going revision of the international system for classifying insecticide resistance mechanisms. This system is run by IRAC and is used to develop pesticide labeling systems for resistance management purposes worldwide. This revised and more accurate system was needed for our expanded database which includes data on resistance mechanisms. The new system is available (MOA scheme 05) at the IRAC website.

Impacts: We know the database system is being used widely from the access statistics and feedback from users, but so far, it is hard to gauge its impact. The impact will develop slowly over time as entries build up, particularly through the web-based submission system. This is a long-term project with an expected and increasing impact occurring over many years.

Summary: A comprehensive database has been created which records known examples of resistance to insecticides, including Michigan and the surrounding states. This provides important information to pest managers and pesticide regulators on the occurrence, spread, and impact of resistance in order to help sustain the availability of critical tools for pest management.

Funding Partnerships: IRAC (Insecticide Resistance Action Committee) – joint industry group; USDA/CSREES; Michigan State University: Generating Research for Economic, Environmental and Ecological Needs (GREEEN).