MATING DISRUPTION FOR INSECT CONTROL: WHERE ARE WE?

Dan Mahr
Department of Entomology, University of Wisconsin - Madison
Tom Baker
Department of Entomology, Iowa State University, Ames

Introduction.

Many pests are the most damaging when in their juvenile stages. Most of our pest management practices, including the use of insecticides, target the damaging stages. Using these approaches, sometimes damage can occur between the time the pest problem is recognized and control is conducted. One novel insect control approach, "pheromone mediated mating disruption," interrupts the reproductive cycle so that no eggs or young are produced.

Pheromones are volatile chemical odors involved in communication between individuals of the same species. Lots of animals, including most insects, produce pheromones. There are several different types of insect pheromones. One type that is used in pest management is called sex pheromone. Individuals of one gender produce and liberate the chemical to attract individuals of the other sex for mating purposes. Almost every type of insect produces its own unique pheromone.

Once the chemistry of a pheromone is determined, we can use that information in several ways in pest management. Artificially synthesized pheromone is used to bait lures to trap insects. This is used to monitor flight and egg-laying periods so that controls can be more precisely timed. In addition to monitoring, pheromones can also be used to control insect populations. Although several methods have been tried, the one most widely used, and with greatest application to cranberry, is mating disruption. Although biologically quite complex, it is probably most easily explained as follows. Female moths produce a very small amount of pheromone to attract males. By artificially increasing the amount of pheromone in the field much higher than what females produce, males can not find the females. Mating does not take place; eggs are not laid; larvae are not produced.

A little history.

The science of pheromone research is very young. The chemical nature of the first insect pheromone was discovered only in 1959. But mating disruption was already being proposed as a possible control method by the early 1960s. The first successful, but very limited, field trial was conducted in 1967. Work on cranberry pests was started in 1992 in British Columbia, Canada, by Dr. Sheila Fitzpatrick, working with blackheaded fireworm. In 1996, both Dr. Fitzpatrick and Dr. Tom Baker started conducting field work in Wisconsin. Work on mating disruption of sparganothis fruitworm was started in 1997 in New Jersey by Dr. Sridhar Polavarapu of Rutgers University. A large two-year project looking at mating disruption of both species was started in Wisconsin in 1999 by Dr. Mahr of the University of Wisconsin - Madison, in collaboration with several scientists.

Target pests.

Mating disruption is still somewhat limited in scope because of a variety factors. It is probably most widely used in perennial crop situations, such as orchards, vineyards, and forests. But it also has use in annual crops, and is used world-wide for the control of an important pest of cotton. It is used mostly against a variety of types of moths. Moths are mostly nocturnal and have a great need for chemical communication. The chemistry of moth pheromones has been substantially researched, and the chemical nature of the pheromones of over a hundred species is known. Also, moth larvae are often key pests in many crops, and these key pests dictate pest control practices. In some situations, the use of conventional pesticides has been greatly reduced when mating disruption has been adopted. Mating disruption is a method approved and supported by the U.S. Forest Service for controlling the spread of gypsy moth, a serious pest of rural and urban forests. Each year, the United States treats hundreds of thousands of acres to contain gypsy moth. Where conventional insecticides are used, there is significant impact on non-target species. Mating disruption is effective and is preferred because it is so specific. Nearly 80,000 acres in Wisconsin will be treated with gypsy moth pheromone in 2001. Another important example is codling moth, which historically has been the key pest of apples in Washington state. Tens of thousands of acres are treated yearly with codling moth pheromone. Because of its selectivity, beneficial natural enemies of other pests are being conserved using this approach, and there are fewer secondary pest problems.

Benefits and drawbacks.

Interestingly, the same aspects of mating disruption that contribute to its benefits, namely its specificity and low use rates, also contribute to its drawbacks. Pheromones are not intended, in nature, to be toxic, so their toxicity is very low and they are considered to be very safe to use. In addition, they are active at very low concentrations. Even the "large" amounts that we use for mating disruption amount to only grams per acre. Because of their high degree of specificity there are very few impacts on non-target organisms such as wildlife, fish, pollinators, and beneficial insects important in biological pest control. This may result in a decreasing need for insecticidal control of pests of secondary or occasional importance that may be adequately controlled by their natural enemies. Another potential benefit to a few growers is that some types of pheromone deployment technologies are likely to be approved for organic production.

The drawbacks of mating disruption relate entirely to the cost of this technology. Because use rates are low, and crops such as cranberry are of limited acreage, there is no "economy of scale" in producing the pheromone. Costs are expected to decrease as manufacturing technology becomes more efficient and as usage rates decrease, but currently season-long control of a given pest is at least somewhat higher with mating disruption than with conventional insecticides. Because of their selectivity, a different pheromone is needed for each pest species; where pheromone technology hasn't been developed, other pest control methods are necessary. This adds to the total overall cost of pest management, especially if a farm has perennial problems with more than one type of serious pest.

Pheromone deployment methods.

Several methods have been developed to deploy pheromones in agricultural settings for mating disruption. Two different methods have been commercialized for use in cranberry. Microencapsulated sprayable pheromone has been developed and produced by 3M Canada, and, starting in 2001, will be marked through an agreement with Rohm and Haas Chemical Company. These products are formulated as liquids to be applied through conventional pesticide application equipment. They are labeled for application by aircraft, ground equipment, and chemigation. All three methods have been evaluated in our research with apparently equivalent results. Sprayable pheromone needs to be applied once or twice per generation, depending on population size and flight duration.

The second deployment method involves point-source applicators. Essentially, these are small plastic bags filled with pheromone; these are called MSTRS®. They are hung on stakes so that they are a foot or so above the tops of the vines, at a rate of eight per acre. One deployment lasts for an entire flight period.

In side-by-side research trials for the past two years, the two deployment methods resulted in statistically identical results as measured by trap captures in decoy-female traps.

Research results: blackheaded fireworm.

Based on the favorable early research in British Columbia and Wisconsin, funding was acquired to conduct two final years of research on blackheaded fireworm mating disruption. This research was conducted in 1999 and 2000.

Methods. Four farms each were chosen in central and northern Wisconsin. Each farm had one plot (replicate) each of four different treatments: sprayable pheromone, mechanical MSTRS, MSTRS Baggies, and no pheromone. Each plot was 4-11 acres. Cooperators had final say on all pest management decisions, and insecticides were used for various target pests on virtually all research plots in both years. Three types of data were gathered: pheromone trap data, sweep samples for larvae, and fruit injury at harvest.

Results. In both years and on all farms, all pheromone treatments drastically and significantly (by statistical measures) reduced the number of male moths captured in "decoy female" sticky traps. These traps were baited with special lures loaded only with sufficient pheromone to mimic the output of an individual female moth. The following graph is representative of the flight data collected during the two year period. Note that it is only from the beds that were not treated with pheromone that we had large trap catches. The numbers of fireworm on the northern farms in this study were very low, but, other than the numbers being only a tiny fraction of those from central farms, the lines are similar.

Larval populations were low in all of our research plots. There were no significant differences in either numbers of larvae in sweep samples or amount of fruit injury between any of the plots. In other words, pheromone-treated plots had no more larvae nor suffered greater injury than the standard insecticide-treated plots. However, bear in mind that pheromone plots were also treated with insecticides as necessary.

Dr. Fitzpatrick is continuing her research in British Columbia, and has been monitoring farms that are using mating disruption on a commercial scale. Her results continue to be positive, and farms that are committed to mating disruption have generally had very favorable levels of control.