TECHNICAL APPROACHES TO MATING DISRUPTION OF BLACKHEADED FIREWORM

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Introduction

In my previous discussion, "Mating Disruption: What is it and How does it Work?", I told you about pheromone-based mate location behavior in moths, and how mating disruption interferes with this behavior. I briefly described the formulations of synthetic pheromone used for mating disruption of blackheaded fireworm and explained how tests of mating disruption are evaluated. Finally, I showed results of mating disruption tests done in Wisconsin in 1996.

Here I will explain in more detail the technical aspects of taking mating disruption technology from the research trial to the farm. I will first discuss the properties of the MEC (MicroEnCapsulated) formulation of pheromone, then describe the steps involved in registering MEC. I will go step-by-step through the process of using MEC to disrupt mating of blackheaded fireworm moths in cranberries. Finally, I will discuss ways in which mating disruption might be enhanced with other pheromone-release technologies (e.g., MSTRS) or augmented with biological control agents.

The MEC (MicroEnCapulated) Formulation of Fireworm Pheromone

The MEC formulation of fireworm pheromone is a water-based suspension of the main pheromone component, Z 11 - 14:Ac, encapsulated in microscopic, polyurea-based shells. The formulation contains 8-20% water and 20% Z 11-14:Ac by weight. The polyurea-based shells, which are 25-35 microns in diameter, are somewhat adhesive and protect their contents to some degree from the sun's ultraviolet radiation. There is no sticker or ultraviolet protectant in the formulation. In the field, the polyurea-based shells degrade slowly by hydrolization, oxidation and biological degradation.

The process of formulating MEC by encapsulating Z 11- 14:Ac into polyurea-based shells is done by chemists at 3M Canada. The chemists are willing to try to improve the field performance of MEC if necessary by changing the shell size and thickness of the wall to slow the release of pheromone, or by adding stickers (latex-based adhesives) to the formulation. The polyurea-based shells are also being used to encapsulate pheromones of other moth pests of forests, grapes and cranberries (Sparganothis), and 3M is working closely with various scientists on field tests of these materials.

The MEC formulation can be applied by helicopter, fixed-wing aircraft, sprayer or through the sprinkler system.

MEC: From Research Material to Registered Product

The MEC formulation of pheromone belongs to the category of "straight-chain lepidopteran pheromones" established by the Environmental Protection Agency (EPA). As such, MEC can be used in research trials on up to 250 acres per year, so long as the total amount of active pheromone ingredient does not exceed 150 grams per acre per year. Cranberries produced in MEC-treated research plots can be marketed normally and need not be destroyed.

Registration of straight-chain lepidopteran pheromones such as MEC is supposed to be a more streamlined process than registration of other materials. Toxicity data in EPA files and in the public domain demonstrate that alcohols, acetates and aldehydes with a chain length of 11-18 carbon atoms have very low acute oral, acute dermal and acute inhalation toxicities, as well as ecotoxicites. The toxicities of these straight-chain lepidopteran pheromones are lower than the testing limits of the EPA. Therefore, minimal or no toxicology data are required for registration, making the registration process is less much costly than it would otherwise be to the registrant. Efficacy data are not required, although the registrant is required to have such data on file. Some research scientists believe that the lack of requirement for efficacy data creates a "buyer-beware" situation. However, if buyers are aware of the history of research and development of the pheromone product, there should be no surprises when the product is used in the field. Cranberry growers are a shining example of well-informed buyers.

At least two registrations must be obtained for MEC in the United States: one for the technical active ingredient (Z 11 - 14:Ac), and one for the end-use product (MEC). Three companies are involved: Bedoukian, which produces Z 11- 14:Ac; 3M Canada, which formulates the pheromone; and Ecogen, which markets the end product.

The cost of MEC to the grower has not yet been established. In my discussions with the companies involved, I have frequently heard that the pheromone is expensive but the microencapsulation technology is not. The companies realize that MEC needs to be cost-effective compared with other management options, or they won't sell any. MEC will be marketed by Ecogen under the registered tradename "NoMate BHF MEC".

Technical Aspects and Management Protocol for Using MEC as a Mating Disruptant

At the time of this writing, MEC is still a research material. It may be registered for commercial use by the summer of 1997. Here I will describe the technical aspects and management protocol involved in using MEC in research trials, with a view to commercial use.

Considerations Prior to MEC Treatment. For research trials, and for commercial use in future, the farm to be treated with MEC should be isolated. If there are adjoining farms, they should also be treated with a mating disruptant, so that area-wide management is achieved. The farm(s) to be treated should have low to moderate populations of fireworms. To determine whether populations are low to moderate, a monitoring program should be used. Pheromone trap data from the previous year, along with larval data from the current year' are used in determining if populations are low to moderate. For these reasons, it is important to keep good records from year to year. At present, we have "gut-feeling" or relative thresholds for deciding about population size. The farms with the highest trap counts and sweep samples are "high". Those that with no history of fireworm populations are "zero". Those in between, tending more toward the "zero" farms than the "high" farms, are low to moderate. If mating disruption is used on a farm with moderately high populations, insecticide applications will be needed along with MEC for two or three years, until populations are reduced.

The relative thresholds may seem unnecessarily fuzzy and imprecise. One reason that better thresholds have not yet been established is that different cranberry growing regions use different kinds of pheromone traps and larval monitoring methods. In British Columbia, where we use wing traps that can hold 300-400 males, our experience suggests that fields with 150 or fewer males per trap at peak catch have low to moderate fireworm populations. In Wisconsin and Washington, smaller delta-type traps are used and these hold at most about 200 males. Where the delta-type traps are used, low to moderate fireworm populations would probably be indicated by 100 or fewer males per trap at peak catch, but more experience is needed to support this threshold. In British Columbia, where we sample visually for fireworm larvae, experience suggests that an average of 1 larvae per 2 square feet of vines is a moderate population. In Wisconsin and Washington, where larvae are sampled with sweep nets, the threshold for a moderate population has yet to be determined. It is probably as important to know the location and number of "hot spots" (patches with many larvae) as to know whether populations are low to moderate.

Monitoring Program for Areas to be Treated with MEC. The monitoring program begins with sweep-samples or visual searches for larvae in April and May. The objective of sampling for larvae is to find out when they have hatched from eggs and where the hot spots are. The size and number of larvae found will guide the IPM manager or grower in deciding when and where to apply insecticide. The location of hot spots will indicate where extra attention is needed. (A computer mapping program called a Geographic Information System can help to map hot spots. We are developing such a program in British Columbia.) Where there are many larvae, there are likely to be many moths and, in these areas, synthetic pheromone likely will not prevent males from finding females. The hot spots are usually around field edges.

After the spring insecticide has been applied and any hot spots have been identified and treated, pheromone traps should be placed in fields. IPM managers already use pheromone traps for routine monitoring, and these should be placed as they normally would be. The lures in the delta-type pheromone traps contain 1 milligram of the three-component blend of fireworm pheromone. These "high" lures will accurately detect the beginning, peak and decline of both the first and second flights of fireworms, even after MEC treatment. The "high" lures are like super-females that males can detect even in an atmosphere of synthetic pheromone.

When the first males are caught in "high" pheromone traps, marking the beginning of the first flight, MEC should be applied. In research trials, the rate we use is 180 milliliters of MEC containing 36 grams of Z 11 -14:Ac per acre. Following MEC application, "low" pheromone traps should be placed in the fields. The "low" lures contain 0.01 milligrams of the three-component blend of fireworm pheromone. The "low" lures are like regular females that males should not be able to detect in an atmosphere of synthetic pheromone. For this reason, the "low" traps are sentinel traps. In future large-scale research trials, or when MEC is used commercially, I will probably recommend that some "low" traps be placed near known hot spots, and others away from hot spots. They should be at least 50 feet from "high" traps. I believe it is better to have the "low" and "high" traps in separate, but adjoining, fields. The specific guidelines for the number and placement of "low" and "high" traps have yet to be determined, but will be worked out in next year's trials.

The "low" traps tell us if mating disruption is working. In research trials, we compare catches in "low" traps placed in MEC-treated fields with catches in "low" traps placed in control fields. If mating disruption is working, the catches in MEC-treated fields will be zero or very low compared to catches in control fields. In future commercial use of MEC, where there will be no control fields, the numbers of males caught in "low" traps will be considered in relation to the numbers caught in "high' traps. When few or no males are caught in "low" traps and many males are caught in "high" traps, it is likely that males are flying but unable to find females. About four weeks after MEC application, the number of males in "low" traps may increase and there may still be males coming to the "high" traps. This will be an indication that males are still flying but the MEC is wearing off. At this point, the IPM manager or grower will need to decide whether to reapply MEC and cover the remaining part of the first flight, or wait and reapply at the beginning of the second flight. Based on knowledge and experience gained so far, I lean towards recommending that the first flight should be entirely covered, even if it means leaving the latter part of the second flight unprotected. As I stated in the previous paper, it may be necessary for the pheromone companies to lengthen the active life of MEC or to lower the price so that three applications can be made when necessary.

After peak catch in the "high" pheromone traps, sweep-samples or visual samples should be taken to assess the numbers of summer (second-generation) larvae present. If the IPM manager or grower decides that a post-bloom application of insecticide is warranted, it should be applied (in research trials or in future commercial use). Monitoring for larvae later in the summer, after the second peak catch in "high" pheromone traps, is not necessary unless larval populations earlier in the year have been extremely high. Females of the second flight lay mostly diapause eggs, which overwinter and hatch the following spring. If larval populations earlier in the year have been very high, there may be enough second-flight females laying enough non-diapause eggs to result in hot spots of larvae late in the season. However, if an insecticide application is being considered in late summer, one must pay close attention to the pre-harvest interval on insecticide labels.

In research trials or in future commercial use of MEC, the following three-year program should be adhered to, if possible. In the first year, monitoring and insecticide application should continue as normal, and MEC applied as suggested above. In the second year, monitoring should be done in spring and, if necessary, insecticide should be applied to control spring (first-generation) larvae. MEC should be applied, and monitoring continued as usual. Careful monitoring of summer (second-generation) larvae will determine if populations have been sufficiently reduced by mating disruption. By the second year of the mating disruption program, if populations of fireworms were low in the first year, it should not be necessary to apply insecticide to control summer (second-generation) larvae. In the third year of the program, monitoring will determine if a spring insecticide is necessary. MEC should be applied as suggested above and, by the third year, fireworm populations should be low and a summer application should not be required.

Mating disruption using MEC will reduce the need for insecticides, especially summer applications, to control blackheaded fireworm larvae. We don't yet know if the need for insecticides will be totally eliminated.

Enhancing Mating Disruption and Future Use of Biological Control Agents. In my previous paper, I said that upwind edges of fields may require extra treatment, because the wind tends to blow MEC into the centre of the field and leave pheromone-free air at the upwind edge. Similarly, helicopter-applied insecticide or MEC may not reach edges or portions of fields near marshes, houses or powerlines. In these situations, it may be helpful to use MSTRS, the Metered Semiochemical Timed Release Systems, to apply disruptant pheromone to the missed or upwind edges. For further consideration, I refer you to the discussion of MSTRS by Baker and Mafra-Neto. Other agricultural systems have similar problems. In cotton, before the plants are fully leafed out, the air circulation through the crop is good and twist-tie ropes are applied to promote mating disruption of pink bollworm. Later in the season, when plants have all their leaves and air circulation is minimal, a MEC formulation is used. For mating disruption of codling moth in Europe, orchard borders are protected by applying a double rate of controlled-release devices.

In British Columbia, Dr. Henderson of E.S. Cropconsult is studying the use of a native strain of the tiny egg parasitoid, *Trichogramma,* against fireworm eggs in late summer. This tiny wasp diapauses inside overwintering eggs. It emerges the following summer to reproduce and deposit its tiny eggs inside diapause eggs laid by fireworm females of the second flight. *Trichogramma* will likely be a valuable complement to mating disruption, and should reduce the need for insecticides even further.

Concluding Remarks

We are making steady, straightforward progress toward the use of mating disruption and fewer applications of insecticide to control the blackheaded fireworm of cranberries. The microencapsulated, sprayable formulation of fireworm pheromone is easy to apply, and may be improved if necessary by modifying the size of the microcapsules or the thickness of their polyurea-based walls. Registration of the MEC formulation of pheromone is not far off. MEC will be best introduced to on-farm use through a three-year program, in which MEC is used in addition to insecticides the first year, then in place of the summer insecticide treatments in the following two years. A thorough management protocol, involving monitoring of larvae and pheromone trapping of moths, is the cornerstone of this program. Accurate, up-to-date information about the numbers and locations of fireworms will show where mating disruption is effective and when insecticides need to be applied.

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