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Pheromone mating disruption: Novel, non-toxic control of the European corn borer

Abstract: *The European corn borer is one of the most damaging insects in Iowa cornfields, causing more than $100 million in crop losses each year. In this project, the sex attractant pheromone of the European corn borer was used to obstruct the ability of the adult male moths to locate females for mating. In the first year, efforts focused on mating disruption in a small area, while in the second year dispensers were deployed on a larger scale and evaluated for efficacy.*

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$29,340 for year one
$37,232 for year two

Background

European corn borer *(Ostrinia nubilalis*) larvae feed on the leaves and tunnel into the stalk, ear shank, and ear of corn plants. Depending on the stage of the corn plant, there is a 6 percent yield reduction for each of the first six European corn borer larvae that bore into the stalk. The combined losses due to first and second generation European corn borer average 15 bushels an acre in Iowa corn.

Although European corn borer larvae are intimately associated with the cornfields, once they turn into adults, they migrate from the cornfields to tall, grassy areas on the edges of the fields where they aggregate. It is in these aggregation sites that virgin European corn borer females release sex pheromones to attract males for copulation. The mated female moths leave the aggregation sites to lay egg masses on susceptible corn plants in the vicinity.

In Iowa alone, annual crop losses to this pest approach $100 million. However, *O. Nubilalis* is considered the most underscouted and undertreated insect of corn. Methods available for its control, including the use of chemical and microbial insecticides, have not proved very satisfactory. Basic sex pheromone research on this species is among the most complete of any moth species. However, virtually no research had been conducted on the possible use of sex pheromones to control the European corn borer by disrupting the mating process.

Project objectives were to:
- Quantify the amount of pheromone necessary to promote male attraction and disruption to the pheromone sources,
- Adapt the Shin-Etsu rope release technology to the pheromone systems of the European corn borer,
- Determine the density of pheromone rope dispensers needed to achieve European corn borer mating disruption in grassy areas,
- Evaluate European corn borer oviposition rates and larval damage to corn in fields adjacent to grassy areas with pheromone disruption systems, and
- Test the strategy of using a high-release, low-longevity pheromone dispenser to preferentially target the first generation of European corn borer.

Approach and methods

Pheromone dispensers The sex pheromone of the Iowa strain of the European corn borer was distributed via two different dispensers. Shin-Etsu formulation ropes (plastic twist-on ties) were spaced 2 m apart in grassy areas within cornfields**.** The MSTRS™ (metered-aerosol-spray-pad dispenser) developed at Iowa State University also was used. In 1996, this pressurized canister was used to deliver an aerosol, but in 1997 a non-pressurized "pump" version was used to dispense the pheromone spray. A timer mechanism in the machine activated the spray discharge mechanism to release a specified spray frequency per hour at a particular period during the night. A pad was added to this machine to capture the spray and release the pheromone.

The MSTRS™ devices could produce 6,000 recharging sprays of similar strength. The spray time interval, ranging between 5 and 25 minutes, could be varied and in addition, the timer mechanism could program the MSTRS™ to spray pheromone only during a particular time of day, such as during the moths' active period. This ensured that pheromone would not be wasted by sprays being discharged during the daytime when the corn borer is not sexually active.

The MSTRS™ devices were programmed during the first moth flight to emit puffs of pheromone every 25 minutes for 12 hours of the day, between the hours of 6 p.m. and 8 a.m. This corresponded with the active times for *O. Nubilalis.* During the second flight, a shorter span of daily emission but with higher emission frequency per hour was utilized by setting the MSTRS™ to emit every five minutes between 8 a.m. and 2 a.m.

Field locations and experimental design Experiments were conducted at three locations on commercial farms near Ames. Three grassy areas adjacent to cornfields were selected at each location. One plot at each location was used for the MSTRS™ and rope treatments, respectively, and the third served as the check plot. At each location, the check plot was sited at least 2 miles away from the treated plots to minimize the potential effects of drift from the pheromone plots. The rope and MSTRS™ plots were either contiguous or located no more than 0.6 acres from each other.

Assessment of mating disruption Two parameters were used to assess pheromone disruption: 1) numbers of males captured in wing traps, and 2) mating status and mating frequency of free-flying females captured in treated versus untreated fields. Two wing traps baited with the pheromone used in the MSTRS™ were deployed in the middle section of each treated plot, as well as in the check plots. Trap catches were counted every two to three days.

After checking for male trap catch on a given sampling day, workers captured free-flying *O. Nubilalis* females by walking through the grass and using a net to collect any flying females that were disturbed. Collection of females was done for a period of 15 minutes per plot every two days.

Each time a male moth successfully mates with a female, he delivers the sperm in a chitonous packet called a spermatophore. The spermatophore remains in the female's reproductive tract even after all the sperm is used and even when the female mates again, obtaining more spermatophores. Thus, the number of spermatophores in a female's reproductive tract is a direct measure of how many times she has mated with males in the area. Females collected from the grassy plots were preserved in glass vials containing 70 percent ethanol, and were later dissected under the microscope at 10x, and examined for presence and number of spermatophores.

Results and discussion

A significant disruption of pheromone source location was achieved by both dispensers at all three locations during the first and second flights of adults. Disruption of pheromone source location in the MSTRS™ plots averaged 97.3 percent and 96.7 percent during the first and second flights, respectively. This level of disruption was much similar to that found in the rope-treatment plots, 96.6 percent (first flight), and 96.7 percent (second flight).

Levels of disruption of trap catch were not significantly different among the locations.

A significant reduction in the percentage of females that had mated was recorded for females captured in the MSTRS™ plots during the first flight. No telling effect on location was noted. While approximately 97 percent of females captured in the untreated check plots during the first flight had mated at least once, about 20 percent of the females captured in the MSTRS™ plots and 13 percent of the females in the ropes plots remained unmated throughout the first flight season. The same trends of reduction in the percentage of mated females in pheromone-treated fields were recorded during the second flight, although these were not significant. Analysis of the data collected on a day-to-day basis shows that a very high (up to 50 percent) level of mating disruption was achieved in pheromone-treated fields during the beginning of the first flight. However, as the season progressed, the proportion of mated females in these treated plots increased and the field population also increased during this period.

In addition to the approximately 15 to 20 percent reduction in the number of mated females in both the MSTRS™ and rope plots recorded during this study, significant decreases in the frequency of mating per female also were recorded for first- and second-generation *O. Nubilalis* females captured in pheromone-treated fields. Mating frequency was reduced early in the flights over disruptant plots and seemed to stay at lower levels throughout the flights. On average, each female captured in the untreated check plots during the entire study had mated twice. This was significantly higher than the 1.5 and 1.57 average number of matings recorded in the MSTRS™ and rope fields, respectively.

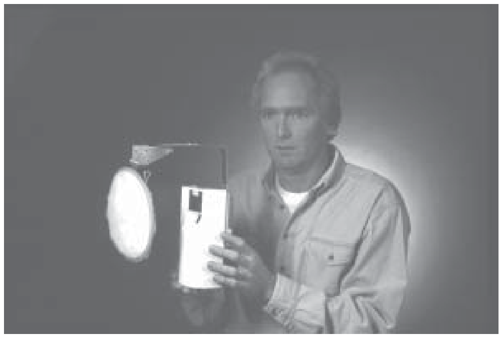
A close look at the data suggests that both dispensers seemed to fare better in the first location than in the other two, especially during the second flight. The better performance may be attributed to the unique landscape for the pheromone in this location. Also, this is the one location in which both types of dispensers were deployed next to each other along the same long strip of grass.

It remains to be seen whether the significant, but modest reduction in mating frequency of females in pheromone-treated plots could translate into reduction in oviposition of *O. Nubilalis* and reduced damage. A laboratory study was performed to investigate the effects of lower frequency of mating and delayed mating on fecundity and fertility of corn borer females. These experiments meshed with field results showing that female corn borers that mated at least twice had a significantly higher fecundity (630 eggs/female) and fertility (77.5 percent fertile) compared with once-mated females (540 eggs/female and 64.9 percent fertile). In addition, multiply-mated females deposited a significantly larger portion of their egg complement relative to singly-mated or unmated females.

Females that experienced a three-day delay in first mating showed a significant reduction in fecundity (437 eggs/female) compared with females that mated soon after emergence (591 eggs/female). A one-week delay in mating further reduced fecundity and fertility. Furthermore, all of these reductions in fertility and fecundity due to lower frequency of mating and delay of mating took place without other field mortality effects that could further enhance the effects of mating disruption on corn borer population suppression.

Conclusions

The level of mating disruption achieved in the current study is encouraging since it was achieved in small plots requiring mated females to move only short distances from the untreated to treated portions of the grass, especially within the strips that were contiguous with the treated portion.



Tom Baker with MSTRS™ machine

One key consideration when using widely-spaced, strong sources of pheromones for mating disruption is that the geometry of deployment of such a low number of devices is important. It must be considered that the smaller the plot, the greater the amount of edge there is to protect relative to the interior area of crop. In principle, the strong, widely-spaced dispenser technologies should work better over a very large, regularly-shaped area where there will be fewer pheromone-plume-free holes along the edge.

Use of the correct pheromone blend should be even more important with widely-spaced, high-emission rate dispensers, which will more likely depend on the attraction of males from far downwind in order to achieve optimal results. Another consideration will be whether the plumes need to travel long distances below canopy level (as in orchards) compared to above the canopy level (as for field crops). The within-canopy movement could dissipate the pheromone plume strength through adsorption on the foliage, as well as by shearing the originally emitted pheromone strands into finer, less-concentrated strands.

Impact of results

Further measurements are needed if pheromone mating disruption involving traditional technologies as well as the MSTRS™ or puffers or even other new types of high-emission rate, widely spaced dispensers is to continue to gain increased usage as an Integrated Pest Management tactic. It is essential that an assessment of their efficacy include actually measuring the mating frequency of freely flying females in addition to the amount of egg-mass deposition or crop damage assessments. It also will be crucial to account for other factors that affect the ability to measure success, such as whether area-wide or smaller-plot local applications were used.

With the increasing use of transgenic Bt corn, there are opportunities for pheromone-mating disruption to play an important role in *O. nubilalis* pest management. Area-wide use of widely spaced retrievable mating disruptant dispensers such as MSTRS™ could provide a way to not only help suppress populations of European corn borer on non-Bt corn hectarage, but also could help preserve susceptibility of corn borers to Bt corn by reducing mating between any resistant adults that may emerge from Bt corn. Concurrent use of mating-disruption tactics therefore could complement Bt corn plantings by slowing the development of resistance. If significant reduction of mating can be achieved in grassy areas where both susceptible and resistant adults may aggregate, then benefits beyond crop damage reduction in resistance management may be significant. Indeed, in other transgenic crops, such as cotton, pheromone mating disruption should be considered as a possible co-treatment for slowing the onset of resistance.

Education and outreach

Several scholarly publications discussing the project have appeared, with one set to appear in the *Journal of Insect Physiology*. This project was the subject of feature stories in the ISU College of Agriculture's 1996 annual report, the *Leopold Letter*, the Fort Dodge and Iowa Farm Press newspapers.

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