FIRST ATTEMPTS AT DISRUPTING SEX PHEROMONE COMMUNICATION IN THE BLACKHEADED FIREWORM IN WISCONSIN USING A NOVEL CONTROLLED-RELEASE DEVICE

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Abstract

The results of experiments using a novel, controlled release system, called the Metered Semiochemical Timed Release System, or MSTRS™, for disrupting mating or pheromone source location by males of the blackheaded fireworm are described. In this system, pheromone is emitted at rates ca. 20 times higher than existing dispensers. Fewer dispensers are therefore needed for effective disruption and they can easily be deployed in and around cranberry beds and retrieved at the end of the season for re-use in subsequent seasons. Unlike existing systems, MSTRS allows the user not only to choose how frequently pheromone is discharged but also to regulate the die1 periodicity of this emission to correspond to the time of activity of the adults of the targeted pest insect. In addition, the pheromone is protected from oxidation and UV degradation since it is housed in pressurized canisters.

Introduction

There has been much progress over the past ten years or so in improving the release-rate characteristics of some of the most commercially successful pheromone mating disruption formulations. However, none of the existing controlled-release technologies allow the user to actively alter the release rate. The existing systems are all passive systems that emit pheromone continuously according to ambient wind and temperature conditions.

We recently described a new system, called Metered Semiochemical Timed Release Systems, or MSTRS™ (Mafra-Neto and Baker, 1996a), in which an aerosol canister containing pheromone is placed in a machine and an aerosol spray-burst is emitted onto a large pad on a timed basis (e.g., every 15 minutes). Pheromone is then emitted from the pad at extremely high rates, ca. 20 times higher than most existing dispensers. Fewer dispensers are therefore needed for effective disruption. Unlike existing systems, ours allows the user not only to choose how frequently pheromone is discharged but also to regulate the die1 periodicity of this emission to correspond to the time of activity of the adults of the targeted pest insect. Pheromone is not wasted by being passively emitted from the reservoir during periods of the day when the insects are inactive. In addition, the pheromone is protected from oxidation and UV degradation since it is housed in pressurized canisters.

Significant work on disrupting mating of this serious pest of cranberries has been undertaken by Fitzpatrick et al. (1995), and has shown much promise for this technique, using Shin-Etsu ropes or Ecogen Spirals (Scentry/Ecogen, Billings, Montana) with a total application rate of ca. 70 gm pheromone/acre. One problem with these dispensers, however, is that they must be retrieved at the end of the season due to the potential for the buildup of environmentally unacceptable levels of plastic in the cranberry marshes.

The placement and retrieval of a high number of point sources on the cranberry beds would also result in unacceptably high foot traffic, which would damage the delicate, slow-growing plants. The use of MSTRS devices would be advantageous because only a few dispensers would be necessary per acre, mostly deployed around the perimeter of the beds where they could be fairly easily retrieved without incurring crop damage. Furthermore, the MSTRS can be stored for re-use in subsequent years.

Materials and Methods

We used MSTRS devices and affixed them to wooden stakes at a height of 20cm above the cranberry plant canopy. The canisters contained either 8 or 20 gm of *R. naevana* pheromone, which is a blend of (Z)- 11-tetradecenyl acetate, (Z)- 11-tetradecenyl alcohol, and (Z)-9-dodecenyl acetate in a ratio of 9:3:1 (McDonough et al., 1987; Slessor et al., 1987). These components were purchased from Bedoukian Research, Inc., diluted in reagent alcohol to a weight of 40 gms solution, and formulated with propellant in the cans for a total weight of 160gms inside each can.

Devices containing the 8gm of pheromone in the cans were deployed at a density of S/acre along and within cranberry beds or series of beds that averaged ca. 3 acres in total area. Two configurations were used for this density of devices, one being a perimeter-only treatment with MSTRS spaced ca. every 100 ft. at the edges of the beds. The second consisted of the same density of devices and amount of pheromone per acre overall, but three devices were removed from the perimeter (remaining devices being more widely, but evenly spaced) and instead were deployed across the centers of the beds, bisecting them longitudinally. The cans containing 20 gms of pheromone were deployed at a density of 2/acre along the same sized beds, such that there were only 9 machines around the perimeter of the 3-acre beds.

Treatments as well as 3-acre control plots several hundred meters from the treated beds were replicated 3 times in different grower locations within ca. 30 miles of each other in the cranberry growing region near Babcock, Wisconsin. During the first flight of moths, the machines were programmed to discharge every 15 minutes, 24 hours per day. During the second flight, they were programmed to discharge in the night-only mode, in which a light-sensor triggers them to begin discharging every 15 minutes only around sunset, and they continue to do so until triggered to stop by the meter around sunrise.

Disruption was assessed by counting the number of males captured in wing traps baited with 10 µg of the above pheromone blend on a rubber septum, a lure that has been shown to be comparable in attractancy to females (Fitzpatrick et al., 1995). The wing traps were placed, 3 per 3-acre plot, at locations in the interior of the marsh, and not closer than-100 ft. from the nearest machine. The number of males captured was assessed weekly, the males removed, and trap bottoms replaced as needed.

Results and Discussion

During the first flight, disruption averaged 99% in the first grower location, and 95% in the second grower location (Figs. lA,B) regardless of the MSTRS deployment pattern. However, disruption averaged only 82%, 80%, and 57% for the S/acre cross pattern, the 2/acre perimeter pattern, and the S/acre perimeter pattern, respectively, in the third grower site (Fig. 1C), which had a history of very high populations of fireworm and low yields compared to the industry average in the region. During the first flight, captures in the control plots at the three sites averaged 52.3,73.4, and 63.3 males per trap per week over the six-week flight period. Unlike the treated beds in the first two grower

locations, the 3 acres comprising the treated areas for each of the three MSTRS deployment arrays in the poor-disruption location (Fig. 1C) were comprised of six, 0.5-acre beds each separated grass-covered dikes. Thus, it is possible that the aerial transport of pheromone plumes from the MSTRS over the disruption areas could have been disturbed in these plots, resulting in lower efficacy of disruption. In all three locations, the MSTRS devices were deployed at the same time as a sprayable formulation of pheromone (microencapsulated, called MEC; Scentry/Ecogen) was applied directly to the cranberry beds; the MSTRS were as effective in disrupting pheromone source location as the sprayable formulation in all plots (Sheila Fitzpatrick, personal communication).

During the first flight, sweep samples were taken in most plots to assess larval infestation levels. These samples included our check plots used for trap counts in the beds not treated with disruptant shown in Fig. 1, and in some cases in addition included other beds in the same location that were not used for any pheromone trapping whatsoever. These we have called "normal practice" plots. As can be seen in Table 1, for the first, second, and third grower locations the larval infestation rates were not significantly lower in the MSTRS-treated plots than in the check plots. The check plot sweep samples were at or near zero in most cases, and so it would be difficult to reveal an effect of the disruptant on larval density in this experimental setup.

However, it is clear that our data reveal no reduction in the population density of the next generation of larvae, and therefore no reduction in mating or egg-laying significant enough to control this insect in these plots. This may be because the moths appear to be highly aggregated in the beds, and the appropriate measure of disruption would be to assess the ability of the disruptant to prevent mate-finding within these aggregations, which is the distance that males must naturally move while following a female's pheromone plume. If the adult moths are in fact highly aggregated like this, then it is highly unlikely that we would fortuitously place our three monitoring traps in each bed in the centers of such aggregations. Therefore, even in the check plots we are measuring the traps' ability to lure males out of their aggregations, and hence in the MSTRS disruption plots (and MEC plots or any other disruptant formulation) we are only measuring the ability of the pheromone disruptant to reduce the attraction of males out of the aggregations, not the ability of males to locate pheromone sources (such as females) within an aggregation. This situation would need to be addressed in future experiments by attempting to place monitoring traps appropriately, and of course, by using the most stringent measure of successful disruption, reduction of mating, by freely flying females as assessed by examining captured females for the presence of spermatophores injected into females by males.

During the second flight, in which the night-only emission of pheromone was tried, disruption was not as good as during the first flight in most plots, but still averaged 86.7% in the first location overall for all MSTRS configurations (Fig. lA), 85.4% in the second location (Fig. lB), and 53.8% in the third, poorest disruption location (Fig. 1C). Our measurements of the emission rates from the pads during the daytime when they are not being recharged shows that after 14 days of night-only emission, the pads from the MSTRS containing cans with 8 gms of pheromone release Z11-14:Ac at 8 µg/minute during the first three hours of daylight, and then by nightfall this rate diminishes to 2.5 µg/minute. It is not clear exactly when during the day (or night) that *R. naevana* mate, but it is possible that the night-only discharge and slow diminution of emission rate from the pads during the day may be sub-optimal compared to 24-hr discharge as during the first flight. On the other hand, population levels may have been somewhat higher during the second flight and caused a poorer percentage disruption of male attraction to traps. The higher adult population levels might not be reflected in the check plot capture levels if the

traps themselves are at or near saturation when accumulation of scales from 100- 150 males would prevent efficient capture of further males entering the traps.

On the other hand our results are encouraging in this first attempt at using MSTRS on this species, in that they show that a relatively few MSTRS per acre can effectively disrupt pheromone source location by *R. naevana* at levels of 98% disruption for an entire flight period on 3-acre cranberry beds. The machines proved to be highly durable, and examinations of the batteries and the ability of the machines to produce sprays during the entire season showed that greater than 98% of the machines and batteries were unimpaired and functioning perfectly all season long. This was encouraging since many of the beds were spray-irrigated and regularly drenched the machines and pads, and in addition, the usual summer thunderstorms with high winds occurred in the area.

It is likely that the geometry of deployment of such a low number of release devices is important, and it must be considered that the smaller the plot, the greater the edge area there is to protect relative to the interior area of crop. In principle, the MSTRS technology should work better over a very large, regularly shaped area where there will be fewer pheromone-plume-free holes along the edges. Also, dispersion of the pheromone plumes will probably be aided by deploying the devices on the grassy banks of the dikes rather than on the beds themselves, as was done this time.

Finally, it must be considered that the efficacy of widely-spaced dispensers such as these, whose plumes need to sweep for tens, and perhaps hundreds of meters horizontally over the crop canopy to both attract and habituate males sufficiently that they are prevented from mating, will likely be more dependent upon ambient meteorological conditions than will be numerous lower-emission-rate point sources spaced only meters apart throughout the crop. This vulnerability may be accentuated for species that mate during the daytime, when adiabatic lapse rates are highest, and unstable, rising air can carry plumes from disruptant dispensers up and away from the canopy.

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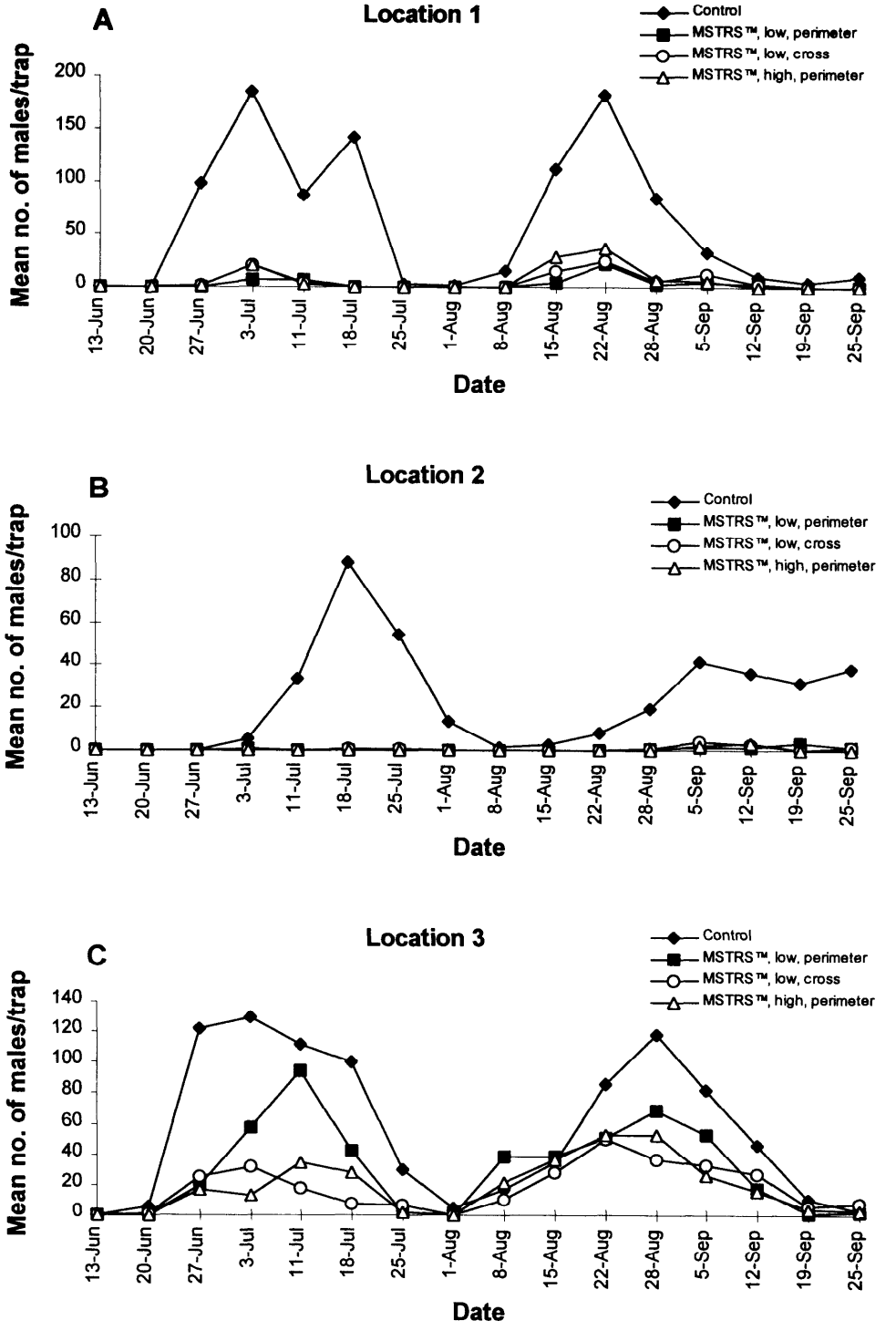

Figure 1. Mean capture of male blackhead fireworm e three locations in Wisconsin in which either 2 or 5 MSTRS™ devices per acre were deployed. The devices were activated before the first flight began and continued to release pheromone throughout the flight (ending August l-8) from either 20-gm cans (2/acre) or 8-gm cans (Uacre). During the second flight the MSTRS were programmed to release pheromone onto the pads only at night.

Table 1. Infestation rates of blackbeaded fireworm as assessed by sweep samples taken from the same plots (locations 1, 2, and 3) as illustrated in Figure 1.

Location 1	Date			
Treatment	7/15-7/18	7/22-7/25	7/29-7/31	8/5
Control	0.9 ± 0.6	0.1 ± 0.4	0.0 ± 0.0	0.0 ± 0.0
MEC	3.0 ± 1.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
MSTRS™, Low, Perimeter	2.0 ± 0.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
MSTRS™, High, Perimeter	0.8 ± 0.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
MSTRS™, Low, Cross	1.0 ± 0.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Normal Practice	0.3 ± 0.6	1.7 ± 1.5	0.0 ± 0.0	0.0 ± 0.0

Location 2	Date			
Treatment	7/15-7/18	7/22-7/25	7/29-7/31	8/5
Control	0.0 ± 0.0	0.6 ± 0.7	0.0 ± 0.0	—
MEC	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	—
MSTRS™, Low, Perimeter	0.0 ± 0.0	0.3 ± 0.8	0.0 ± 0.0	—
MSTRS™, High, Perimeter	1.0 ± 1.7	4.0 ± 4.0	0.0 ± 0.0	—
MSTRS™, Low, Cross	0.0 ± 0.0	4.7 ± 3.8	0.0 ± 0.0	—
Normal Practice	0.0 ± 0.0	2.0 ± 1.4	0.0 ± 0.0	—

Location 3	Date			
Treatment	7/15-7/18	7/22-7/25	7/29-7/31	8/5
Control	5.3 ± 6.7	7.3 ± 6.8	0.0 ± 0.0	0.0 ± 0.0
MEC	1.5 ± 2.8	3.6 ± 5.2	0.5 ± 1.0	0.7 ± 0.8
MSTRS™, Low, Perimeter	5.5 ± 4.4	9.0 ± 8.4	2.0 ± 2.7	1.7 ± 1.7
MSTRS™, High, Perimeter	5.0 ± 4.2	7.5 ± 0.7	0.0 ± 0.0	0.0 ± 0.0
MSTRS™, Low, Cross	0.8 ± 1.0	2.5 ± 1.7	2.0 ± 2.7	2.5 ± 2.1
Normal Practice	—	—	—	—