FURTHER EVALUATION OF MATING DISRUPTION AS A PEST MANAGEMENT TOOL FOR INDIANMEAL MOTH IN ORGANIC DRIED BEANS

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The Indianmeal moth *Plodia interpunctella* Hübner is an economic pest of dried beans in storage, despite the fact that dried beans are poor hosts. Conventional dried beans have been protected by regular application of materials such as DDVP or pyrethrins via fogging systems; however, in the corresponding organic product line this is not a viable option. Here we present efficacy and economic data from an observational study in progress, and suggest that: 1) mating disruption has the potential to be a practical means of pest management for the Indianmeal moth in poor hosts such as dried fruit and dried beans; 2) that this method might not be as suitable in commodities that support faster development of this pest; and 3) that new monitoring methods are needed to support the use of mating disruption in commodities where it has greater potential to support population growth.

Materials and Methods

Storage area. A warehouse in Sutter CA containing organic dried beans was monitored and treated. Details concerning dimensions and contents are given with Figure 1. Mating disruption was initiated beginning in May, and all commodity was moved into this warehouse at the end of July.

Mating disruption. Mating disruption was attempted using CheckMate membrane emitters (Suterra LLC) placed ca. April 29 as described in Table 1. A previous study demonstrated that the single component (Z,E)-9,12-tetradecienyl acetate (ZETA) disrupts mating with efficacy equal to that of a blend of components more representative of the blend released by the calling female (reference 2, Table 4).

Monitoring. Indianmeal moth prevalence and response to pheromone were monitored on a weekly basis using flight traps baited with emitters containing ZETA, mating assays, and oviposition traps, arranged as shown in Fig. 1. Monitoring with flight traps began on Mar 18 2003, using Pherocon IC traps baited with IMM+4 lures (Trécé Inc., Adair, OK) changed every 2 weeks. Mating assays consisted of nested round plastic pint cups suspended beneath a Pherocon IC trap top, with the upper half of the inner cup coated with Fluon. The Fluon-lined cups contained 3 unmated females with the ends of one pair of wings clipped. These females were placed in the trap for up to 7 days and then returned to the laboratory for determination of mating status by dissection. Mating data are shown starting in July. Oviposition traps were constructed similarly to the mating assays except that a single cup containing about 150 ml of Indianmeal moth bran

diet was suspended from the trap top. Diet was changed every week starting Mar 18, 2003, cultured ca. 4 weeks at 26EC 16:8 L:D, and examined for Indianmeal moth.

Results and Discussion

Efficacy. Flight traps and mating assays (Table 2) show that individual Indianmeal moth adults were captured outside in the dump pits on two separate weeks in the spring, before the organic commodity was moved into the protected area. Three of 8 females were mated and six adults were captured in the outside traps in August (Table 2) attesting to increased prevalence outside warehouse 1 at that time. In addition 1 female was found mated inside the protected area in July, and individuals were captured in two of the five flight traps inside the protected area in August. No Indianmeal moth were recovered from any of the oviposition cups up until July 22, the latest that had been cultured and examined at this writing.

Economic considerations. Mating disruption was much more economical compared to the fogging practice it is intended to replace in this instance (Table 3). In scaling mating disruption to industrial proportions we have reduced the rate used by an order of magnitude compared to previous researchers (Table 4). If a release rate comparable to these previous studies is used, then costs are similar or slightly higher for mating disruption.

Limitations. *1) Initial population density.* In the Indianmeal moth as in other lepidopterans, mating disruption works better with a low initial population density. Thus, this practice is better viewed as a preventative rather than a control measure, and would ideally be in place before commodity is moved into a clean, empty storage area and/or in spring as daily average temperatures rise.

2) Development rate. The Indianmeal moth is a pest of a wide variety of commodities, and develops much more quickly on some than others. In those in which development is slower, individuals from eggs laid at the same time emerge at widely different times. Since the Indianmeal moth adult is short-lived and has a very short time in which it can mate and produce offspring, commodities supporting slower development, such as dried beans and dried fruit, should maintain a lower adult population density compared to commodities like nuts and grain, which support rapid development. *3) Monitoring.* Currently pheromone-baited sticky traps are widely used for monitoring for the Indianmeal moth. While moths captured in such traps are cause for concern either in the presence or absence of mating disruption, in the presence of mating disruption the absence of moths captured in such traps is not as strong an indicator of the absence of infestation in the stored commodity. Thus the development of alternative practical detection technologies, such as immunological assays for eggs or female attractants, would assist the development of mating disruption as a practical control technology.

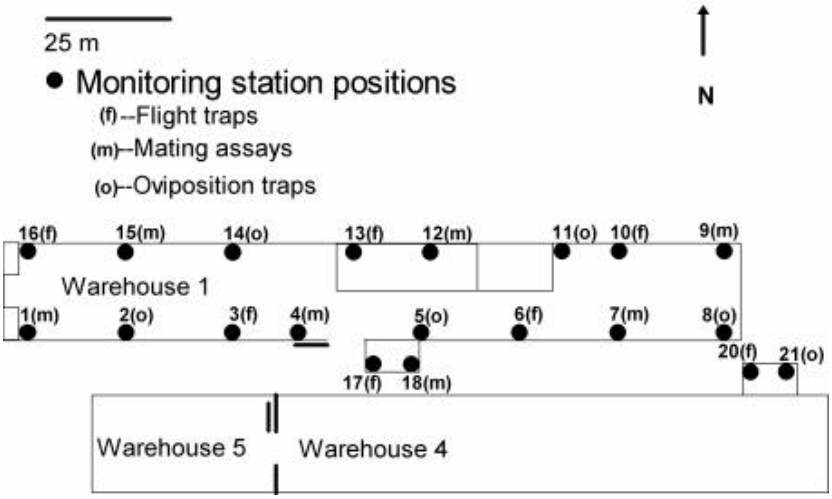

Figure 1. Floor plan for the organic dried bean storage area, Sutter, CA. Warehouse 1 is 15.2 m wide, 53.9 m long, 5.3 m high at the sides and 8.7 high in the middle; i.e., a volume of 7,142 m^3. Beginning in late July, contents included dark red kidney, black turtle, cranberry, alubia, and navy beans comprising ca. 8 tonnes of commodity in 1.2 m x 1.2 m x 1.2 m cubic steel bins and ca. 150 tonnes of 25-kg sacks, shrink-wrapped in pallets of 40. The structure near trap positions 11-13 is a pair of mills used for processing and packaging dried beans, and is a source of much dust. Warehouse 5 contained finings (debris cleaned from dried beans and sold as animal feed) until mid-July. This was considered to represent a potential source of Indianmeal moth infestation, despite the fact that fogging was used to suppress population in this area.

Table 1. Characteristics and distribution of CheckMate™ Emitters containing ZETA

Emission rate per device:	0.3 mg/day
Estimated useful life:	200 days
Emitters per unit area:	40 per 100 m^2 (40 per 1,000 ft^2)
Emitters per unit volume:	7.5 per 100 m^3 (2.13 per 1,000 ft^3)
Distribution:	Approximately every 1.31 m along lateral supports located 1.14, 2.27, 3.56, and 4.54 m above the ground along the south and north walls

Table 2. Males in flight traps and observations from mating assays

Location	Trap ID Number	Apr(4 [a])	May(5)	June(4)	Jul(5)	Aug(4)
Inside, south	3	0	0	0	0	1
	6	0	0	0	0	1
Inside, north	10	0	0	0	0	0
	13	0	0	0	0	0
	16	0	0	0	0	0
Outside	17	2	0	0	0	0
	19	0	0	0	0	2
Inside, south	1	-	-	-	0/6[b]	0/9
	4	-	-	-	0/12	0/9
	7	-	-	-	0/12	0/9
Inside, north	9	-	-	-	0/12	0/9
	12	-	-	-	1/12	0/9
	15	-	-	-	0/12	0/9
Outside	18	-	-	-	0/12	0/9
	20	-	-	-	0/12	3/8

[a]Number of weeks sampled

[b]Number of females with spermatophore/number of females recovered for that month

Table 3. Comparison of materials costs for 200 days for fogging and mating disruption practices used

Practice	Cost per m^3
Mating disruption with membranes at present rate	$0.038
Fogging with DDVP	$0.260

Table 4. Comparison of release rates used for disruption of Indianmeal moth mating with ZETA

Location and reference	Amount used (mg/d)	Volume treated (m^3)	Rate used ($mg/m^3/d$)
Gainesville FL[1]	17.9	89.3	0.20
Ames IA[2]	144	126	1.14
Lund Sweden[3]	7.2	15.6	0.46
	72	15.6	4.61
	360	15.6	23.04
Patterson CA[4]	40.3	2,294	0.02
Sutter CA[5]	206.3	9,218	0.02

[1] **Sower, L. L., and G. P. Whitmer. 1977.** Population growth and mating success of Indian meal moths and almonds moths in the presence of synthetic sex pheromone. Environmental Entomology 6: 17-20.

[2] **Fadamiro, H. Y., and T. C. Baker. 2002.** Pheromone puffs suppress mating by *Plodia interpuntella* and *Sitotroga cerealella* in an infested corn store. Entomologia Experimentalis et Applicata 102: 239-251.

[3] **Ryne, C., G. P. Svensson, and C. Löfstedt. 2001.** Mating disruption of *Plodia interpunctella* in small-scale plots: effects of pheromone blend, emission rates, and population density. Journal of Chemical Ecology 27: 2109-2124.

[4]**Burks, C. S., J. R. McLaughlin, J. R. Miller, and D. G. Brandl. 2001.** Mating disruption for control of the Indianmeal moth in a warehouse, pp. 3 pages. *In* G. Obenauf and R. Obenauf [eds.], 2001 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. Methyl Bromide Alternatives Outreach, San Diego, California.

[5]Present report