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DETERMINING THE EFFICIENCY OF SEX PHEROMONES IN CONTROLLING THE PINK BOLLWORM, *PECTINOPHORA GOSSYPIELLA* (SAUNDERS) (LEPIDOPTERA: GELECHIIDAE), IN COTTON FIELDS IN ISRAEL1

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ABSTRACT

Hollow fiber and microencapsulated formulations of the sex pheromone (a 1:1 mixture of *(Z,Z)* and *(Z,E)-7,* 11-hexadecadienyl acetate) of *Pectinophora gossypiella* (Saunders) were tested as to their efficiency in controlling the pink bollworm in cotton fields in Israel. The treatments tested were: pheromonal applications together with pesticide treatments as required; pesticide treatments alone; and pheromonal applications alone. The criteria used to assess treatment efficiency included number of males captured in pheromone traps, number of infested flowers and green bolls, mating status of females, and number of mating pairs collected during night scoutings. Successive pheromone applications gave good trap shutdown. Larval infestation in both flowers and bolls was suppressed in the treated plots as compared with control plots. Shortening the intervals between pheromone applications improved mating disruption efficiency. *KEY WORDS: Pectinophora gossypiella,* pink bollworm, cotton, pheromones, Israel.

INTRODUCTION

The pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) is a major pest of cotton in Israel, especially *in* the Bet She'an Valley. PBW pheromone traps have been widely adopted in Israel to monitor pest populations in cotton in order to achieve better control (Neumark and Teich, 1971; Shoham, 1985). Pheromone in hollow fiber may be applied for mating disruption (McLaughlin & Shorey, 1972; Shorey, 1974). The hollow fiber formulation (NoMate PBW) was the first commercial pheromone formulation used for direct control of an important agricultural pest (Brooks et *al.,* 1979). Large-scale experiments (Critchley *et al.*, 1983, 1985) have demonstrated its practical value for control of the PBW. The first attempts to control cotton pests in Israel by pheromone application were made on the PBW (Chen *et al.*, 1978) and on *Spodoptera littoralis* (Boisduval) (Kehat *et al.*, 1983).

In the present study two PBW pheromone formulations — hollow fiber and microencapsulated — were tested as to their efficiency in controling the PBW in cotton fields in Israel.

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MATERIALS AND METHODS

The tests were carried out in the Bet She'an Valley on ten pairs of plots of the Pima variety and of the Acala variety (Table 1). The sex pheromone (a 1:1 mixture of (*Z,Z*) and (*Z,E*)-7,11-hexadecadienyl acetate) in hollow fiber formulation (NoMate PBW produced by Sandoz; 7.6% a.i. gossyplure pheromone) was tested on eight pairs of plots, and the microcapsules (produced by I.C.I., 2% a.i. of the same sex pheromone) on the two other pairs. All plots were treated with pesticide sprayings (not specifically against the PBW).

One 0.5 ha plot in Sede Eliyyahu, hereafter referred to as the "biological plot" (Table 1), was treated with hollow fibers and subsequently with microcapsules. No pesticides were applied to this plot throughout the season.

TABLE 1. DATA ON TEST PLOTS AND TREATMENTS IN THE BET SHE'AN VALLEY DURING 1985

Location and Plot		Variety	Size (ha)	Pheromone formulation	Number of pheromone treatments	Number of pesticide treatments
Nir Dawid	a	Pima	25	–	–	10
	b	Pima	20	hollow fibers	8	5
Sede Eliyyahu	a	Acala	13	–	–	13
	b	Acala	25	hollow fibers	8	12
Sheluhot south	a	Pima	15	–	–	8
	b	Pima	14	hollow fibers	8	8
Sheluhot north	a	Pima	15	–	–	6
	b	Pima	15	hollow fibers	8	7
Bet Alfa	a	Pima	13	–	–	7
	b	Pima	12	hollow fibers	7	4
Hefzi Bah	a	Pima	9	–	–	7
	b	Pima	20	microcapsules	6	7
Sede Nahum 12	a	Pima	14	–	–	8
	b	Pima	15	hollow fibers	9	8
Sede Nahum 7	a	Acala	25	–	–	11
	b	Acala	20	hollow fibers	8	8
Tirat Zevi	a	Pima	14.5	–	–	11
	b	Pima	16.5	hollow fibers	8	10
Reshafim	a	Pima	20	–	–	11
	b	Pima	20	microcapsules	6	9
Sede Eliyyahu biological plot		Acala	0.5	hollow fibers +microcapsules	10	0

a = control plots; b = treated plots

The hollow fibers were dispersed at a height of 15-20 m above the crop canopy from an airplane equipped with two special pods attached to both wings. Prior to spreading, the fibers were mixed with "Biotac" glue at 40g fibers + 270 cc glue/ha, so that the fibers would adhere to the cotton foliage. There was 3 g a. i./ha. There was an average of one fiber per 1 m^2. The encapsulated liquid formulation was sprayed from an ordinary airplane 2.5 above the cotton canopy. Spraying volume was 30 l/ha, with 10g a.i. of the pheromone.

All treatments were applied in the early morning hours, although the hollow fibers can be spread at any time of the day. Monitor traps were used to determine intervals between treatments, and any increase in trap catches indicated a decline in pheromone efficiency. However, to follow the producers' instructions, intervals did not exceed 21 days. The interval between some of the treatments in the "biological plot" at Sede Eliyyahu was shortened to 7-10 days. The first treatment was applied on 2 May, before the appearance of squares. In most plots one pheromone-baited dry funnel trap was placed every 3 ha. In the biological plot only two traps were used. The traps were checked at least twice a week.

The rate of PBW infestation in flowers was determined between 13 June and 14 July in all test plots from weekly samples of 500 flowers per plot. To determine the rate of PBW infestation in bolls, 100 large green bolls per plot were checked weekly beginning on 9 July.

Between 15 May and 11 Sept. 1985 the PBW moth populations were sampled during the night, using 6 volt miners' lanterns. Single moths and copulating couples were collected and placed in separate jars. All collected females were dissected to check their spermatheca; the presence of a spermatophore indicated that mating had occurred.

RESULTS

The results of the pheromone trap catches are illustrated in Figures 1-3. In general, the pheromone treatments caused a significant decline in trap catches. One exception, which substantiates the general rule, is illustrated in Fig 3-*x* (Reshafim), where an accidental delay in pheromone application beyond the 21-day limit resulted in an immediate increase in trap catches.

In the "biological plot" (Fig. 4), the number of collected females was low until the sixth treatment; however, with an outbreak of PBW in August, the number of females collected was high even when the intervals between pheromone treatments were shortened. It is worth noting that, although this plot was under a full biological control regime, it may not have been adequate for such tests, due to its small scale.

Increasing moth populations from August onwards were recorded in the treated plots as well as in the control plots, although, as already pointed out, the increase in trap catches in treated plots was lower than in the untreated control.

The PBW infestation in cotton flowers and bolls in the different pairs of plots is recorded in Table 2.

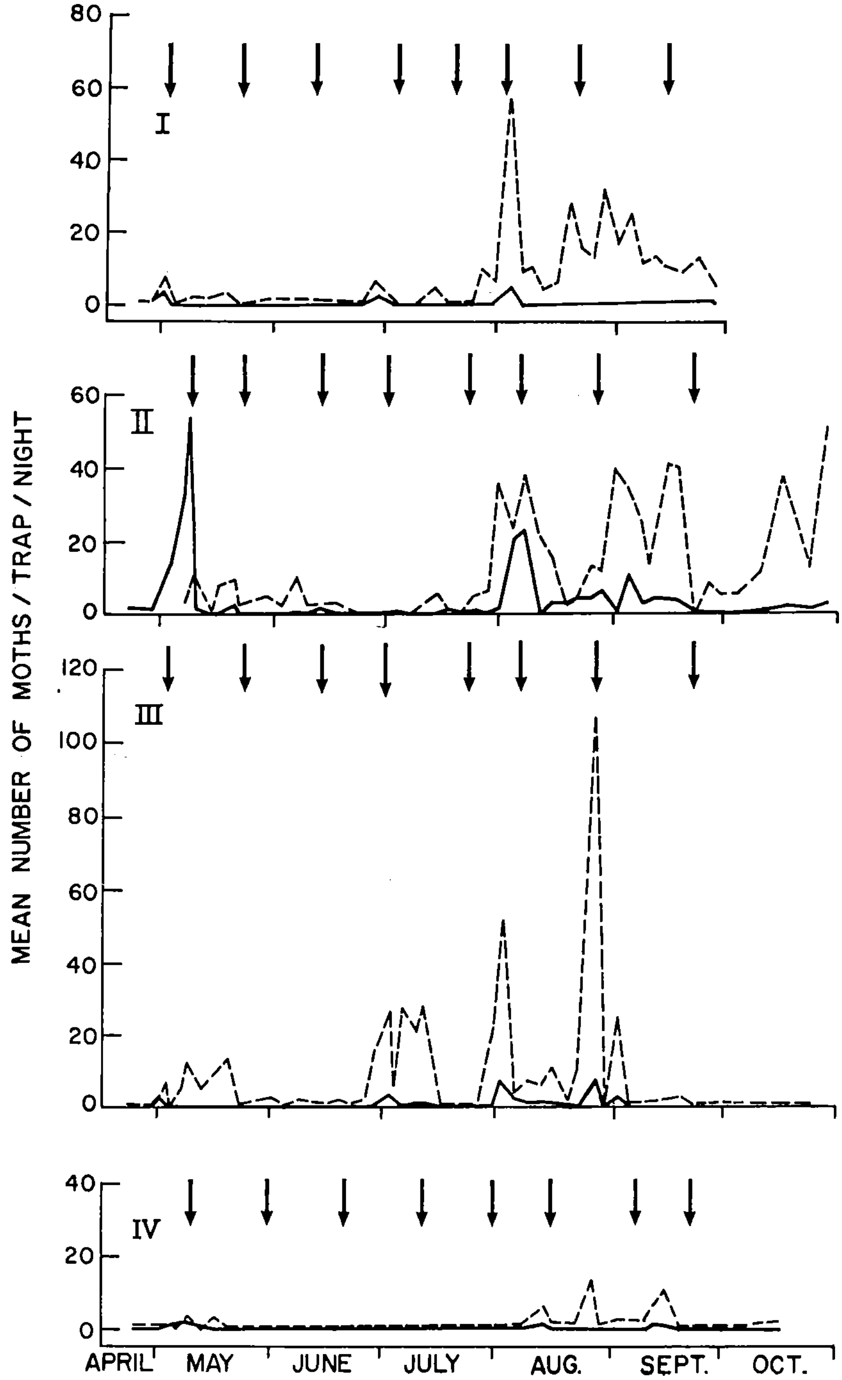

Fig. 1. PBW moth trap-catches in pheromone treated plots (————) and in control plots (– – – – –), 1985; I – Nir Dawid, II – Sede Eliyyahu, III – Sheluhot south, IV – Sheluhot north; arrows indicate pheromone applications.

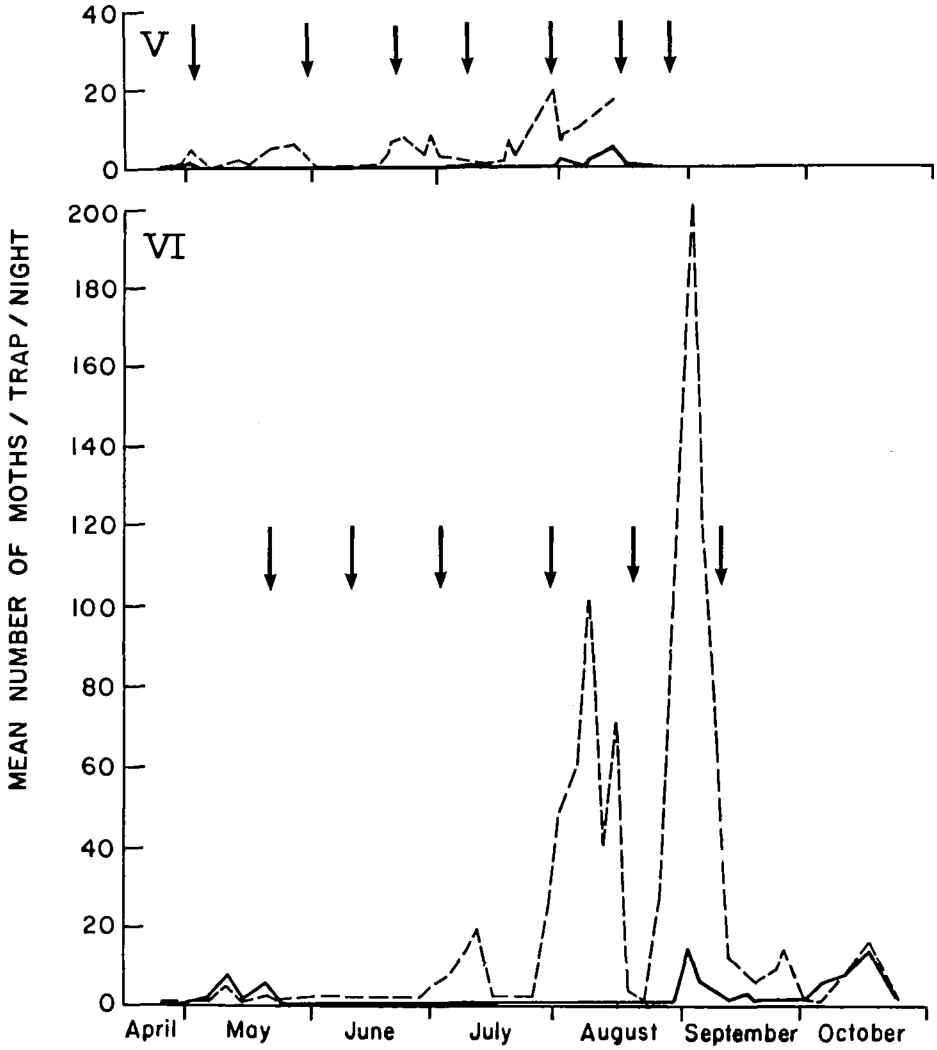

Fig. 2. PBW moth trap-catches in pheromone treated plots (————) and in control plots (– – – – –), 1985; V – Bet Alfa, VI – Hefzi Bah; arrows indicate pheromone applications.

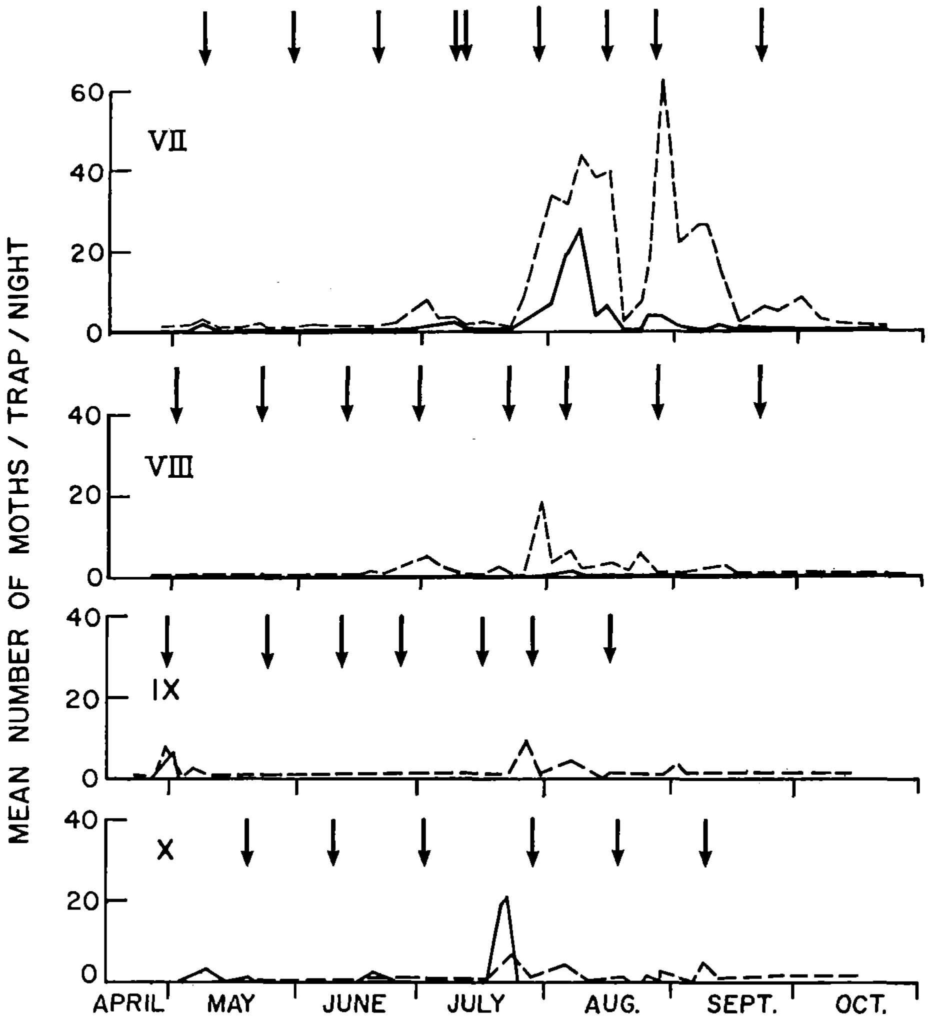

Fig. 3. BPW moth trap-catches in pheromone treated plots (————) and in control plots (– – – – –), 1985; VII – Sede Nahum 12, VIII – Sede Nahum 7, IX – Tirat Zevi, X – Reshafim; arrows indicate pheromone applications.

TABLE 2. INFESTATION OF COTTON FLOWERS AND COTTON BOLLS BY PBW LARVAE, BET SHE'AN VALLEY, 1985

Location and plot		Infested flowers (no.)	Infested flowers (%)	Infested bolls (no.)	Infested bolls (%)
Nir Dawid	a	1	0.05	0	0.0
	b	3	0.15	0	0.0
Sede Eliyyahu	a	67	2.70	142	17.75
	b	32	1.30	73	8.11
Sheluhot south	a	2	0.10	22	2.44
	b	7	0.35	6	0.60
Sheluhot north	a	5	0.25	9	1.00
	b	0	0.00	0	0.00
Bet Alfa	a	18	0.90	30	3.75
	b	3	0.15	1	0.13
Hefzi Bah	a	8	0.40	6	0.60
	b	4	0.20	0	0.00
Sede Nahum 12	a	6	0.40	11	1.10
	b	2	0.13	13	1.30
Sede Nahum 7	a	2	0.13	11	1.10
	b	1	0.06	3	0.30
Tirat Zevi	a	5	0.25	0.	0.00
	b	3	0.15	0	0.00
Reshafim	a	6	0.24	0	0.00
	b	2	0.08	0	0.00
Total					
control plots		120	0.60	231	2.46
treated plots		57	0.30	96	1.01

a – control plots; b – treated plots; each sample = 500 flowers and 100 bolls

TABLE 3. DATA ON MATED FEMALES OF PBW MOTHS IN THE BIOLOGICAL PLOT, SEDE ELIYYAHU, 1985

Date	Number of scouts	Scouting time (min)	Number of collected moths		Mated females (%)	Average number of spermatophores per trapped female
			females	males		
15.V	4	90	21	4	76.2	0.8
22.V	5	30	4	4	100.0	1.5
03.VII	5	30	5	30	80.0	1.0
10.VII	5	60	7	23	42.9	0.4
17.VII	5	60	19	5	42.1	0.4
24.VII	5	60	13	12	38.5	0.4
07.VIII	3	60	62	119	30.8	0.3
14.VIII	3	60	52	56	13.5	0.1
21.VIII	3	90	18	31	22.3	0.2
28.VIII	3	90	58	68	51.8	0.5
28.VIII	3	90	33	53	69.7	0.7
11.IX	3	90	23	65	82.6	0.8

TABLE 4. NUMBER OF COPULATING PAIRS OF THE PBW COLLECTED IN THE BIOLOGICAL PLOT, SEDE ELIYYAHU, 1985

Date*	Scouting time	Copulating pairs
3.VII	02.30 – 03.00	4
10.VII	23.00 – 23.30	0
	02.15 – 02.45	1
7.VIII	22.30 – 23.00	0
	01.00 – 01.30	0
	02.30 – 03.00	19
	03.00 – 03.30	30
14.VIII	00.45 – 01.15	0
	01.40 – 02.10	2
	03.00 – 03.30	8
	03.30 – 04.00	15

* Three scouts on each date.

The number of infested flowers in the control plots (120) was twice as high as in the treated plots (57). Infestation level during the 1985 flowering season was relatively low, but in nine out of the ten pairs of plots infestation in the treated plots was about half that in the controls.

The average infestation in the bolls in control plots was more than double that in the treated plots (231 *vs* 96). In six out of the ten pairs of plots there was a significant advantage to the treatment: in three cases there was no infestation and in one case (Sede Nahum 12) there was no difference. The low level of infestation in the treated plots is of particular importance, considering that no direct pesticide treatments *against PBW* were applied, and that the total average number of pesticide applications per treated plot was lower by approximately one treatment per season as compared to control plots (8.0 *vs* 9.2 treatments).

In many cases no PBW moths were captured, in nocturnal moth scouting, even when the monitor traps indicated high moth populations. At the same time, other moths (*e.g. Earias insulana* or *S. littoralis*) were captured. Only in the biological plot, in which populations were high, was it possible to collect single moths and mating pairs (see Fig. 4 and Tables 3 and 4). The number of virgin females increased as intervals between the pheromone treatments became shorter.

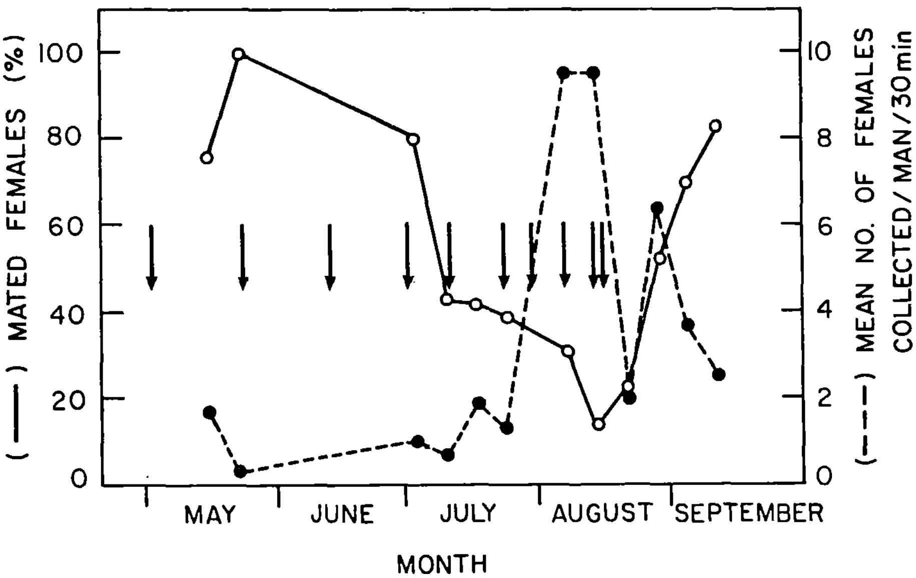

Fig. 4. Percent PBW-mated females and PBW population level in the Biological Plot, Sede Eliyyahu, 1985; arrows indicate pheromone applications.

DISCUSSION

The low rate of trap catches of PBW moths in the treated plots as compared with the controls may be attributed to two main factors: male confusion due to excess of the sex pheromone (direct effect), and reduced population due to suppression of female fertilization over a number of generations; the latter factor has a cumulative effect.

An absolute lack of trap catches was not obtained. The catches were low when the population level was low or intermediate, and rose at the time of the population outbreak in August – September. Consequently, the efficiency of the pheromone treatments in August and onward decreased. The efficacy of pheromone treatments should be evaluated according to the following criteria: (*a*) the initial rate of flower infestation at the beginning of season: (*b*) the rate of boll infestation during season; (*c*) the number of pesticide treatments; and (*d*) the decline in number of mating pairs and in female insemination.

In this study it was found that the infestation rate in both flowers and bolls in the treated plots was lower than in the untreated control.

No definite conclusion could be reached on female insemination due to the small number of females collected, and it is possible that moth activity occurs mostly at or close to dawn. However, in the biological lot at Sede Eliyyahu, with its high population, moths were captured at all hours of the night, and a decline in female insemination, respective to an increased frequency in pheromone treatments, could be noted clearly. However, this finding may be considered as merely an indication, due to the small size of this plot (0.5 ha).

There is no doubt, then, that manual collection of moths and recording of female insemination (fertilization) are important tools in testing the efficiency of the confusion system, but it is recommended to carry out the collections at or close to dawn.

It is of great importance to reduce the development of the PBW population as early in the season as possible, and particularly by biological means. It is well known that the biological equilibrium in a field is obstructed by early pesticide treatments. On the other hand, the outcome of no pesticide treatments might result in problems later in the season. In view of the low level of infestation in the treated plots, it may be concluded that pheromone treatments may well serve to suppress the pest population already at the beginning of the season, and without interrupting the population of beneficial insects.

The differences in the levels of infestation between the treated and untreated plots were remarkable even in this relatively small-scale test. We believe that larger, and even regional-scale treatments, would produce better results, especially as the effect of moth migration between the plots would be minimized. Development of new pheromone formulations and/or other methods (such as spraying), to suppress populations of additional pest, would enable a reduction in the number of pesticide treatments.

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