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APR 03 1997
ALMOND BOARD OF CALIFORNIA

Project Number: 96-NOW2

DISRUPTION OF PHEROMONE COMMUNICATION FOR CONTROL OF PEACH TWIGBORERS AND NAVEL ORANGEWORMS IN ALMONDS

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ABSTRACT

Earlier, we found for a number of moth species that it doesn't matter how close together or far apart synthetic pheromone evaporators are placed, as long as a critical concentration of pheromone is maintained in their mating environment. Following this lead, we developed the concept of "puffers". They are time-clock-activated machines for dispensing periodic puffs from aerosol canisters charged with predetermined blends and amounts of desired pheromone components. During 1996, we installed 105 puffers in a square160-acre block of almonds in Kern County, keeping them there from early April through the end of October. The 105 puffers were arrayed at 2/3 tree height, mainly in trees around the perimeter, with 20 on each 1/2-mile-long side. The remaining 25 puffers were equally spaced from each other in a 5x5 array in the interior of the orchard. Puffer canisters were filled with the two-component PTB pheromone blend, plus a neutral diluent and a propellant. As the season progressed, we learned how to improve the performance of these canisters, changing the size of aerosol metering valves, the amount of pheromone released in each puff, the propellant, and, especially, the proportion of propellant to other materials in the cans. We attribute a lack of complete protection of the almond block against infestation by PTB worms to have been mainly due to our not being ready for all the problems that this new technology presented to us, although we feel that we learned enough about how to correctly operate the system that the likelihood of economic success in using puffers for PTB control is high. During the course of the season, and with repeated experimental can-fillings in our new aerosol-can-filling facility at the UC Kearney Agricultural Center, we settled on 8 mg of pheromone per puff as our 1996 standard rate. This rate of pheromone delivery provided 45 g per acre per season. We feel that material-cost economics may ultimately allow use of pheromone at 3 times this rate, and such higher rates will be evaluated in 1997. The cooperating grower stated that he found no PTB larvae in nuts in the puffer-treated orchard at the end of July, although he did see significant numbers of larvae in his control orchards. However, the inadequacies of our developing system during 1996 allowed enough mating of PTB moths that we found a 3.5% infestation in the nuts at harvest.

BACKGROUND

This project supplements another research project, in which Jocelyn Millar is Principal Investigator, directed toward development of an improved lure, as well as mating disruption techniques, for the Navel Orangeworm. Through the additional research provided by this project, the other major lepidopteran pest of almonds, the peach twig borer (PTB), also is investigated, with the goal of bringing both of these pests simultaneously under control through mating disruption.

We have conducted research on a variety of lepidopterous pests, directed toward permeating the atmosphere with synthetic pheromone, so as to cause male moths to be incapable of finding pheromone-releasing females for mating. We have found that in some species it doesn't matter how close together or far apart the synthetic pheromone evaporators are placed, as long as a critical concentration of pheromone is maintained in the mating environment of the moths. Following this lead, we have developed a method for releasing massive quantities of pheromone from mechanical devices which we call "puffers".

Puffers are time-clock-activated machines for the dispensing of periodic puffs from aerosol canisters charged with predetermined blends and amounts of the desired pheromone components. Compared to conventional devices, puffers have important advantages. These include the following:

1. Blends of pheromone components can be precisely loaded in the canisters so the optimum quantities of each component are released into the mating environment of the moths. This allows the mating of multiple pest species to be disrupted simultaneously.
2. The release rate of each component in each puff remains constant, from the first to the last puff from the canister (about 75 days later, with our present technology); this release rate is not affected by temperature or wind.
3. Highly reactive chemicals such as the navel orangeworm moth pheromone are protected from chemical breakdown, since they are not exposed to oxygen or light while in the canister.
4. The massive release rates of pheromone chemicals from the puffers means that puffers can be spaced at great separations in the field - fewer than one per acre, giving considerable savings in application labor expense.

In initial small plot studies in almonds using puffers in 1995, we demonstrated the feasibility of disrupting natural pheromone communication between males and females of peach twigborers (PTB) and navel orangeworms (NOW). In 1996 research, we shifted to large, commercial scale experiments to control PTB in almonds and peaches by permeating orchards with the pheromone odor during the entire growing season. We had intended to include NOW pheromone also in the almond tests, but due to a series of problems encountered by the two suppliers with whom we had contracted to provide that pheromone, no NOW material was supplied for our 1996 tests.

To avoid a repetition of earlier scheduling and quality-control problems that we met in contracting with the commercial aerosol-can-filling industry to custom-fill small batches of cans with various experimental pheromone and propellant blends, we built and equipped during 1996 our own aerosol-can-filling facility at the UC Kearney Agricultural Center in Parlier. This facility, which has state-of-the-art commercial-scale equipment, is, to our knowledge, the only such facility in a university laboratory in the United States.

More details concerning aerosol can filling and this facility are found in the Navel Orangeworm Report for 1996 by Millar and Shorey

OBJECTIVES:

1. In large plot (whole orchard), but short duration tests, contrast several techniques for dispensing PTB pheromone from puffers, including densities of puffers deployed, positioning of puffers relative to each other, release rate of pheromone from the puffers, and timing of release of pheromone from the puffers, so as to maximize communication disruption among male and female PTB.
2. In season-long, commercial-scale deployment of a maximum practicable number of puffers and amount of pheromone released from the puffers, determine in several sizes of commercial orchards the efficacy of PTB and NOW communication disruption and resulting larval control.

PROCEDURES

Puffer machines were equipped with hooks for fastening to the limbs of trees, at 2/3 tree height. The aerosol canisters were filled in our UC Kearney Agricultural Center can-filling facility with the desired quantity of PTB pheromone, neutral diluent, and propellant, depending on the specifications of each particular test.

After puffers were deployed in the field, their efficacy in disrupting communication among male and female moths was monitored by the use of sticky traps that were baited with PTB synthetic pheromone lure. Numbers of male moths captured in such traps deployed in untreated control orchards served as an index of ability of male moths to orient to the source of pheromone (which is normally a female ready for mating), and lesser numbers of males captured in pheromone-permeated orchards were used in calculating the amount of communication disruption obtained.

<u>1. In large plot (whole orchard), but short duration tests, contrast several techniques for dispensing PTB pheromone from puffers, including densities of puffers deployed, positioning of puffers relative to each other, release rate of pheromone from the puffers, and timing of release of pheromone from the puffers, so as to maximize communication disruption among male and female PTB.</u>
These tests were conducted in Kern County, CA, using several different strategies for deploying puffers at 2/3 tree height (trees were about 20 feet high) in and/or around a 160-acre block of almonds:
1. 100 puffers arrayed in an equally spaced 10x10 grid (about 260 feet between machines). Machines set to puff during night-time only, at a 15-min interval.
2. 100 puffers arrayed around the perimeter only, at about a 130-foot separation. Machines set to puff during night-time only, at a 15-min interval.
3. 100 puffers arrayed around the perimeter only, at about a 130-foot separation. Machines set to puff during the entire 24-hour period of each day, at a 25-min interval.

4. 117 puffers arrayed with 100 around the perimeter, at about a 130-foot separation plus 17 along the orchard north-south and east-west mid-lines, at about 260-foot separation. Machines set to puff during night-time only, at a 15-min interval.

Puffer canisters were prepared as described elsewhere in this report so they released 8 mg of PTB pheromone in each puff. Each strategy was evaluated for efficacy in preventing male moths from orienting to 17 PTB-lure-baited traps hung in trees throughout the protected orchard at the same height as the puffers. Weekly trapping results in these monitoring traps in the protected orchard were compared with results from 12 similar traps hung in a total of three untreated (no pheromone) control orchards located at least 0.5 mile away in a general upwind direction from the protected block. During September and October, 1996, the above strategies were evaluated during one week intervals for communication-disruption efficacy (as determined by the amount of "shut-down" of the monitoring pheromone-baited traps. This was regarded as a preliminary, fact-gathering test, and one to two replicates were conducted for each of these strategies. Results of the monitoring trap evaluations are included in Table 1.

2. In season-long, commercial-scale deployment of a maximum practicable number of puffers and amount of pheromone released from the puffers, determine in several sizes of commercial orchards the efficacy of PTB and NOW communication disruption and resulting larval control. To determine the potential for season-long control of PTB using the puffer method, the same 160-acre almond orchard described above was provided with PTB pheromone released from puffers continuously for 6 months in1996. We installed 105 puffers on trees in the block, keeping them there from early April through the end of October. Puffer canisters were filled with the two-component PTB pheromone blend, plus a neutral diluent and a propellant.

The 105 puffers used in the orchard were arrayed at 2/3 tree height, mainly in trees around the perimeter, with 20 on each 1/2-mile-long side. The remaining 25 puffers were equally spaced at about 400 feet apart, in a 5x5 array in the interior of the orchard. During the latter part of the season, after harvest, we varied the pattern of placement of puffers in the orchard; this was the basis for the short-term tests described under Procedure 1, above.

Initially, the puffers were set to release pheromone at 25-min intervals throughout the day and night. However, after determining that during mid- and late-season PTB moths almost invariably mate between midnight and dawn, we set the puffers by use of their built-in day/night switch to release puffs of pheromone at 15-min intervals during night-time hours only. During the early part of the season, pheromone was formulated in the canisters so that 6 mg of the material were released in each puff. During the course of the season, and with repeated experimental can-fillings in our facility at the UC Kearney Agricultural Center, we settled on 8 mg of pheromone per puff as our 1996 standard rate. This rate of pheromone delivery calculates to 0.384 g of pheromone released from each puffer per day, or, with 1 puffer per 1.5 acres, 0.25 g per acre per day.

Seventeen PTB pheromone monitoring traps were kept constantly in place in the pheromone-treated block as well as in 4 other almond blocks that were conventionally treated with insecticides at hull split and used as controls. The results obtained from weekly inspection of these monitoring traps are given in Table 2.

RESULTS

The season-long trial to prevent damage to almonds by PTB larvae, by disruption of mating in the 160-acre orchard, was a qualified success. With the puffer technique being so new, a variety of unexpected problems arose and were dealt with. During much of the season, between 90 and 100% of male moths were prevented from orienting to the monitoring traps releasing pheromone in the puffer-protected orchard, as compared to the situation in the control orchards

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As the season progressed, we learned how to improve the performance of these canisters, changing the size of aerosol metering valves, the amount of pheromone released in each puff, the propellant, and, especially, the proportion of propellant to other materials in the cans. We attribute a lack of complete protection of the almond block against infestation by PTB worms to have been mainly due to our not being ready for all the problems that this new technology presented to us - and especially to the fact that our new propellant became overpressurized in cans during hot weather, preventing them from releasing pheromone when activated. However, our learning curve was very steep, and we learned enough about how to correct the inadequacies and to correctly operate the system that the likelihood of future economic success in using puffers for PTB and NOW control is high.

During the 180-day season of protection, PTB pheromone was expended at 45 g per acre per season. We feel that material-cost economics may ultimately allow use of pheromone at 2 to 3 times this rate, and such higher rates will be evaluated in future research.

The pheromone-treated block was not treated with insecticides at hull split. During most of the growing season, from April through October, numbers of male PTB moths captured in the monitoring traps inside the pheromone-treated orchard averaged 90% lower than in the control orchards. For reasons that we do not understand, during the period from mid-September through November, the numbers of males of PTB captured in monitoring traps in the puffer-protected orchard dropped nearly to 0, while the numbers remained high in the control orchards. This was the same period when we were evaluating a number of alternative strategies for deploying the puffers in almonds (Table 1), but, due to the low numbers of male moths captured in the traps in that block during that time, little can be said regarding the relative efficacy of the various strategies; they all looked excellent.

The cooperating grower stated that he found no PTB larvae in nuts in the puffer-treated orchard at the end of July, although he did see significant numbers of larvae in his control orchards. However, the inadequacies of our developing system during 1996 allowed enough later mating of PTB moths that we found a 3.5% infestation in the nuts at harvest.

Our 1996 research provides encouragement that, with perfection in the details of positioning puffers, the release rate of pheromone from puffers, and the timing of release of material from puffers, effective control of PTB in almonds can be achieved.

Our experience in using puffers to protect peaches provides further encouragement that this research may be headed in the right direction. We arrayed puffers in and around a nearly square 85-acre block of peaches in Madera County, CA, at the rate of about one puffer per acre. PTB pheromone was released at somewhat less than the rate used in the almond trial described above, giving a total release of about 25 g per 150-day season. Oriental fruitmoth pheromone was simultaneously released from the same puffers, at the same rate. Despite the fact that the collaborating grower did not spray the block with insecticides at any time during the season, infestations of both of these pests were at very low levels, being lower than was recorded in a nearby peach orchard that was protected by conventional insecticide sprays.

Table 1. Mean numbers of males of the peach twigborer captured in seventeen pheromone-lure-baited monitoring traps located within a 160-acre almond orchard serviced by puffers in various arrays and with various timings of pheromone release, in comparison to mean numbers captured in three non-pheromone-treated control orchards.

Date deployed (1996)	No. of puffers for 160A	Timing strategy	Mean males/ week/trap Puffer	Control	% Reduction
9/13	100 (10x10)	Night only, 15-min interval	0.6	8.6	93
9/18	100 (perim. only)	Night only, 15-min int.	0.7	48.3	98
9/27	100 (perim. only)	Day and night, 25-min int.	0.4	101.1	99+
10/4	117 (100 perim +17 internal)	Night only, 15-min int.	0.3	73.7	99+
10/11	100 (10x10)	Night only, 15-min int.	0.2	50.8	99+
10/18	100 (perim. only)	Night only, 15-min int.	0.0	4.2	99+
10/25	117 (100 perim +17 internal)	Night only, 15-min int.	0.0	1.3	99+

Table 2. Mean numbers of males of the peach twigborer captured in seventeen pheromone-lure-baited monitoring traps located within a 160-acre almond orchard serviced by 105 puffers (80 equally spaced along the perimeter and 25 equally spaced within the interior), in comparison to mean numbers captured in three non-pheromone-treated control orchards.

Date	Mean males/week/trap		
(1996)	Puffer Block	Control Blocks	% Reduction
4/17	21.4	17.0	---
4/24	13.1	56.2	77
5/1	9.0	19.9	55
5/8	1.9	7.4	74
5/15	2.1	24.6	91
5/22	2.0	17.5	89
5/29	0.6	8.6	93
6/5	0.0	9.8	99+
6/12	0.1	3.3	97
6/19	1.5	8.4	82
6/26	8.1	3.8	---
7/5	7.2	6.2	---
7/12	2.3	2.7	15
7/19	0.8	7.3	89
7/26	2.1	5.8	64
8/2	10.6	51.0	79
8/9	16.1	69.4	77
8/16	13.1	50.8	74
8/23	22.1	61.9	64
8/30	22.8	79.5	71
9/4	7.7	139.2	94
9/11	1.9	22.1	91
9/18	3.0	46.3	94