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SYNTHESIS AND FIELD TESTING OF NEW MATING DISRUPTION AND ATTRACTANT BLENDS FOR PEACH TWIG BORER, *Anarsia lineatella* Zeller (LEPIDOPTERA: GELECHIIDAE)

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INTRODUCTION

The peach twig borer (PTB), Anarsia lineatella Zeller, is a major pest of almonds and stone fruits in North America, Europe, and Asia (Summers et al., 1959). In California, there are as many as four generations per year. Damage is caused by the developing larvae tunnelling in fruits, buds and shoots. Damage can be so severe that in some crops, prophylactic pesticide sprays are routinely applied, even in non-bearing orchards.

Until recently, PTB infestations in California were controlled by a combination of pesticide treatments. However, developing resistance to registered insecticides and cross resistance to other pesticides, plus the increasingly restrictive limitations placed on the use and registration of currently used pesticides has created an urgent need for alternative management strategies.

Two components of the PTB pheromone were identified by Roelofs et al. (1975) as E5-decenol (E5-10:OH) and E5-decenyl acetate (E5-10:Ac). Traps baited with blends of the two components captured male moths. There were discernable differences between geographically separated populations, with a central California population responding to all blends of the two components approximately equally, while a Washington state population responded preferentially in traps baited with E5-10:OH as a single component.

Roelofs et al. (1975) also mentioned that field trials during their first two years were hampered by trace amounts of a strong behavioral antagonist in their synthetic formulations. The antagonist was not isolated and identified.

Pheromone-mediated mating disruption has been successfully applied to the control of two other important gelechiid moth pests, the pink bollworm and the tomato pinworm. Mating disruption may represent an environmentally safe strategy for control of PTB, and small-scale field trials were begun in California several years ago. Trial formulations are now available from several suppliers. Fruit yield losses were reduced in disrupted areas as compared to untreated control blocks, but considerable numbers of male moths were still caught in pheromone-baited traps placed throughout the disrupted blocks, indicating that male insects were still able to locate point sources of pheromone. On the basis of these observations, we established the following objectives.

PROJECT OBJECTIVES

1. Reexamination of potential pheromone components in the pheromone glands of PTB, with particular emphasis on identifying trace components as possible synergists.

2. Determination of the number and ratio of components released by calling female moths by aeration of calling females.

3. Synthesis and field testing of potential pheromone synergists and antagonists.

4. Study of the pheromone-mediated behavior of the male moths.

SUMMARY OF 1990 RESULTS.

Work on objectives 1-3 led to the identification of a number of new compounds from pheromone gland extracts. These compounds plus a number of related compounds were synthesized and tested as attractants in sticky traps. No new attractants were found, but compounds which strongly inhibited the attractive response were identified. The inhibitory compounds were selected for mating disruption trials in 1991.

RESULTS FROM 1991 FIELD SEASON.

Mating Disruption Trials:

Two new compounds were selected for small scale (2 acre) mating disruption trials. These compounds had been synthesized in milligram amounts for field testing as attractants in 1990. These small scale syntheses required considerable modification in order to produce the multigram quantities of each test compound required for field testing. At this point, details of the structures and syntheses remain confidential, to avoid jeopardizing future patent or licensing opportunities. If required, details of the syntheses will be made available at a later date.

Field trials were conducted with combination peach twig borer-oriental fruit moth mating disruption dispensers from BASF (Ludwigshafen, West Germany). Test compounds (named "Red" or "Black" for convenience) were loaded into the BASF dispensers by syringe (40 mg/dispenser). The syringe holes were sealed up with a hot-melt glue gun. Approx. 800 dispensers were loaded in total, sufficient for treatment of 2 acres/test compound.

Loaded dispensers (200/acre) were set out in 2 acre blocks within a large almond orchard, with trees on a 22' x 25' spacing (Fig. 1). Blocks were separated from each other by a minimum of a quarter mile. Dispensers were fastened 10-12 feet up in the trees. Treatments consisted of untreated checks, the standard PTB blend, standard blend + Red compound, or standard blend + Black compound (Fig. 1). Two check blocks were used, one for each of the different varieties of almonds used (Merced or Butte). Treatments were applied in mid-June, 1991.

The efficacy of the disruption program was monitored with two pheromone sticky traps (Trécé 1C) placed in each block. Lures were changed biweekly, and trap bottoms were changed as required. Trap catches over the season are summarized in Fig. 2. Trap catches were suppressed in all treated blocks until the beginning of August. In mid-August, control in the standard blend and Red compound blocks, as measured by the trap catches, began to break down. Trap catches in the Black compound block remained at a low level until mid September, by which time the dispenser contents were largely depleted.

In all cases, the pheromone treatments had some effect, as the trap catches in the untreated check plot were approx. an order of magnitude higher than in any of the pheromone blocks until late in the season.

All blocks were harvested between Sept. 10-12, 1991, and random samples of 500 nuts were taken from each block. Nuts were split open and checked for damage. The results are summarized in Table 1. The Merced variety check block suffered major damage, with 42% total insect damage, 39% of which was from PTB. The Red compound treated block (Merced) also suffered serious damage (18% overall, 15.6 % PTB). In the second group, damage levels overall were lower. The Butte variety check and standard blend treated blocks suffered approximately equal levels of damage (10.2 and 7.2 % respectively. However, the Black compound treated block had only 0.2 % damage (1 insect-damaged nut out of 500 tested). The Black compound may provide enhanced mating disruption control of PTB. It is recommended that the Black compound be subjected to larger scale tests (10 acres) in 1992 to verify these results.

Field Tests of Attractant Formulations

In 1990, we conducted a small scale test of the attractiveness of the PTB standard pheromone blend versus a blend containing the standard compounds plus all of the newly discovered minor compounds in the pheromone gland. This test was repeated on a larger scale this year. Sticky traps (Trécé 1C) were baited with lures containing either the standard blend [E5-10:Ac (400 μg) + E5-10:OH (100 μg)] or the standard blend + minor components [E5-10:Ac (400 μg), E5-10:OH (100 μg), E4-10:Ac (5μg), Z4-10:Ac (5 μg), 10:Ac (20 μg), Z3,E5-10:Ac (5 μg), E3,E5-10:Ac (10 μg)]. Traps were replicated six times in each of almond, peach, and plum blocks. Traps were spaced approx 200 ft apart, placed ~8 ft high in the N-NE quadrant of trees. Traps were counted daily at each site.

In all three host crops, there was no difference between the attractiveness of the standard blend and the complete blend; summed trap captures were virtually identical (Table 2). It appears that the minor components in the pheromone gland play no part in the attraction of male moths.

In a further test of the pheromone blend, the effect of the blend ratio of the two major components of the pheromone (E5-10:Ac and E5-10:OH) was tested. Traps were baited with lures containing increasing amounts of E5-10:OH, with four replicates of each treatment. Sticky traps were hung out in almond orchards, as described above.

Traps were counted daily, changing the trap bottom at each count due to the large numbers caught.

The results indicate that the single component E5-10:Ac is as good or better than any combination of E5-10:Ac with E5-10:OH (Table 3). As the proportion of E5-10:OH increased, the trap catches decreased. E5-10:OH alone as a trap lure was not significantly better than the blank.

These results suggest that it may be possible to use only a single component in PTB mating disruption dispensers, instead of the normal two component blend, at least in central California. A single component dispenser should be cheaper and easier to produce, lowering the cost of pheromone-based control programs. However, from the original work done on identification of the PTB pheromone (Roelofs et al, 1975), it is known that PTB in Washington state are attracted by pheromone blends rich in the alcohol, not the acetate. Thus, a more extensive survey of the optimal attractant blends for California populations of PTB is needed before recommending changes to currently used lures or mating disruption dispensers.

It should also be mentioned that anecdotal information on trap catches and analytical data show that the purity of the pheromone components used in attractant trials is crucial to the outcome of experiments. We have found that some commercially formulated lures made with impure materials were minimally attractive, and that manually prepared lures made with commercially available compounds of 95% purity, were also not very attractive. Commercial materials of sufficient purity are available, but the purity should be very carefully checked before use in order to obtain reliable results.

<u>Behavioral Responses of Male Moths to Pheromone.</u>

We attempted observations of male PTB moth behavior in response to pheromone sources in a wind tunnel, using male moths from our laboratory colony. However, it was found that under the low light levels required, reliable observations of the male moths were not possible. The flight pattern was too fast and too erratic to follow. We will attempt to repeat these experiments with a low-light video camera, which is available on loan from another researcher at UCR.

Projected Work for 1992.

1. Synthesis and large scale mating disruption trials with the "Black" test compound.
2. Survey of populations of PTB from different regions of California, and different hosts, to determine whether the single component, E5-10:Ac is the only compound required in lures and mating disruption dispensers.
3. Finish tests of male moth mate-finding behavior.

Table 1. 1991 Almond Damage Survey in Mating Disruption Test Plots.

	Check	Red	Check	Black	Standard Blend
Variety	Merced Almond	Merced Almond	Butte Almond	Butte Almond	Butte Almond
Location	Selma	Selma	Selma	Selma	Selma
Grower	Dighiera	Dighiera	Dighiera	Dighiera	Dighiera
Disruption type	None	BASF OFM/PTB	None	BASF PTB/OFM	BASF PTB/OFM
Total Nuts Checked	500	500	500	500	500
Total Infested Nuts/Halls	209	90	78	9	61
% Total Insect Damage	41.8	18	15.6	1.8	12.2
DAMAGE BY INSECT					
OFM	0.8	0	0	0.8	1.2
OLR	0.8	0.8	0	0	0
PTB	38.6	15.6	10.2	0.2	7.2
Filbert Worm	0	0	0.2	0	0
NOW	1.6	1.6	5.2	0.8	3.8

TABLE 2. Comparison of trap catches in traps baited with the PTB pheromone standard blend versus the standard blend + minor components.

		Trap catch (males)	
Host Crop	Lure[a]	Mean[b]	Std. error
Almonds	Standard blend	729 a	38
	Std Blend + Minor Comp.	723 a	44
Plums	Standard Blend	340 a	52
	Std Blend + Minor Comp.	345 a	73
Peaches	Standard Blend	96.2 a	12.2
	Std. Blend + Minor Comp.	72.5 a	29.8

[a]Traps replicated 6 times, counted daily. Standard blend, E5-10:Ac (400 μg) + E5-10:OH (100 μg); standard blend + minor components, E5-10:Ac (400 μg), E5-10:OH (100 μg), E4-10:Ac (5μg), Z4-10:Ac (5 μg), 10:Ac (20 μg), Z3,E5-10:Ac (5 μg), E3,E5-10:Ac (10 μg).

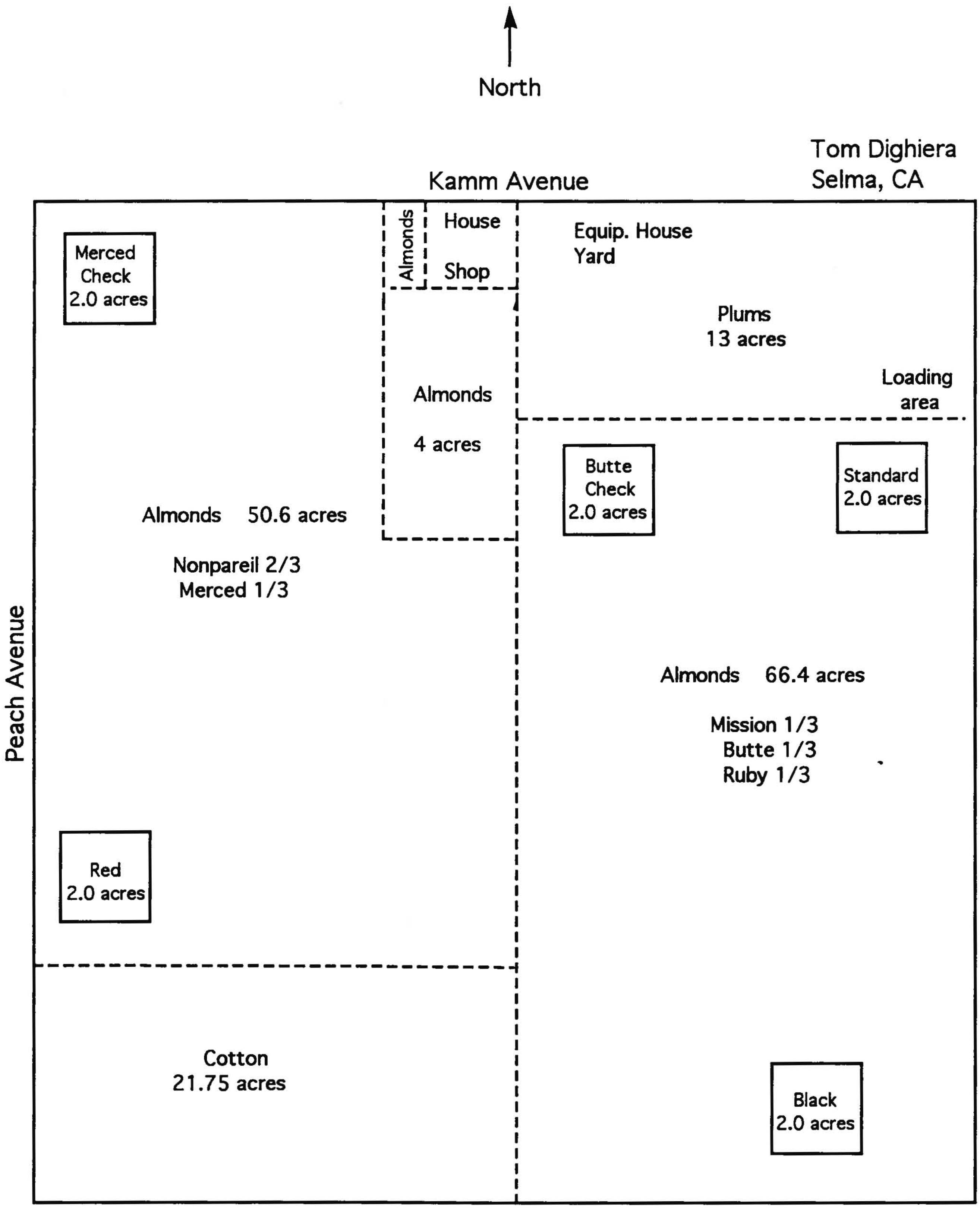
[b]Mean catch/trap/count period, traps counted 3 times. Traps were out Sept. 26-Oct.1 in plums, Oct. 2-4 in almonds, and Oct. 23-31 in peaches.

TABLE 3. PTB trap catches in response to blends of E5-decenyl acetate and E5-decenol.

Blend Ratio(μg) (E5-10:Ac : E5-10:OH)	Trap Catch (male moths)	
	Mean[a]	Std. Dev.
500 : 0	337 a	43
500 : 25	336 a	67
500 : 50	318 a	53
500 : 125	329 a	51
500 : 250	308 a	41
500 : 500	296 a	60
0 : 500	13.9 b	7.9
Blank	2.8 b	4.6

[a]Mean catch /trap/day. Treatments replicated four times, set out Sept. 30-Oct. 3, 1991, counted daily.

Figure 1. PTB Mating Disruption Test Plots.



Tree spacing = 22'X25' (25' between rows)
Trees/acre = 80

Figure 2. Pheromone trap catches in almond orchards treated with trial mating disruption treatments.