Possible new race of *Amorbia cuneana* discovered in avocado

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The finding could be useful in developing more effective pheromone controls

Pheromones, chemicals emitted by one organism to attract others of the same species, often consist of two or more components. The species specificity of a sex pheromone thus can stem not only from differences in type of components but also from their number and relative proportions. Growers and pest control advisors commonly use traps baited with synthetic sex pheromones to monitor specific insect pests as an aid in making pest management decisions such as timing of chemical sprays or, in some cases, releases of beneficial parasites or predators. Blacklight traps also may be used, but pheromone traps capture, almost exclusively, the insect species targeted by the pheromone used and they do not require a source of electricity.

Determination of sex pheromones can also be helpful in determining species status of insects. Two or more insect populations are separate species if they are reproductively isolated in nature. If the females of separate populations emit pheromones that attract only males of their own population, the populations are reproductively isolated and merit separate species status. If these populations interbreed to some extent, however, they could be called races within the same species—distinct but interbreeding populations. Field-trapping experiments with a synthetic sex pheromone for *Amorbia cuneana* (Walsingham), a pest of California avocados and citrus, has revealed three populations that use different pheromones.

Amorbia cuneana pheromone

The *A. cuneana* pheromone was initially identified as a combination of two components—(E,Z)-10,12 and (E,E)-10,12 tetradecadien-1-ol acetates—in a 1:1 ratio. The pheromone was synthesized and field-tested as a lure for *A. cuneana* males infesting California avocado and citrus crops (*California Agriculture*, May-June 1988).

We then tested traps baited with *A. cuneana* pheromone lures of the 1:1 component ratio in avocado groves in several southern California counties. The pheromone was effective in Riverside, Orange, Ventura, and Tulare counties, but not in San Diego and Santa Barbara counties, even though blacklight traps in the latter two counties indicated high populations were present.

To account for this disparity, pheromone components were analyzed from moths in both Santa Barbara and San Diego counties. Pupae were collected and sent to the U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) Laboratory in Yakima, Washington, where the sex pheromones were analyzed from individual emerged female moths. The ratio of the pheromone components was found to be approximately 9:1 EZ:EE in moths from both Santa Barbara and San Diego counties in contrast to the 1:1 ratio of the Orange County females on which the original identification of the pheromone was based. This report describes experiments to clarify the status of these different *Amorbia* populations in California.

Methods

We conducted trapping studies in commercial avocado groves in San Diego and Santa Barbara counties to determine which pheromone component ratio is most attractive to male *A. cuneana* moths. Traps were hung from peripheral branches of trees 5 to 8 feet above the ground and spaced no closer than 90 feet within and between trap rows. There were five replicates in the Santa Barbara County test, and four in San Diego County, in a randomized complete block design.

Rubber septa containing 0.2 mg of pheromone with 98.5:1.5, 90:10, 80:20, and 50:50 ratios of EZ to EE were tested as lures in Pherocon 1C insect traps in both locations. An extra coating of Stickem Special was applied to trap bases to improve efficiency. The rubber septa were impaled on straight pins hung from the top inside center of the traps.

Traps were checked every two or three days and each time were rotated one position within the blocks to minimize bias in catch due to location. Trap catch data were statistically analyzed (ANOVA and DMRT tests). After the Santa Barbara County test, the septa were sent to the USDA-ARS laboratory for analysis of the pheromone ratios, because of the ease with which the isomers change from the EZ to the EE isomer. Septa from San Diego were not analyzed because that test lasted only eight days.

We also determined the component ratios of pheromones from female offspring of seven singly mated pairs originating from a low-ratio area. Pupae were collected from an avocado grove in Ventura County and separated by sex. Upon adult emergence, single male/female pairs were maintained in separate cages. Progeny of their matings were kept separate and reared on artificial diet. Upon pupation, females were collected and sent to the Yakima laboratory for determination of ratios of sex pheromone components.

Results

Traps in Santa Barbara County were left in the field for 19 days and checked every 3 days. The two highest EZ:EE ratios were

TABLE 1. Effect of pheromone component ratios on trap catch of male *Amorbia cuneana* in Santa Barbara and San Diego counties

EZ:EE ratio	Trap catch: Total	Trap catch: Per trap-day*
Santa Barbara†		
98.5:1.5	1,403	14.8 a
90:10	926	9.7 a
80:20	39	0.4 b
50:50	24	0.3 b
San Diego‡		
98.5:1.5	332	10.4 a
90:10	152	4.8 b
80:20	83	2.6 bc
50:50	14	0.4 c

* Means followed by the same letter are not significantly different, ANOVA and DMRT (P=0.05).
† Santa Barbara test conducted August 24 - September 11, 1982, with five replicates of each ratio.
‡ San Diego test conducted October 14-22, 1982, with four replicates of each ratio.

TABLE 2. Pheromone component ratios found in offspring of single mated *A. cuneana* pairs

Single mated pair	Number of: Female progeny	Number of: Females having given EZ% values ± SD*
A	12	12 (36.8 ± 1.7)
B	8	2 (35.6 ± 2.2)
		6 (59.5 ± 3.2)
C	13	13 (36.7 ± 1.5)
D	8	8 (36.4 ± 0.9)
E	14	8 (37.0 ± 1.9)
		6 (57.9 ± 1.9)
F	9	6 (35.4 ± 1.6)
		3 (55.1 ± 0.7)
G	16	16 (37.1 ± 1.3)

* Ratios are expressed as a percentage of EZ (± standard deviation), which is a percentage of total EE+EZ.

most effective, and the two lower EZ:EE ratios captured relatively few moths (table 1).

Analysis of the septa after this test showed that, after 19 days, EZ:EE ratios in all septa had decreased to below the average figure of 89.2:10.8 found in the females. The ratios found in the lures indicate that, during the test, those with initial values of 98.5:1.5 and 90:10 EZ:EE were changing, mainly throughout the range found in the females, while the 80:20 lures would have been, at best, marginal at the beginning of the test and considerably below the values found in females during much of the test. Thus males in this area greatly preferred the percentages found in females native to this area.

In San Diego, the 50:50 EZ:EE lures caught very few moths, while catches of the other treatments increased with increasing EZ:EE ratio (table 1).

All seven single pair matings between low-ratio moths produced either all progeny in the 37 percent EZ range or progeny in both the 58 percent and 37 percent ranges (table 2). These results suggest that the females in the low-ratio areas consist of two races.

Conclusions

Results of pheromone gland analyses and trapping studies in Santa Barbara and San Diego County avocado groves suggest that males in the dominant populations of *Amorbia cuneana* respond to high-ratio EZ:EE (greater than 8:2) female sex pheromone. These findings contrast with the response to low-ratio EZ:EE (equal to or less than approximately 1:1) previously found in males from Riverside, Orange, Ventura, and Tulare counties. The current evidence suggests that high- and low-ratio populations may not cross-respond. If so, the possibility exists that such populations represent different species. In the case of the low-ratio population collected in Ventura, limited "forced" mating trials suggest that the existing differences could possibly involve two races.

Growers and pest management professionals can benefit from this research in at least two ways: (1) it is possible to learn which pheromone ratio is most effective in their particular area, and (2) the pheromones have potential use in timing control procedures in an integrated pest management (IPM) strategy.

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Uniformity of low-energy precise-application (LEPA) irrigation machines

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Machine movement and soil characteristics are important

Since a major source of saline subsurface drainage water in the San Joaquin Valley is nonuniform irrigation, increasing the uniformity of applied water should help solve the problem. The higher the uniformity, the greater the potential for drainage reduction with little effect on yield.

Low-energy precise application (LEPA), developed in Texas to reduce irrigation energy costs, has been reported to have a high potential uniformity. This system uses a center-pivot or a linear-move machine with drop tubes that discharge water directly into a furrow. A nozzle or emitter at the end of the drop tube controls the flow.

Uniformities between 94 and 97 percent have been reported for an experimental system in Texas with the only losses stemming from a drop in hydraulic pressure along the 480-foot lateral and possible manufacturing variability among the outlets. Because of these reported high uniformities, LEPA has been advocated as a way to reduce drainage in the San Joaquin Valley. At the reported uniformities, subsurface drainage could be reduced to 5 to 6 percent of the applied water with little adverse effect on yield.

There are possible problems, however. Because the discharge rate from drop tubes of LEPA systems is much higher than the soil's intake rate, ponding in the furrow may occur. This creates a potential for surface runoff and lower application uniformities. In west Texas, runoff is prevented by furrow dikes or checks.

A source of nonuniformity not considered in the Texas study is variation in the discharge time (defined here as the discharge opportunity time [DOT]) between checks, which depends on both the spacing of the furrow checks and the movement characteristics of the machine. Although classified as continuous-move, LEPA machines actually move in a start/stop pattern, which may result in significant nonuniformity of the applied water. Computer modeling by Arizona researchers showed uniformities ranging from 60 percent for a 3-foot check spacing to about 80 percent for a 30-foot spacing. Ponding of applied water may also contribute to nonuniformity because of variability of the soil infiltration rate between checks.

For these reasons, a LEPA system may have considerably lower uniformity than that determined by measuring only hydraulic losses. This study was designed to evaluate the effect of these sources of nonuniformity on the performance of LEPA.

Procedures

We measured the discharge opportunity times of a linear-move machine designed for either drop tubes or spray nozzles every 40 inches. Span length was 150 feet, with eight spans on either side of the engine/pump tower. No furrow checks were used.

Movement characteristics of towers 1 (adjacent to engine tower), 3, 5, 7, and 8 (outermost and control tower) were determined by monitoring tower movement along a 195-foot sample area divided into 3-foot intervals. Since the grower was using spray nozzles at the time of the test, we simulated drop tubes discharging into a furrow by establishing a reference point on the towers. Times required for the reference point to move each 3 feet were recorded, along with on/off times and distances per move. The movement times were considered as the discharge opportunity time for each interval. Different check spacings were simulated by grouping the smaller intervals into progressively larger sets. Uniformity (Christiansen's coefficient of uniformity) for the discharge opportunity times was calculated for each simulated spacing.

The effect of the variability of the soil intake rate was analyzed using data obtained during an experiment on furrow irrigation by W. W. Wallender. For this experiment, furrow intake rates were measured in consecutive 3.2-foot intervals. Intake rates between checks were simulated for different spacings by grouping the 3.2-foot intervals into sets of 6.5-, 9.8-, 13.1-, 26.2-, and 52.5-foot intervals.