TRAPPING FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE) ADULTS IN TRAPS BAITED WITH PHEROMONE AND A SYNTHETIC FLORAL VOLATILE COMPOUND

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ABSTRACT

Field experiments were conducted to determine the effectiveness of the floral compound phenylacetaldehyde in increasing capture of fall armyworm, *Spodoptera frugiperda*, males in pheromone-baited traps. Plastic Unitraps were placed in cotton and corn fields in north-central Florida and were baited with commercial sex pheromone and synthetic phenylacetaldehyde released from hollow polyethylene stoppers and glass microcapillary pipets. Addition of phenylacetaldehyde as a lure was not effective in collecting more moths and actually reduced numbers of moths captured compared to pheromone-baited traps. Nontarget Hymenoptera were also collected in traps; more Sphecoidea were found in phenylacetaldehyde-baited traps compared to pheromone-baited traps.

Key Words: insect behavior, *Spodoptera*, phenylacetaldehyde, monitoring

RESUMEN

Experimentos de campo fueron llevados a cabo para determinar la efectividad del compuesto floral fenilacetaldehido en incrementar la captura de machos del gusano de otoño *Spodoptera frugiperda*, en trampas con carnada de feromona. Trampas de plástico "Unitraps" fueron colocadas en campos de maíz y algodón en regiones del centro-norte de Florida y se les preparo con feromona de sexo comercial y fenilacetaldehido sintético soltados de tapones huecos de polietileno y de pipetas microcapilarias de cristal. La adición de fenilacetaldehido como atrayente no fue efectivo en la colección de mas polillas y en realidad redujo el numero de polillas capturadas en comparación con trampas con señuelo de feromona. Himenóptera en general también fueron colectadas en trampas; mas Sphecoidea fueron encontradas en trampas con fenilacetaldehido comparadas con trampas de feromona.

Populations of adult male *Spodoptera frugiperda* (J. E. Smith) (fall armyworm) are monitored in agricultural systems with a multicomponent sex pheromone as a lure in traps (Mitchell et al. 1985; Tumlinson et al. 1986). However, chemicals other than sex pheromones have been isolated, identified, and bioassayed as moth attractants. Phenylacetaldehyde, along with other chemicals, has been isolated from many flowering plants and shrubs including *Zea mays* L. (Poaceae) (Cantelo & Jacobson 1978), *Araujia sericofera* Brothero (Asclepiadaceae) (Cantelo & Jacobson 1979), *Abelia grandiflora* (André) (Caprifoliaceae) (Haynes et al. 1991), *Cestrum nocturnum* (L.) (Solanaceae) (Heath et al. 1992), and *Gaura* spp. (Onagraceae) (Shaver et al. 1998). Field trapping with flowers or synthetic phenylacetaldehyde captured low numbers of *S. frugiperda* (Cantelo & Jacobson 1979). Synthetic phenylacetaldehyde was tested in flight tunnel bioassays with fall armyworm males and was found to increase upwind flight (from 65.4% to 85.2%) and contact with the source (from 43.8% to 69.3%) in combination with a sex pheromone lure (Meagher & Mitchell 1998).

Advanced pest management techniques used to correlate adult populations with resulting larval densities, or with management strategies such as autodissemination of a pathogen, may require improved attraction and trap capture of moths. My major objective for this research was to test phenylacetaldehyde as an enhancement to sex pheromone in the collection of male fall armyworm in field tests. Because of the collection of nontarget Hymenoptera in related studies (Meagher & Mitchell 1999), a secondary objective was to compare collection of aculeate Hymenoptera in pheromone- and phenylacetaldehyde-baited traps.

MATERIALS AND METHODS

1997

An experiment was conducted in northwestern Alachua County, Florida, from 21 July to 10 October. All-white Universal Moth Traps or Unitraps (Great Lakes IPM, Vestaburg, MI) were placed along pivot roads and edges in an 80-ha field of cotton, *Gossypium hirsutum* L. This field was surrounded by ≈ 400 ha of cotton, separated by paved and unpaved roads and forested strips.

Traps were baited with lures containing sex pheromone of the fall armyworm and phenylacetaldehyde. Three treatments were used: (1) Trécé® (Trécé, Inc., Salinas, CA) red septa lures containing components of the *S. frugiperda* pheromone, (2) phenylacetaldehyde (Aldrich Chemical Co., Milwaukee, WI) placed in hollow polyethylene stoppers (Kimble, Vineland, NJ, purchased through Thomas Scientific, Swedesboro, NJ, #9713-F28), or (3) a combination of both lures. Pheromone lures were attached to the bottom of a cork that was placed in a hole in the canopy of the Unitrap. The stopper with phenylacetaldehyde (0.5 ml per stopper) was hot-gun glued (Arrow Fastener Co., Saddle Brook, NJ) to the bottom of the cork, which was placed in the trap canopy. The combination lure was composed of a cork with attached stopper and the pheromone lure attached to the side of the cork. All traps contained insecticide strips to kill moths that were captured (Hercon® Vaportape II containing 10% 2, 2-dichlorovinyl dimethyl phosphate, Hercon Environmental Co., Emigsville, PA). Trap contents were removed three times per week and pheromone and phenylacetaldehyde lures were replaced every two weeks. The experiment was designed as a randomized complete block with three blocks of the three treatments. The location of each trap within each block was changed weekly.

1998

In late March, fields in the same area in northwestern Alachua county were planted to silage corn (*Zea mays* L.). An experiment was designed to compare capture of fall armyworm males in Unitraps that presented two lower release rates of phenylacetaldehyde in combination with Trécé *S. frugiperda* pheromone lures. Phenylacetaldehyde was injected into disposable 100 µl glass microcapillary pipets (Kimble, Vineland, NJ) that had been flame-sealed at one end, and filled so that there would be a 10-mm length of the vapor-air column above the liquid. Holes were drilled into corks that were placed in the canopy of the Unitrap, and microcapillaries were placed in the corks. The double phenylacetaldehyde release rate contained two microcapillaries of the synthetic compound. Therefore, the three treatments were: (1) Trécé *S. frugiperda* pheromone lures, (2) Trécé lures plus phenylacetaldehyde in one microcapillary pipet, or (3) Trécé lures plus phenylacetaldehyde in two pipets. Traps contained insecticide strips to kill insects. The experiment was designed as a randomized complete block with four blocks of the three treatments, and trap location within a block was randomized weekly. Trapping began 27 April and ended 12 June. Additionally, all aculeate Hymenoptera that were captured were sorted and numbers were compared across treatments.

Release Rates

Release rates of phenylacetaldehyde in the stoppers used in the 1997 experiment were determined by the modified techniques of Heath & Manukian (1992). Briefly this system consists of a glass chamber (25.7 cm long and 7.6 cm ID) constructed of Pyrex glass with a glass frit inlet, a ground-glass joint outlet, and a multiport collector base to which the collector traps were connected. Collector traps were made from a 4.0 cm long by 4.0 mm ID piece of glass tubing and contained 50 mg of Super-Q® (Alltech Assoc., Deerfield, IL) as the adsorbent. Two stainless steel frits were used to contain the adsorbent. The collector traps were connected to stainless steel tubing by 0.64 cm unions and 0.64 cm ID Teflon® ferrules. These traps were cleaned by soxhlet extraction with methylene chloride for 24 h and dried in a fume hood prior to use. The airflow rate through the volatile collection system was 1 L/min during a 1-h collection period. Volatiles from the lures collected on the traps were eluted using 100 µl of high purity methylene chloride. Tetradecane was added as internal standard prior to analysis. Release rates were determined from three lures on days 3, 5, 7, and 14. The lures were held in a hood without airflow between analyses.

Gas chromatographic analyses were conducted with a Hewlett-Packard Model 5890A Series II gas chromatograph, equipped with a cool on-column capillary injector (septum injector) and flame ionization detector. Helium was used as the carrier gas at a linear flow of 18 cm/sec. A combination of three fused silica columns connected in series by GlasSeal® connectors (Supelco Inc., Bellefonte, PA) was used. A deactivated fused silica column, 8.0 cm long by 0.5 mm ID, was connected between the injector and the retention gap column. This column permitted the use of 0.4 mm OD stainless steel needles with a septum injector for on-column injections. The retention gap column used was 10 m by 0.25 mm ID deactivated fused silica and the analytical column used for analysis was a 30 m by 0.25 mm ID (0.25 µm film) SE-30.

Release rates of phenylacetaldehyde in the microcapillaries used in the 1998 experiment were determined in a manner similar to that reported by Weatherston et al. (1985a, b), by which rates are estimated mathematically based on size of microcapillary, length of vapor-air column above the liquid, and volatility of the formulated compound.

Statistics

For each experiment, insect numbers were compared across treatments in a split block analysis of variance (ANOVA), where treatment was the main plot and date was the subplot (Steel & Torrie 1980). To satisfy ANOVA assumptions, counts were *log* (x + 1) transformed before analysis. Treatment means or treatment combinations were separated by a LSD mean separation test or orthogonal comparisons (PROC GLM, CONTRAST statement, SAS Institute 1996). Untransformed means (±SE) are given in text and figures, whereas statistical results refer to transformed data.

Results

1997

Fall armyworm males were collected from late July through early October, with a peak capture of over 100 moths per night per trap in early September (Fig. 1). Traps baited with pheromone alone consistently captured more moths than traps baited with both pheromone and phenylacetaldehyde, or traps baited with phenylacetaldehyde alone (mean ± SE, moths per night: pheromone alone 21.6 ± 3.0, pheromone + phenylacetaldehyde 13.7 ± 1.6, phenylacetaldehyde alone 0.12 ± 0.03; $F = 196.7$; df = 2, 4; $P < 0.0001$). The release rate for phenylacetaldehyde in the stoppers over the 14-day period averaged 492.9 ± 15.1 µg/h (Fig. 2).

1998

Male fall armyworm numbers in traps were low until late May (Fig. 3). More moths per night were collected from 29 May through 15 June in pheromone-baited traps (27.1 ± 5.0) than pheromone + phenylacetaldehyde-baited traps (12.5 ± 3.4) ($F = 5.1$; df = 2, 6; $P = 0.0511$). Capture in pheromone + double phenylacetaldehyde-baited traps (13.6 ± 2.4) was intermediate. The release rate for phenylacetaldehyde in the microcapillary tubes was initially 230.8 ng/h for the single tube and 461.6 ng/h for the double rate.

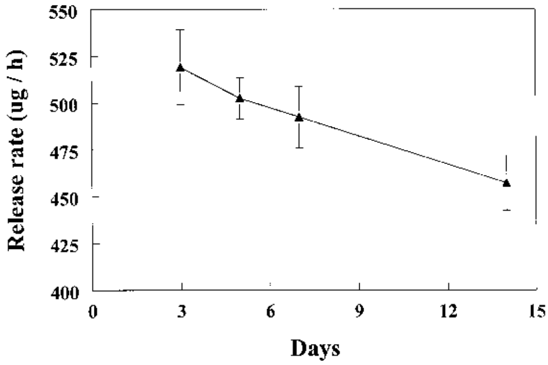

Fig. 2. Release rate (µg/h) of phenylacetaldehyde from hollow polyethylene stoppers over 14 days.

Several species of Hymenoptera were collected in relatively large numbers, including the bumblebee *Bombus pennsylvanicus* (De Geer), and the wasps *Scolia n. nobilitata* (F.), and *Larra bicolor* F. (Table 1). More Sphecoidea were found in phenylacetaldehyde-baited traps than pheromone-baited traps (Fig. 4) (contrast: $F = 6.5$; df = 1, 6; $P = 0.0436$). Numbers of Apoidea, Scolioidea, Vespoidea, and Tiphioidea were similar among the different treatments ($P > 0.05$). These results generally agree with those found in Meagher & Mitchell (1999).

Discussion

Previous research showed a numerical increase in captures of males with traps baited with both sex pheromone and phenylacetaldehyde with five moth species (Noctuidae, Plusiinae) (Creighton et al. 1973). In fact, most of the successful studies of attraction to phenylacetaldehyde have been completed with species of Plusiinae (Smith et al. 1943; Creighton et al.

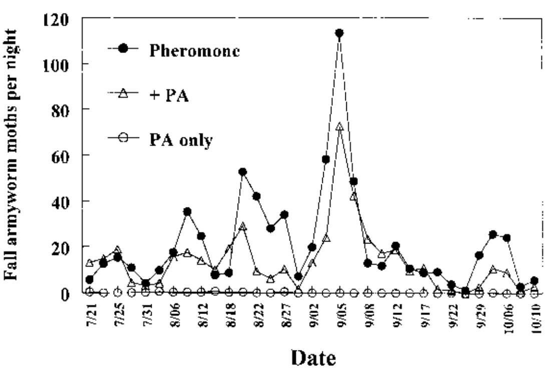

Fig. 1. Collection of male fall armyworm in Unitraps baited with sex pheromone, phenylacetaldehyde (PA only), or a combination (+PA), Alachua Co., FL, 1997.

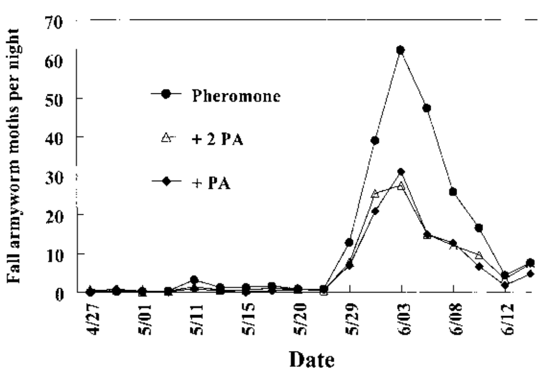

Fig. 3. Collection of male fall armyworm in Unitraps baited with sex pheromone only, or combinations with two rates of phenylacetaldehyde (+PA and +2 PA), Alachua Co., FL, 1998.

TABLE 1. SPECIES AND NUMBER OF HYMENOPTERA COLLECTED IN THE 1998 FLORAL LURE EXPERIMENTS, ALACHUA CO., FL.

Superfamily/family/tribe/genus/species	Number collected
Apoidea	
Anthophoridae	
Anthophorinae	
Melissodes spp.	4
Xylocopinae	
Xylocopa virginica (L.)	2
Unidentified anthophorids	12
Apidae	
Bombinae	
Bombus bimaculatus Cresson	1
B. fraternus (Smith)	3
B. impatiens Cresson	7
B. pennsylvanicus (De Geer)	53
Apinae	
Apis mellifera L.	6
Halictidae	
Halictinae	
Agapostemon splendens (Lepeletier)	11
Scolioidea	
Scoliidae	
Campsomerinae	
Campsomeris (*Dielis*) *plumipes fossulana* (F.)	8
Scoliinae	
Scolia (*Discolia*) *n. nobilitata* (F.)	20
Sphecoidea	
Sphecidae	
Larrinae	
Larra bicolor F.	19
Philanthinae	
Cerceris bicornuta Guérin	11
Sphecinae	
Ammophila sp.	7
Bicyrtes quadrifasciata (Say)	3
Eremnophila aureonotata (Cameron)	1
Sceliphron caementarium (Drury)	1
Sphex sp.	1
Tiphioidea	
Tiphiidae	
Myzininae	
Myzinum sp.	7
Vespoidea	
Vespidae	
Polistinae	
Polistes carolina (L.)	2
Polistes sp.	13

1973; Cantelo & Jacobson 1979; Haynes et al. 1991; Landolt et al. 1991; Heath et al. 1992). However, our research with laboratory-reared fall armyworm (Noctuidae, Amphipyrinae) in a flight tunnel showed increased percentages of upwind flight and source contact in combination with a sex pheromone lure (Meagher & Mitchell 1998). The disappointing results in these field experiments showed that wild *S. frugiperda* moths were not attracted to phenylacetaldehyde-baited traps alone, or in combination with sex pheromone. Landolt et al. (1991) and Heath et al. (1992) reported that cabbage looper, *Trichoplusia ni* (Hübner), moths responded to release rates ranging

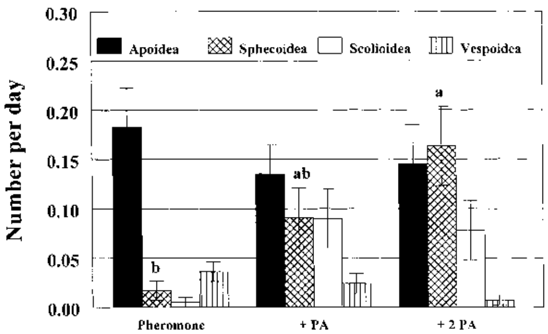

Fig. 4. Number of Hymenoptera captured per day in phenylacetaldehyde- (+PA) or double rate phenylacetaldehyde-baited (+2 PA) bucket traps in corn. All traps contained Trécé *S. frugiperda* pheromone lures, Alachua Co., FL, 1998. Means within Sphecoidea followed by the same letter are not significantly different.

from 50 ng/h to 4 µg/h in flight tunnel and screen-cage bioassays. Because counts were lower in the combined phenylacetaldehyde + pheromone-baited traps, it is assumed that fall armyworm moths were able to perceive phenylacetaldehyde at the release rates tested (230 ng/h—500 µg/h), but were repelled from those traps.

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