COTTON FLEAHOPPER RESPONSES TO ODORS FROM SELECTED HOST PLANTS

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Abstract

Several field studies have indicated that cotton fleahoppers (*Pseudatomoscelis seriatus* Reuter) prefer some wild host plants to cotton (*Gossypium hirsutum* L.). The relative attractiveness of volatiles from selected wild plants to adult cotton fleahoppers was determined in a series of two-choice olfactometer bioassays. Fleahoppers were attracted by volatiles from each of three flowering wild plants - false ragweed (*Parthenium hysterophorus* L.), wooly croton (*Croton capitatus* Michx.), and horsemint (*Monarda punctata* L.) - in preference to volatiles from squaring cotton. Odors of false ragweed were preferred to those of wooly croton and horsemint which were comparable in attractiveness. Revolatilized chemical compounds, collected from the head-space volatiles of each of the three wild plants tested, retained their attractiveness. These results indicate there is good potential for successful isolation and identification of the preferred attractants, and the subsequent development of synthetic mimic attractants that may be useful in the development of new attractant-based biorational management techniques for cotton fleahoppers.

Introduction

The cotton fleahopper is an important early-season pest of cotton in Texas, Oklahoma, Louisiana, and Mississippi that caused estimated losses of more than $36 million in 1997 (Williams, 1998). Adults and nymphs damage young cotton plants by sucking the sap from young squares and terminal growth, causing excessive fruit shedding and abnormal whip-like growth of the plant (Reinhard, 1926).

Fleahoppers feed and reproduce on a large number of wild plants (Reinhard, 1926, 1927; Schuster et al., 1969), with the most important species belonging to the genera *Oenothera*, *Monarda*, *Solanum*, and *Croton* (Hixson, 1941). They overwinter as diapausing eggs that are inserted during autumn under the bark on woody stems of senescent plants, primarily *Croton* spp. in Central Texas. Egg diapause is broken in the spring with the onset of warmer temperatures and increased rainfall. Newly hatched nymphs feed on an assortment of spring weed species, including *Oenothera* and *Monarda*, and mature to the adult stage in 9 to 20 d, depending on temperatures (Little and Martin, 1942). The fleahoppers complete one or more generations on the weed hosts.

As the season progresses, the wild host plants mature and become increasingly less attractive to adult fleahoppers, which then migrate to cotton (Almand et al., 1976). This migration usually occurs as cotton is beginning to develop young flower buds (pinhead squares). The cotton plant is most attractive and susceptible to fleahopper attack during the first few weeks of squaring.

In cotton production areas where the boll weevil is an important pest, fleahoppers and emerging overwintered weevils move into squaring cotton at about the same time. Conventional management strategies usually involve two or more early-season insecticide applications to control both pests. The insecticides applied to control fleahoppers and boll weevils also frequently kill many arthropods that are important natural enemies of *Helicoverpa* and *Heliothis* spp. The suppression of populations of beneficial arthropods by early-season insecticide applications can lead to damaging outbreaks of *Helicoverpa* and *Heliothis* spp. that otherwise would have been held below economic thresholds (Anonymous, 1973; Gaines, 1942; Ewing and Ivy 1943; Ridgway et al., 1967).

Several reports (Reinhard 1926; Little and Martin, 1942; Holtzer and Sterling, 1980) have indicated that fleahoppers prefer flowering weed hosts such as horsemint and croton over cotton. Our objective was to evaluate the relative attractiveness of volatiles from selected wild host plants and fruiting cotton to adult fleahoppers using two-choice olfactometers.

Materials and Methods

Bioassays were conducted by comparing fleahopper responses to pairs of volatile sources in two-choice olfactometers (Fig. 1) constructed of clear acrylic as described by Beerwinkle and Marshall (1999). In typical assays, volatile source materials to be tested were placed in the volatile-source chambers (upper chambers of B1 and B2, Fig. 1). Then 40 to 50 adult fleahoppers were lightly anesthetized with CO_2 and placed in the arena enclosure (A, Fig. 1) where they were exposed to air streams carrying the volatiles from the two source chambers through their respective capture chambers into the arena. Fleahoppers that were attracted to one or the other volatile sources entered the capture chambers of choice through orifices in the base wall of the triangular arena enclosure. After 4 to 5 hours of exposure to the volatile choices, the olfactometers were inspected to determine the number of fleahoppers that had responded to the respective volatile sources, the number of dead fleahoppers in the arena, and the number of fleahoppers in the arena that were alive but had not responded to the

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volatiles. Handling procedures for fleahoppers used in the bioassays were as described by Beerwinkle and Marshall (1999).

Four sets of bioassay experiments were conducted. In the first set of experiments, responses of fleahoppers to volatiles from each of seven different plants were compared with their responses to air blanks. The seven plant volatile sources included bouquets of fruiting terminals of young cotton, and bouquets of blooms and other parts from each of six different selected wild plants including wooly croton, horsemint, false ragweed, cutleaf evening primrose (*Oenothera laciniata* Hill), firewheel (*Gaillardia pulchella* Gray), and the common sunflower (*Helianthus annuus* L.).

In the second set of experiments, responses of fleahoppers to volatiles from bouquets of plant parts from each of wooly croton, horsemint, and false ragweed were compared with responses to volatiles from fruiting terminals of cotton plants in paired-choice assays. In similar assays, the third set of experiments compared fleahopper responses with all possible paired choices between volatiles from croton, horsemint, and false ragweed. The fourth set of experiments examined the responses of fleahoppers to revolatilized odors from compounds originally adsorbed from head-space volatiles emanating from bouquets of croton, horsemint, or false ragweed by methods described by Beerwinkle and Marshall (1999)

Only a portion of the fleahoppers tested in each experiment responded by entering a capture chamber of choice in the olfactometer. Some died in the arena (usually <15%), while others either were not attracted by the test volatiles or otherwise failed to respond. The number of fleahoppers exposed to volatiles in each test was adjusted for the observed natural mortality before calculating the percentages responding to each of the two choices.

Response data in percentages from the various bioassay experiments were transformed using the inverse sine transformation prior to statistical analyses. Differences in mean response levels to paired volatile sources were compared with paired-sample t-tests.

Results and Discussion

Fleahopper responses were significantly positive ($P = 0.001$, paired t-test) to each of the plant volatiles tested against air blanks in the first set of experiments (Fig. 2). The relative magnitudes of the plant-to-blank response ratios in this series of experiments indicated that, among the volatiles tested, those from false ragweed, horsemint, and wooly croton were the three most attractive to flea hoppers, and that the volatiles from these wild plants would likely be preferred by fleahoppers in comparison to those from squaring cotton plants. Results of the second set of experiments in which fleahoppers were exposed to paired choices between volatiles from bouquets of false ragweed, horsemint, and wooly croton blooms, respectively, and squaring cotton confirmed that fleahoppers were attracted by volatiles from each of the three wild plants in preference to volatiles from fruiting cotton plants ($P < 0.01$, paired t-test, Fig. 3).

The relative magnitudes of the wild host plant/fruiting cotton plant response ratios (Fig. 3) indicated that the volatiles from croton and horsemint plants were comparable in their superior attractiveness to volatiles from fruiting cotton; and the attractiveness of volatiles from false ragweed was superior to the attractiveness of volatiles from croton and horsemint.

When fleahoppers were exposed to all possible combinations of paired choices between volatiles from croton, horsemint, and false ragweed in the third set of experiments (Fig. 4), a similar trend was observed. The mean percent response of fleahoppers to croton volatiles was numerically higher than the response to horsemint volatiles, but the response percentages were not statistically different. However, fleahopper responses to false ragweed volatiles were significantly higher than their responses to both croton and horsemint volatiles ($P < 0.05$, paired t-test).

Results from the fourth set of experiments - in which fleahoppers were exposed to choices between revolatilized head space volatile compounds collected from croton, horsemint, and false ragweed, respectively, and methylene chloride blanks - were significantly positive for each of the three volatile sources ($P < 0.001$, paired t-test, Fig. 5). These results suggest there is good potential for isolating and identifying the active attractant chemical compounds in the volatiles of each of the three weed species tested.

Successful identification of the active chemicals would enable formulations of synthetic attractants that might be useful for developing new attractant-based biorational management techniques for fleahoppers. Synthetic attractants might be used to cause feral fleahoppers to concentrate in defined areas of cotton or some suitable factitious crop where they could be controlled with applications of insecticides only in the defined areas; thus, alleviating the need for broadcast spraying of whole cotton fields. Alternatively, synthetic attractants might be combined with biologically active materials to formulate attract-and-kill baits that are selective for fleahoppers. Successful development of these techniques holds potential for improving management of fleahopper pests through a reduction in use of synthetic pesticides and, coincidentally, a decrease in the detrimental effects on early-season beneficial insect faunas in cotton. Such techniques could contribute greatly to improved integrated pest management (IPM) strategies for cotton production, especially in areas where boll weevils have been eradicated.

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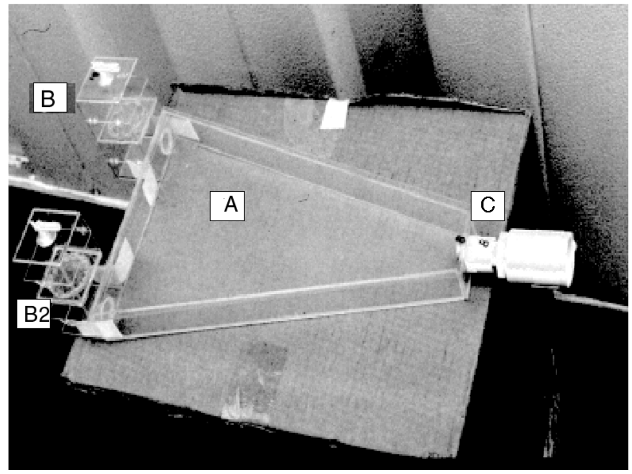

Figure 1. Two-choice cotton fleahopper olfactometer: A, arena enclosure; B1 and B2, volatile-source/fleahopper-capture chambers; C, exhaust fitting.

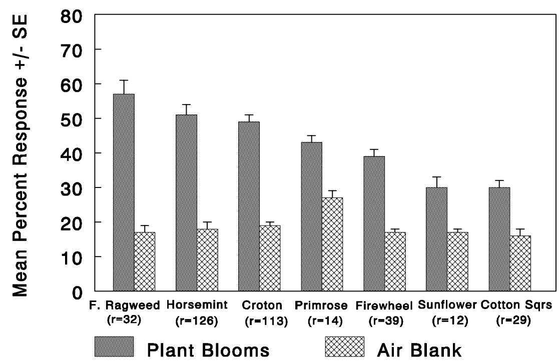

Figure 2. Responses of fleahoppers to choices between volatiles from false ragweed, horsemint, croton, cutleaf evening primrose, firewheel, sunflower, and cotton squares, respectively, and air blanks. All paired comparisons were significantly different at $P = 0.001$.

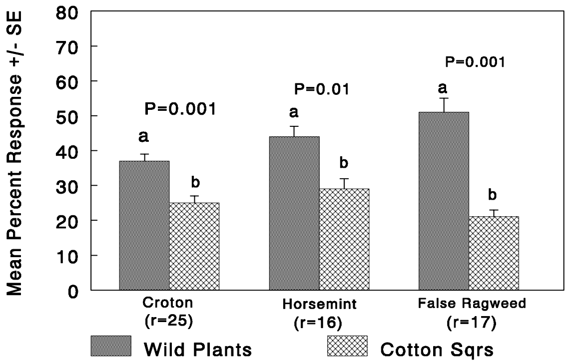

Figure 3. Mean percent responses of fleahoppers to choices between volatiles from bouquets of croton, horsemint, and false ragweed, respectively, and bouquets of cotton squares.

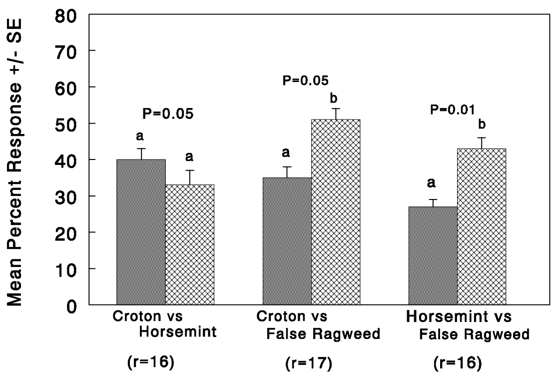

Figure 4. Mean percent responses of fleahoppers to choices between respective pairs of volatiles from bouquets of croton, horsemint, and false ragweed

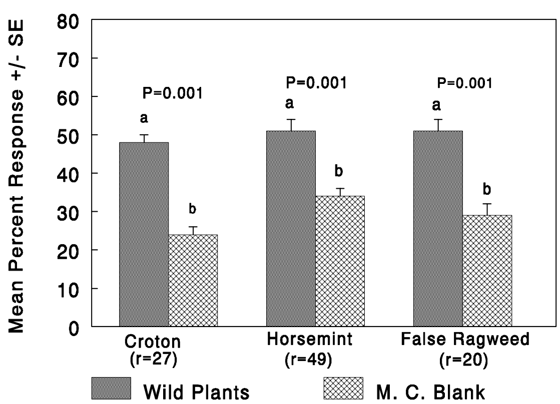

Figure 5. Responses of fleahoppers to choices between revolatilized chemicals collected from head space volatiles from croton, horsemint, and false ragweed, repectively, and methylene chloride blanks.