FINAL REPORT:

Title: Identification of chemical attractants from apple foliage and fruit for codling moth.

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Objectives:

2001 Objectives

Test chemicals for responses of codling moth females
Test chemicals for responses of codling moth larvae
Study moth responses to host odor
Repeat GC-EAD work with walnut

Significant Findings:

1). Codling moth larvae are more strongly attracted to apple fruit that is infested and are not-attracted in laboratory assays to the odors of apple fruit that are undamaged.

2). Codling moth larvae are attracted to three different apple kairomones, but in all cases, amounts of the chemicals required for attraction are dramatically higher than that released by apple fruit.

3). Codling moth adults are more strongly attracted to apple fruit that is infested compared to un-infested fruit.

4). Trapping of male and female codling moth with kairomones was significantly improved in a preliminary trapping test using 2 and 3 component blends of compounds found in induced apple fruit, compared to compounds tested individually.

5). Codling moth adults are attracted to the odor of un-infested Bartlett pear fruit and similarly to the odor from cut Bartlett pear.

Methods:

Codling moth female responses to fruit, fruit odor, and fruit chemistry were evaluated both in a flight tunnel and in the field. Flight tunnel assays included responses to fruit, fruit odors piped into the tunnel, and to solvent washes of fruit. Larval responses to fruit odors and fruit chemistry were evaluated in Y-tube and parallel tube olfactometers.

Volatile collections were made to characterize the odorants released from uninfested and infested immature apple and pear fruit at 2-week intervals through the season. Most of these odorants were characterized, using GC-MS. GC-EAD was used to determine which of the numerous compounds found in apple and pear odor are detected by codling moth females.

One of the chemicals tested is not commercially available and was isolated from an essential oil of a different plant and was purified using both preparatory column and HPLC methods.

Results and Discussion:

Results of flight tunnel assays of female codling moth responses to fruit, fruit odors, fruit washes, and fruit kairomones yielded interesting biological results but no clear identification of the kairomonal attractant from infested immature apples. Codling moth adults were attracted to immature apples, but more so to apples that were infested by codling moth larvae. Moths were similarly attracted to odors of apples piped into the flight tunnel, indicating that the attraction is a response to volatile chemicals from the fruit. Female codling moths were also attracted to the odor of Bartlett pear fruit in the flight tunnel and similarly to the odor of damaged Bartlett pear fruit.

Results of trapping experiments that tested apple fruit kairomones were mixed, but did yield a blend of compounds that attracted more male and female codling moth than any of the single chemical treatments, which included the pear ester. As reported by others for the pear ester, there appeared to be more varied performance of kairomonal lures in the second generation in apple which

obscured results when attempts were made to replicate tests through the season (that is, attraction results seen early in the season were sometimes not repeatable later in the season).

Field tests of synergism of codlemone and apple fruit kairomones did not yield any evidence of the enhancement of trap catch over that of codlemone alone. These tests were conducted during both codling moth flights, with similar results. However, this experiment was done with a limited set of apple fruit kairomones and will be pursued further with additional chemicals and over ranges of release rates. Some fruit kairomones significantly reduced male response (trap catch) to sex pheromone.

Laboratory olfactometer tests of neonate larval responses yielded a series of positive findings. In the first series of tests, it was determined that larvae were not significantly attracted to the odor of fresh-picked apple fruit, unless the apple fruit was infested. Larvae were attracted to the odor, however, of cold-stored thinning apples. Studies to isolate and identify the active ingredients in apple odor are still incomplete but indicate strong activity in two different liquid chromatography solvent fractions (one polar and one non-polar) obtained from volatile collections from infested, fresh-picked apples.

Testing of several chemicals known to be present or increased in the odors produced by infested apples yielded positive responses. E,E-alpha farnesene was identified in New Zealand (Sutherland and Hutchins 1972, Nature 239: 170) as an apple-produced attractant for codling moth larvae. We demonstrated upwind attraction of larvae to this compound at relatively high release rates. Such release rates occur from stored fruit but not immature fresh fruit. This compound may be part of a blend of compounds from apple that are attractive to larvae. Similar results were obtained with a second chemical identified in Europe as likely to be a codling moth attractant in apple. This chemical is not commercially available and was purified for use in assays from an essential oil. Again, attraction of larvae to this chemical was demonstrated, but at release rates that are high compared to our measurements of the compound from attractive apple fruit. Neonate codling moth larvae also responded to the pear ester, ethyl (E,Z)-2,4-decadienoate, at higher release rates. In addition, this response appeared to be limited to a turning response (Y-tube assay) and was not seen in a parallel tube olfactometer test designed to look at upwind forward movement. Experiments are underway to test for evidence of synergism among these chemicals as attractants for codling moth larvae.

Chemical analyses of volatile collections from apple and pear fruit clearly indicate a strong effect of codling moth larval infestation on the odor profile of these fruit. The number of chemicals produced and emitted is increased in response to codling moth damage and the total amount of volatiles emitted is increased greatly. This provides not only more odorants for the codling moth to detect and respond to, but provides a stronger signal that the insect may be able to more readily detect at some distance.

References:

Landolt, P. J., R. W. Hofstetter, and P. S. Chapman. 1998. Neonate codling moth larvae (Lepidoptera: Torticidae) orient anemotactically to odor of immature apple fruit. Pan-Pacific Entomol. 74: 140-149.

Landolt, P. J., J. A. Brumley, C. L. Smithhisler, L. L. Biddick, and R. W. Hofstetter. 2000. Apple fruit infested with codling moth are more attractive to neonate codling moth larvae and possess increased amounts of E,E-alpha farnesene. J. Chem. Ecol. 26: 1685-1699.

Reed, H. C. and P. J. Landolt. Attraction of mated female codling moths, *Cydia pomonella* L. (Lepidoptera: Tortricidae), to apples and apple odor in a flight tunnel. Florida Entomol. (In press).

Budget:
Identification of chemical attractants from apple foliage and fruit for codling moth.
Peter J. Landolt
Project Duration: 1999-2001
Current Year: 2002

Year	Year 1 (1999)	Year 2 (2000)	Year 3 (2001)
Salary		21,200	34,000
Benefits		6,700	
Supplies		6,000	5,000[2]
Travel		500	
Total	29,000	34,400	39,000

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Total Project funding: $102,400