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Olive fruit fly adult response to attract-and-kill bait stations in greenhouse cages with weathered bait spray and a commercial table olive orchard

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ABSTRACT

Attract-and-kill bait stations and olive foliage sprayed with insecticidal bait spray and exposed to 0–4 weeks of weather were evaluated for efficacy by olive fruit fly, *Bactrocera oleae* (Rossi), adult mortality. Mortality in greenhouse cage tests was significantly higher after three days than one day of exposure to non-weathered bait spray on bait stations and foliage, and on bait stations exposed to weather for three weeks. Mortality increased with an increase in insect exposure time, and decreased as bait spray weather exposure increased. Mortality was higher on bait stations than on olive foliage, and treated foliage showed little toxicity after 4 weeks in weather. In a commercial orchard, bait station efficacy was determined by captures of adults on yellow panel traps. Day temperatures were slightly higher on the underside of the station than top from 2 May to 10 July, similar on the top and underside 11 July to 7 August, and slightly lower on the underside from 8 August to 4 September. Fruit length increased from 0.4 on 16 May to 3 cm on 24 September and on 30 May attained 1 cm, the minimum size to produce one adult. No larvae or adults emerged from collected fruit. More adults were captured in an untreated row than a row with bait stations until 22 August and significantly so for the period ending on 11 July. Maximum adult captures occurred during 2 weeks prior to 19 September. Attract-and-kill bait stations would help reduce insecticidal applications and table olive production costs.

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Introduction

Olive fruit fly, *Bactrocera oleae* (Rossi) (Diptera: Tephritidae), is a key pest of table olives in California and is primarily controlled in orchards grown for canned fruit using foliar spot sprays of the registered insecticide, GF-120 NF Naturalyte Fruit Fly Bait (Dow AgroSciences, Indianapolis, Indiana, USA). Foliar applications of insecticidal bait are unprotected and exposed to the weather which can result in a loss in toxicity. Piñero et al. (2009) developed an inverted yellow saucer, bait station for attraction and control of oriental fruit fly, *Bactrocera dorsalis* (Hendel). The bait station resulted in better control of larval infestations in commercial papaya orchards than foliar sprays (Piñero et al., 2010) by protecting the bait spray from rainfall.

Implementation of attract-and-kill bait stations can reduce applications of foliar sprays by attracting pests to the treated devices. Yokoyama (2014) found in greenhouse cage tests that olive fruit fly adults were attracted to a yellow attract-and-kill trap or bait station constructed with corrugated plastic in an inverted cylindrical pan shape formed from a disk and collar (Fig. 1). Adults were most frequently observed under the devices and the response was related to lower temperatures on the underside, especially when air temperatures were high. The attract-and-kill bait station can provide olive fruit fly with shelter from the heat and application of insecticidal bait spray on the underside may reduce loss of toxicity caused by exposure to weather (Piñero et al., 2009). The degradation of GF-120 bait spray is primarily attributed to heat and sunlight (Mangan et al., 2006).

Attract-and-kill bait stations are advantageous in controlling small pest populations (El-Sayed et al., 2009) such as in the San Joaquin Valley where olive fruit fly numbers are low due to lethal high temperatures during summer (Wang et al., 2009; Yokoyama, 2012a). Thus, the attract-and-kill bait station developed for olive fruit fly control was determined to have great potential for olive orchard pest management. The attract-and-kill bait stations were highly attractive to adults and mortality from exposure to applications of insecticidal bait spray was better on bait stations than on foliage (Yokoyama, in press). The bait station developed in this study would attract olive fruit fly adults to the underside, maximize exposure to the bait spray, and protect the toxicant from degradation by sunlight and high temperatures.

Table olives are grown in the San Joaquin Valley and economic methods are sought to control the pest because olive fruit fly damage is not tolerated in canned fruit. The objectives were to determine if insecticidal bait sprays applied to the underside of the attract-and-kill bait station would prolong insect toxicity by protecting the bait spray

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Fig. 1. Attract-and-kill bait station sprayed with insecticidal bait in a commercial olive orchard.

from exposure to weather in comparison to traditional applications on olive foliage; and, to evaluate the capacity of the attract-and-kill bait station to reduce the incidence of olive fruit fly in a commercial olive orchard grown for canned fruit.

Materials and methods

Cage tests

Mission or Manzanillo olive fruit infested with olive fruit fly larvae was collected from olive trees in Davis and Lodi, California in November 2013. The infested fruit was placed in 7.8 l plastic containers, covered with organdy cloth, and held at ≈23 °C until the third instars emerged from the fruit and pupated. Pupae were placed in petri dishes in polyethylene screen cages, 35 cm wide by 35 cm long by 56 cm high, supported by a polyvinyl chloride pipe frame on benches in a glass greenhouse. Adults were counted after emergence, and the pupae were removed to limit the number of adults in each cage. The insects were provided with honey for food smeared on the top of the cage and water in a plastic container with a sponge wick. Each cage was considered a replicate and 3 replicate cages were used to test unexposed and weather exposed attract-and-kill bait stations or olive foliage bundles treated with insecticidal bait spray.

Olive foliage was collected from a Manzanillo olive orchard at the University of California, Kearney Agricultural Research and Extension Center, Parlier, CA. The terminal ends of 10 branches 25.4 cm long were loosely arranged with the cut ends tied together in a bundle with string. The surface area of the leaves was approximately equivalent to the surface area of the bottom of the 40.6 cm diameter attract-and-kill bait station. Ten milliliters of insecticidal bait spray (40% GF-120 NF Naturalyte Fruit Fly Bait) was sprayed on the underside of each attract-and-kill bait station (Fig. 1) and on each olive foliage bundle. Three bait stations and three foliage bundles were prepared for each week of exposure or non-exposure to weather. The bait stations and foliage bundles were tied to a polyvinyl chloride pipe frame outside the greenhouse and exposed to weather for 1–4 weeks. The treated attract-and-kill bait stations and olive foliage were covered during any period of precipitation to prevent removal of insecticidal bait residue from the foliage.

At the end of each week of exposure to weather, each attract-and-kill bait station and foliage bundle was placed in a separate cage with olive fruit fly adults about 1 to 6 days-old. A control cage was prepared from the same group and age of adults to determine natural mortality. Adults had a sex ratio of 43.7 ± 1.3%, mean ± standard error of the mean (SEM) females determined from five replicates of 100 adults selected at random from control cages. The number of dead adults was counted at approximately 24, 48, and 72 h intervals and reported as percentage mortality of the total number of adults in each cage. Temperature and humidity outside and inside the greenhouse were monitored every 15 min with dataloggers (HOBO Pro v2, U23-002, Onset Computer, Bourne, MA) with a temperature sensor on a 1.8 m cable.

Field tests

Attract-and-kill bait stations were installed in a commercial Manzanillo olive orchard in Terra Bella, California from 18 April to 24 September 2013. The trees were spaced about 6.1 m apart within each row and about 9.1 m between rows that were planted in an east–west direction. Six attract-and-kill bait stations, one per tree spaced one tree apart, were placed in one randomly selected row. The attract-and-kill bait station was fastened at the top with plastic coated wire and attached to limbs in the north, upper tree canopy (Fig. 1). Numbers of olive fruit fly adults were determined from captures on yellow panel Pherocon AM traps (Trécé, Adair, OK), with a clear packet (10.5 cm wide by 10.5 cm high) of ammonium bicarbonate bait (15–20 g), and a plastic dispenser (1.7 cm wide by 4.8 cm long) containing pheromone (1,7-dioxaspiro [5,5] undecane, 80 mg) supplied by Vioryl, Athens, Greece. One yellow panel trap was placed in the upper canopy on the north side of each of three trees that were between trees with bait stations in the same row. Three yellow panel traps were placed opposite of these trees in an untreated control row that was 9.1 m north of the treated row, and used to compare olive fruit fly adult numbers between the rows. Two attract-and-kill bait stations that had temperature sensors on the top and underside monitoring temperatures every 15 min with dataloggers (HOBO Pro v2, U23-002, Onset Computer, Bourne, MA) were placed in separate trees in the treated row.

The underside of the attract-and-kill bait stations was sprayed with 10 ml of 40% insecticidal bait spray on 18 April, 2 May, and 10 September.