NOTE

An Ultrasonic Fogging Device for Managing *Bemisia argentifolii* (Homoptera: Aleyrodidae) in Greenhouse Vegetables[1,2]

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Bemisia argentifolii Bellows and Perring and other whiteflies are problematic in greenhouses across the United States. A high percentage of the adult and immature stages are found on the lower surface of leaves on many vegetables (Simmons, 1994, Environ. Entomol. 23: 382-389). Most conventional insecticide applicators, whether in a field or in a greenhouse system, do not provide good coverage to the bottom leaf surface. Inadequate whitefly mortality is often the result. Commercial greenhouses can harbor whiteflies all year, and infested seedlings or migration from greenhouses may be a meaningful source of field infestations in the spring (Simmons and Elsey, 1995, J. Entomol. Sci. 30: 497-506). There are several advantages for having technologies with reduced rates of toxic compounds in vegetable production. We recently entered into a cooperative research and development agreement with Strauch and Sons, Inc., Bethesda, MD, to evaluate an ultrasonic fogging device for managing *B. argentifolii* on vegetables in the greenhouse using low dosages of contact insecticides. This is the first report on the use of this device as an insecticide applicator.

Trials were conducted in two greenhouses; each was 6.1 m by 4.6 m and covered with 4-mil plastic. A fogger unit (model FG-620; Shira Aeroponics Inc., Rehovot, Israel) was situated outside one greenhouse and an opening was constructed through which the duct of the fogger (hereafter called the fog duct) was inserted. According to the manufacturer, the device dispenses $\approx$ 15 liters of water per hour and produces $\approx$ 5 microns diam moisture droplets, which behave as a gas. The fogger is 46 $\times$ 71 cm and 48 cm high, and weighs $\approx$ 32 kg. The fog duct was 21.5 cm diam and was turned upward at about 45 degrees. Its bottom was 1.1 m from the floor of the greenhouse. A 0.9-m high bench was constructed in each greenhouse to hold the test plants.

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[2]This article reports the results of research only. Mention of a proprietary product does not constitute an endorsement or recommendation for its use by USDA.

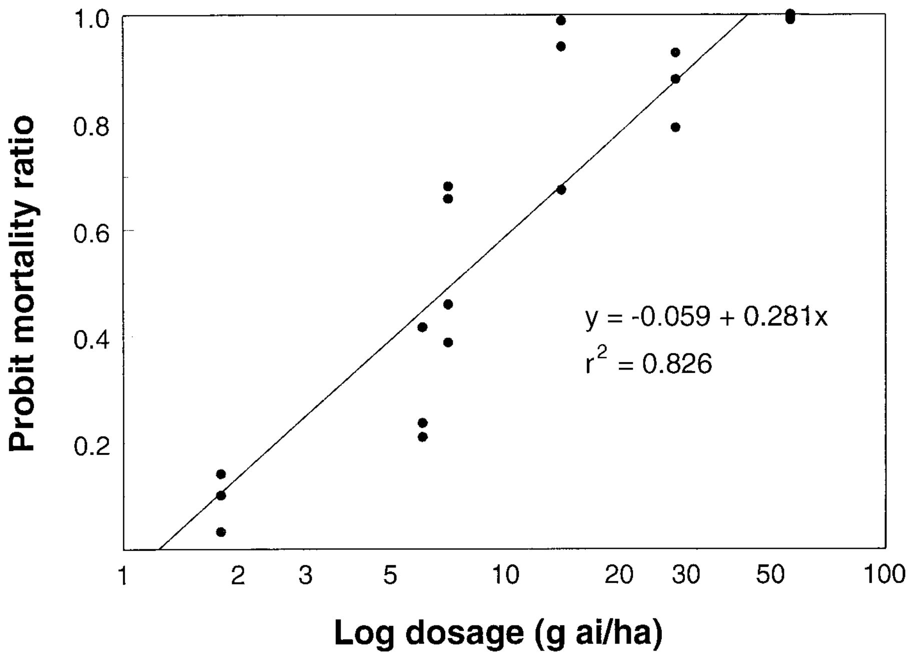
An initial test was conducted to see if insecticide materials were able to reach the lower surface of leaves. Sugar esters from *Nicotiana glutinosa* L. were used for the residue trial. Teflon disks, 5.72 cm diam (three/location), were placed 1.2, 1.8, and 2.4 m from the fog duct. They were positioned 0.9 m from the floor so that at each distance, either the top surface, bottom surface, or vertical surface was exposed. Analyses of the residue on disk samples were conducted by the USDA-ARS, Phytochemical Research Unit using techniques of Severson et al. (1985, J. Agric. Food Chem. 33: 870-875).

Dosage mortality data were collected from whitefly-infested collard (*Brassica oleracea* L.) plants after fogging with various dosages of imidacloprid (Provado 1.6 Flowable, Bayer Corporation, Kansas City, MO) in one greenhouse. Untreated plants were placed in an identical greenhouse and were used as a check. All plants were first grown in a whitefly-free greenhouse. Before each trial, test plants were exposed in a greenhouse infested with *B. argentifolii* for ≈ 1 d. The whitefly colony was established in 1992 from a field of sweetpotato, *Ipomoea batatas* (L.) Lam., and had since been maintained on several vegetables. These whitefly-infested plants were moved to the fog-treated and untreated greenhouses and held ≈ 12 h before the insecticide application. Each trial consisted of three plants per greenhouse. A plant was placed 1.2, 1.8, and 2.4 m from the fog duct; additional plants were set up with the same spacing in the untreated greenhouse. Adult whitefly counts were made before and 24 h after each insecticide test. Dosages of 56.16, 28.08, 14.04, 6.07, 1.80, and 0.0 (water only) g ai/ha were replicated three times (over time); dosage 7.08 g ai/ha was replicated four times.

The number of whiteflies on the bottom surface of three leaves (3 to 5 nodes from top of plant) for each of three plants per replicate was determined. Whitefly counts were not taken on all leaves, although they moved among leaves and plants. Hence, data for the control (no insecticide greenhouse) reflected whitefly dispersal and any natural mortality. If more insects were recovered at the end of each 24 h than at the beginning, the data were adjusted to assume 100% survival. This occurred only once. The number of adults per sampled three leaves per plant ranged from 124 to 1,413 whiteflies at the beginning of the trials. The duration of fogging for each trial was 6 min. Data on temperature and relative humidity at the start of each trial were taken. Dosage-mortality data were analyzed assuming the probit model (LeOra Software 1994, 11199 Shattuck Ave, Berkeley, CA). Correlations of environmental parameters with mortality were conducted after correction for natural mortality (Abbott, 1925, J. Econ. Entomol. 18: 265-267) and after transformation using log base 10 $(x + 1)$ (SAS 1994, SAS Institute, Cary, NC).

A high percentage (76%) of the sugar ester residue was recovered from the bottom of the horizontal exposed surface (3.8 μg/cm^2) compared with the top exposed surface (5.0 μg/cm^2) of the disks. Similarly, vertically-positioned disks received a high amount of residue (4.7 μg/cm^2). These data show that the fogger device can deliver insecticide to the bottom surface where it is needed for whitefly control.

Imidacloprid is one of the newest insecticides for whitefly management. The labeled field rate for whitefly control with the foliar Provado formulation is 112.32 g ai/ha. Tests with the fogger device using dosages of 84.24, 112.32, and 280.80 g ai/ha resulted in 100% mortality. These data were not included in the probit calculations. For the imidacloprid-treated plants, dead adults were observed after 24 h. Good control was obtained using low rates compared with the labeled rate (Fig. 1). The LD_{90} was 27.0 g ai/ha (slope 2.77 ± 0.52; LD_{50} = 9.3 g ai/ha; LD_{10} = 3.2 g ai/ha). Dead



whiteflies were observed with dosages as low as 7.07 g ai/ha. No dead insects were seen in the untreated control or when only water was fogged. Neither vapor pressure deficit nor relative humidity were correlated with mortality, although temperature was positively correlated ($P < 0.01$; $r = 0.56$) with mortality in the fog dosage trials. Additional data are needed such as, required fogging durations for different greenhouse sizes and different environmental conditions. Direct evaluations with conventional application equipment would also be useful.

This fogger may have applications for greenhouse commodities other than vegetables. For example, commercial plants such as poinsettia are good whitefly hosts, but have low damage thresholds for esthetic reasons. The residue analysis indicates that a high percentage of contact insecticide was delivered to the lower leaf surface. It provided good whitefly control with low rates of insecticide. The fogger looks promising for use in a greenhouse system as a convenient and economical method of spray application. Also, it could be used to target other insect pests with low-volume of environmentally-friendly insecticides.

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