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Short communication

Coating combined with dimethoate as a quarantine treatment against fruit flies (Diptera: Tephritidae)

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Abstract

Grapefruits infested with Caribbean fruit fly, *Anastrepha suspensa* (Loew), larvae were coated with Nature Seal containing 1.5% hydroxypropyl cellulose or Sta-Fresh 360 HS with or without 300 ppm dimethoate. Another treatment was dipped in 300 ppm dimethoate in water, and a final group of infested grapefruits remained untreated (control). Coating or dimethoate alone reduced the number of Caribbean fruit fly larvae emerging from grapefruits significantly (95% confidence level). The combination of coating plus dimethoate yielded 93–98.7% less larvae than either coating or dimethoate alone. Dimethoate residues in the pulp of grapefruits coated with Sta-Fresh 360 HS plus dimethoate (<0.005 ppm) were lower than residues in grapefruits coated with Nature Seal plus dimethoate (0.014 ppm) or dimethoate in water (0.009 ppm) three days after coating. These studies show that the combination of coating plus dimethoate may serve as a quarantine treatment for fruits infested with tephritid fruit flies. This combination treatment would allow lower doses of dimethoate than current dimethoate dips.

Keywords: *Anastrepha suspensa*; Grapefruit; Postharvest treatment; Insecticidal dip; Fruit coating

1. Introduction

Hosts of tephritid fruit flies must be subjected to a postharvest quarantine disinfestation treatment before they can be shipped from areas that have fruit flies to areas where they do not exist and might become established. Temperatures of 0–2.2°C for 10–24 days are used as quarantine treatments for various fruits infested

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with fruit flies (Gould, 1994) . Immersion of mangoes in water at 46.1°C is used to disinfest mangoes of fruit flies (Sharp, 1994). Methyl bromide fumigation is used as a quarantine treatment for many commodities (Yokoyama, 1994). Heated air treatments are presently used to ship several fresh commodities to Japan (Hallman and Armstrong, 1994). The systemic insecticides fenthion and dimethoate at dilute concentrations in water are used to disinfest various fruits of fruit flies in Australia (Heather, 1994). Fruit coatings are used to disinfest limes and cherimoyas of a surface mite, *Brevipalpus chilensis* Baker, in South America (Hallman, 1994). A coating probably kills a surface pest by adhering it to the fruit surface and plugging its respiratory and alimentary openings. Hallman et al. (1994) found that coatings applied to fruit surfaces killed fruit fly immatures inside the fruits. Because the coating did not come in contact with the insects, the mode of action obviously was different from that against surface pests. Coated grapefruits had reduced internal oxygen and increased carbon dioxide levels compared with uncoated fruits (Hallman et al., 1994). The mode of action of coatings to fruit fly immatures is probably akin to a controlled atmosphere treatment where lowered oxygen and/or raised carbon dioxide levels in the storage container kill fruit fly immatures (Hallman, 1994).

The objective of this research was to determine if the combination of coating plus dimethoate would provide greater fruit fly mortality than either measure used alone.

2. Materials and methods

Fruit fly survival in coated fruit

'Marsh' white grapefruits (weight about 400 g) were obtained from Ft. Pierce, FL, and placed in a screened-in infestation cage with approximately 200,000 Caribbean fruit fly, *Anastrepha suspensa* (Loew), adults for four–five days. The flies are from a colony reared for more than 220 generations on two diets: an agar-based one (85% of the flies) and a corn cob-based diet (Hallman et al., 1994). After removal from the infestation cage, the grapefruits were washed in a commercial citrus packing line, held at 25 ± 0.5°C for four days, divided into six groups, and then coated. Five different coating mixtures were used: 300 ppm dimethoate (Cygon 2E) in water, 300 ppm dimethoate in Nature Seal (EcoScience, Orlando, FL), 300 ppm dimethoate in Sta-Fresh 360 HS (FMC Corporation, Riverside, CA), and Nature Seal and Sta-Fresh 360 HS without dimethoate. Nature Seal is an edible cellulose-based coating. Sta-Fresh 360 HS is a citrus coating containing alkali-soluble resins and denatured alcohol. The grapefruits were hand-dipped in the coatings for 30 sec, excess coating was wiped off with gloved hands, and the grapefruits were placed in a room at 23 ± 0.5°C, 50–60% relative humidity, to dry. Each grapefruit was coated with approximately 1 ml of coating. The fruits were then placed in plastic trays in metal towers over bins containing sand at 25 ± 0.5°C. The sixth, uncoated group of grapefruits was the control. Larvae emerged from the fruits and dropped into the sand to pupate. The sand was sifted every three–seven days until larvae were no longer emerging, and larvae and pupae were counted. The test was repeated five

times with 26–74 grapefruits per treatment/replicate. The total number of larvae that had emerged, regardless of condition, was divided by the number of grapefruit in each treatment to yield the mean number of larvae emerged per grapefruit. These data were transformed by $\log(n+1)$. The data were subjected to analysis of variance (95% confidence level) using a randomized complete block design. Significant differences between means were tested by the Ryan-Einot-Gabriel-Welsh multiple range test (SAS Institute, 1989).

Dimethoate residues in grapefruit

Grapefruits were coated as above using the three mixtures containing dimethoate. One and three days after coating, a composite of grapefruit pulp from three fruits in each treatment was taken for analysis of dimethoate residues. Pulp was extracted with ethyl acetate three times, the extracts were filtered through anhydrous sodium sulfate, the filtrates were evaporated to dryness, and the residue was resuspended in acetone. The samples were analyzed by capillary gas chromatography with flame photometric detection operating in the phosphorous mode. A reagent blank and known concentrations of dimethoate were used as controls.

3. Results

Fruit fly survival in coated fruit

Fewer larvae were recovered from grapefruits in all of the treatments compared with control grapefruits (Table 1). The combination of coating plus dimethoate yielded 93–98.7% less larvae than either coating or dimethoate alone.

Dimethoate residues in grapefruit

Dimethoate residues in the pulp of coated grapefruits are presented in Table 2. Residues from grapefruits coated with Sta-Fresh 360 HS plus dimethoate were lower than residues in pulp of grapefruits coated with Nature Seal plus dimethoate (days 1 and 3) or dipped in 300 ppm dimethoate in water (day 3 only).

Table 1
Results of analysis of variance for numbers of Caribbean fruit fly larvae emerging from grapefruits subjected to different coatings

Coating	Larvae emerged per grapefruit ± SEM [a]
Nature Seal + 300 ppm dimethoate	0.19 ± 0.13 a
Sta-Fresh 360 HS + 300 ppm dimethoate	0.26 ± 0.16 a
Sta-Fresh 360 HS	3.5 ± 1.6 b
300 ppm dimethoate in water	5.6 ± 1.6 b
Nature Seal	14.4 ± 3.5 c
Control	38.6 ± 6.1 d

[a] Means followed by the same letter are not significantly different at the 95% level, Ryan-Einot-Gabriel-Welsh multiple range test (SAS Institute, 1989). Randomized complete block analysis of variance of $\log(larvae+1)$, $F = 51.88$, $Prob. > F = 0.001$, df = 5 over 20.

Table 2
Dimethoate residues in pulp of grapefruits one and three days after coating with three different treatments

Treatment	Mean ppm dimethoate ± SEM	
	after one day	after three days
300 ppm dimethoate in water	<0.005	0.009 ± 0.002
Nature Seal + 300 ppm dimethoate	0.022 ± 0.011	0.015 ± 0.005
Sta-Fresh 360 HS + 300 ppm dimethoate	<0.005	<0.005

4. Discussion

This research showed that combining a coating with dimethoate increased Caribbean fruit fly mortality greatly compared with a coating or dimethoate alone. This combination should be considered for further testing as a quarantine treatment in areas that allow postharvest applications of insecticides to fruits. The specific combinations used in this research did not provide quarantine security as defined by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS) (Shannon, 1994). APHIS usually requires probit 9 security, which is 99.9968% insect mortality. The highest level of mortality in this study was 99.5% in the combination of Nature Seal plus dimethoate. However, sub-probit 9 mortality levels for insecticide dips against fruit flies are accepted as quarantine treatments in Australia (Heather, 1994). Higher doses of dimethoate, other insecticides, such as fenthion, and different coatings should be examined with the goal of maximizing mortality of fruit fly eggs and larvae and minimizing insecticide residues in fruits.

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