HOT WATER TREATMENT OF LIGHTBROWN APPLE MOTH EGGS ON APPLES AND NECTARINES

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ABSTRACT

Lightbrown apple moth (LBAM, *Epiphyas postvittana* (Walker)) is a pest of quarantine concern on New Zealand apple and summerfruit exports. The potential for using hot water for postharvest control of this pest is now being evaluated. The tolerance of mid-aged eggs of LBAM to hot water treatments was compared when the eggs were allowed to infest onto apples or nectarines. Mortality responses of mid-aged eggs exposed to hot water at 45-57°C were similar whether the eggs were infesting apples or nectarines. As temperature increased, the time required to achieve 99% mortality (LT₉₉) decreased from 26.6 minutes at 45°C to 0.6 minutes at 57°C for apples, and from 29.3 to 0.5 minutes for nectarines.

Keywords: lightbrown apple moth, hot water, disinfestation

INTRODUCTION

Lightbrown apple moth (LBAM, *Epiphyas postvittana* (Walker)) is a pest of quarantine concern on New Zealand apple and summerfruit exports. Interception of the pest can result in rejection of large volumes of produce destined for the USA. At present, postharvest control of LBAM can only be assured by fumigation with methyl bromide. Alternative non-chemical treatments are now being sought for postharvest insect control. Heat treatment is one alternative which has been implemented to control potential infestations of fruit flies on several tropical crops (Armstrong *et al.* 1989; Waddell *et al.* 1993), and is now being considered for temperate fruits.

The first step in evaluating the potential usefulness of hot water to disinfest apples and summerfruit of leafrollers involved comparing responses of the various lifestages of the pests of concern in the absence of the host fruits ('off fruit'). LBAM was identified as the leafroller most tolerant to hot water, and mid-aged eggs of LBAM as the most tolerant egg age of the pest (Jones *et al.* 1995).

In this paper we report on the mortality responses of LBAM eggs infested onto the host fruits ('on fruit'), given that the 'heat sink' effect of the fruit (resulting in a correspondingly longer time to heat the insects) could influence the LT₉₉ (time required to achieve 99% mortality). We compared responses of eggs infesting both apples and nectarines, since their different heating characteristics might also confer different insect mortalities.

METHODS

All experiments were carried out in a 38-litre circulating waterbath (Grant, Model W38-ZD), accurate to $\pm 0.1^\circ\text{C}$ of the temperature nominated for each trial. A separate bath, used for holding the wet controls, was maintained at $20 \pm 0.5^\circ\text{C}$. The treatment temperature was verified before the start of each trial using a digital reference thermometer (RT 200, Industrial Research Limited, New Zealand), certified for accuracy by the Measurements Standards Laboratory of New Zealand, Wellington. A 16-channel data logger (Grant Squirrel, Model SQ32-8U/8U), accurate to $\pm 0.1^\circ\text{C}$, was used to record the temperature of both the water and the fruit pulp at 10 second intervals. Temperature data were transferred from the data logger using the Grant Instruments Squirrel Analysis Program and analysed using the Borland Quattro Pro Spreadsheet.

'Fantasia' nectarines were obtained from the HortResearch Clyde Research Centre, Central Otago, and 'Royal Gala' apples from a Hawkes Bay commercial orchard. The fruit were kept free of insecticidal sprays for ten weeks prior to harvest, but received regular fungicidal sprays. All individual fruit weighed 150-170 g. Fruit were kept in standard coolstorage (0.5°C) and were transferred to 20°C for 24 hours before infestation with the insects.

Insects were sourced from laboratory colonies maintained at 20°C, 60% RH and a photoperiod of 16:8 (L:D) hours at HortResearch, Auckland. Thirty pairs of adult moths were supplied in each of three gauze bag oviposition cages. Ten fruit (apples or nectarines) were placed inside each cage and removed after 24 hours. The egg-infested fruit were held at 20°C for a further 3 days (mid-aged eggs).

Three infested fruit were placed into each of 10 cylindrical plastic netting baskets (comprising one trial), which were assigned to either 'treatment' (eight baskets) or wet control (two baskets). Lead weights were attached to the ends of each basket to ensure submersion. Three treatment baskets were simultaneously immersed into the waterbath (maintaining a constant load of nine fruit), and one removed after different time intervals (15 seconds to 36 minutes depending on the temperature), in order to achieve a range of mortalities. As each sample was removed from the waterbath it was transferred immediately to the 20°C bath for 2 minutes, in order to stop the heating process.

Two 'sets' of three samples were treated in this manner, while the remaining two treatment baskets, representing the longest sample durations for that trial, were placed in the waterbath with one 'probe' and two 'filler' fruit (total nine fruit). Three probes, one 'surface' (inserted just under the surface of the fruit), one 'flesh' (placed 1 cm into the fruit) and one either 'core' (apples) or 'stone' (nectarines) were sealed into the probe fruit using paraffin wax. A 'water' probe measured the temperature of the water in the baths. The water probe and probe fruit were transferred from the treatment to the hydrocooling bath along with the last treatment basket for that trial.

Wet control fruits were held in the 20°C bath for the longest duration tested at each temperature.

Fruit from each basket were left to dry for approximately 30 minutes, then stored in a plastic container with a perforated lid which secured a fine fabric liner, allowing air exchange, and held at 20°C, 60% RH and 16:8 (L:D). Mortality was assessed 10 days after treatment by counting the number of live ('hatched') and dead ('unhatched') eggs.

A total of 10 trials was conducted on apples at 45°C (2 replicates, $n = 14388$), 49°C (2, $n = 10284$), 53°C (3, $n = 20012$) and 57°C (3, $n = 13084$), and eight on nectarines at 45°C (2, $n = 10684$), 49°C (2, $n = 14831$), 53°C (2, $n = 17516$) and 57°C (2, $n = 8238$).

A complementary log-log transformation was applied to the data in order to determine the mortality response versus exposure time at a particular temperature (Maindonald 1988; Preisler and Robertson 1989). Control mortality was excluded when fitting the model to the data, but included in the subsequent determination of the LT_{99} (i.e. estimated time for 99% mortality) using the Maximum Likelihood Program (Ross 1980). From the individual LT_{99} s thus calculated, a mean and SEM were calculated for each temperature. For each value predicted by the model, 95% confidence limits were calculated and used to examine differences in LT_{99} . A comparison based on whether or not these confidence limits overlap is equivalent to a significance test with a P-value of approximately 0.01. All differences are reported to this level of significance.

RESULTS AND DISCUSSION

Representative thermal profiles for apples and nectarines at 49°C indicate that heating at the fruit surface (where the eggs were located) was virtually identical (Fig. 1). In both cases, the surface temperature at the end of the heat treatment was several degrees below the target, which shows the temperature 'lag' between target (49°C) and fruit (44-45°C) temperatures. Higher temperatures were recorded for nectarines than for apples in both flesh (by up to 1.5°C) and core/stone (by up to 5.5°C) locations.

The LT_{99} for mid-aged eggs of LBAM infesting apples decreased with increasing temperature from 26.6 minutes at 45°C to 0.6 minutes at 57°C and from 29.3 to 0.5 minutes for nectarines (Table 1; Fig. 2). There were no differences between the LT_{99} s

FIGURE 1: Temperature profile for apples and nectarines exposed to hot water at 49°C for 7 minutes followed by hydrocooling at 20°C for 2 minutes.

for eggs infesting apples or nectarines, probably largely because their heating profiles were so similar.

LT_{99s} at 45°C for eggs treated on apples (26.6 minutes) and nectarines (29.3 minutes) were considerably longer than the LT₉₉ observed for eggs treated on plastic sheets i.e. ‘off fruit’ (16 minutes) (Jones *et al.* 1995). The greater heat tolerance of pests infesting fruit compared with ‘off fruit’ trials is typical in disinfestation research, as the fruit temperature lag results in a correspondingly longer time to kill the pests.

Since mortalities are the same for LBAM eggs on apples or nectarines, information gained using eggs infesting one crop need not be duplicated on the other. The mortality responses of larval instars of LBAM, which might be found inside the fruit where temperature differences are far greater than at the fruit surface, would be of interest in a further study.

TABLE 1: Estimated times in minutes for 99% mortality (LT₉₉) of LBAM eggs infesting apples and nectarines following exposure to hot water at 45-57°C.

		Temperature (°C)			
		45	49	53	57
On apples		27.2	5.4	1.7	0.7
		26.1	5.1	1.7	0.4
Mean ¹		26.6	5.3	1.7	0.6
SEM		0.55	0.14	0.02	0.08
On nectarines		30.6	7.0	1.8	0.5
		28.1	6.1	1.9	0.6
Mean ¹		29.3	6.5	1.8	0.5
SEM		1.29	0.47	0.07	0.05

¹ Means calculated from log (LT₉₉) values and back-transformed to give the values shown.

FIGURE 2: Estimated times in minutes for 99% mortality (LT_{99}) of LBAM eggs infesting apples and nectarines following exposure to hot water at 45-57°C. The error bars in the legend are the rms of the Ses at all points on the respective lines. Equations where t = temperature: on apples $\log y = 37.284 [\text{SE } 6.864] - 1.104 [\text{SE } 0.270]t + 0.008 [\text{SE } 0.003]t^2$; on nectarines $\log y = 18.253 [\text{SE } 0.395] - 0.332 [\text{SE } 0.008]t$.

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