

MORTALITY RESPONSES OF TYDEID MITE FOLLOWING HOT WATER TREATMENT

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ABSTRACT

The potential for using hot water to disinfest apricots of tydeid mite (*Orthotydeus californicus* (Koch)) was evaluated. Mites were exposed to hot water at 46-50°C and were treated either in the absence of the host fruit ('off fruit'), taped onto the fruit surface ('adhered' onto fruit) or 'naturally infested' onto the fruit surface. At all temperatures tested, the time required to achieve 99% mortality of the pest (LT₉₉) was lower for mites treated off fruit than for adhered mites, which was in turn lower than for naturally infested mites. As temperature increased from 46 to 50°C, the LT₉₉ for naturally infested mites decreased from 10.3 to 6.7 minutes.

Keywords: tydeid mite, apricots, hot water, disinfestation

INTRODUCTION

Apricots accounted for 36% of New Zealand's summerfruit exports (by volume) in the 1994-95 season. Currently the main market for export apricots is Australia (68%) (Taylor 1995). Identification of tydeid mite (*Orthotydeus californicus* (Koch)) on apricots has caused export consignment rejections for the past five summerfruit seasons under the pre-clearance programme implemented by the Australian Quarantine Inspection Service (AQIS) (G.F. McLaren, pers. comm. 1995).

Hot air and hot water treatments are being evaluated worldwide for non-chemical postharvest disinfestation, and have recently been implemented to control potential infestations of fruit flies on several tropical crops (Armstrong *et al.* 1989; Waddell *et al.* 1993a). Research to evaluate the usefulness of heat treatments to control pests of quarantine concern on apricots (including tydeids) indicate that treatment in hot air (38-43°C) for durations effective for kill of the pests causes severe damage to the fruit (McLaren *et al.* 1992; Waddell *et al.* 1993b).

Preliminary 'off fruit' studies using hot water at moderate temperatures (40-45°C) indicate that although tydeids (and thrips (*Thrips obscuratus* (Crawford)) are the pests most susceptible to hot water (McLaren and Fraser 1993; Waddell *et al.* 1993b; Jones *et al.* 1995), adequate kill can not be obtained within the tolerance limits of the fruit (McLaren and Fraser 1993; Rose and Lay-Yee 1993). Higher temperatures (46-50°C) however, have shown considerably more promise since apricots appear to better tolerate these temperatures (McLaren and Fraser 1993).

This study examines responses of tydeids to 46-50°C using three infestation methods. Mites were either (1) treated in the absence of the host fruit ('off fruit') to allow precise determination of the basic temperature-mortality response, (2) taped to the fruit surface ('adhered' onto fruit) to examine the 'on fruit' response while ensuring recovery of the mites, or (3) 'naturally infested' onto fruit to test the responses of mites able to exploit the whole fruit surface.

METHODS

'Sundrop' apricots, count size 23-28, were obtained from the HortResearch Clyde Research Centre, Central Otago in the 1993/1994 and 1994/1995 seasons. The fruit were kept free of insecticidal and miticidal sprays for ten weeks prior to harvest, but

received regular fungicidal sprays. Fruit were placed in coolstorage at 0°C and transferred to 20°C for 24 hours before infestation with the mites. Apricot leaves infested with tydeid mites were transported overnight from HortResearch Clyde to Auckland for use in experiments the following day.

All experiments were carried out in 38-litre circulating waterbaths (Grant, Model W38-ZD). Treatment baths were 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. In all 'on fruit' trials, 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.

Mites 'Off Fruit'

Twenty adult mites were individually collected from apricot leaves with a fine paint brush, and placed dorsal-surface down onto double-sided tape (Sellotape) on a microscope slide. Eight to ten slides (six to eight 'treatment', two 'wet control') were prepared for one trial. The treatment slides were immersed simultaneously in the water bath and one removed after different exposure times, selected to achieve a range of mite mortalities (3-90 seconds depending on the temperature). As each slide was removed it was cooled immediately in the 20°C bath for 2 minutes in order to stop the heating process. Wet controls were held in the 20°C bath for the duration of the longest sample to determine the relative contribution of drowning and heat to subsequent mortality.

A total of nine 'off fruit' trials were conducted at temperatures of 46°C (three trials, $n = 479$), 48°C (3, $n = 450$) and 50°C (3, $n = 420$).

Mites 'Adhered' onto Fruit

Mites were collected in the manner described above and placed onto double-sided tape adhered to the surface of an apricot. A cross-section of plastic tubing (2.5 cm internal diameter by 1 cm height) was attached with blutac around the area containing the tape to prevent physical damage to the mites. Ten fruit (eight 'treatment', 25-195 seconds) and two 'wet controls' were immersed, removed and hydrocooled as above. In addition to the eight treated samples, one 'filler' and one 'probe' fruit were immersed into the waterbath to maintain a constant load of ten fruit at the start of each trial. Three probes, one 'surface' (inserted just under the surface of the fruit), one 'flesh' (placed 1 cm into the fruit) and one 'stone' (touching the fruit stone) were sealed into the probe fruit using paraffin wax. A 'water' probe measured the temperature of the water. The probe fruit and water probe were transferred to the cooling bath along with the last treated sample.

A total of nine 'adhered' trials were conducted at temperatures of 46°C, (3, $n = 525$), 48°C (3, $n = 545$) and 50°C (3, $n = 499$).

Mites 'Naturally Infested' onto Fruit

A row of nine apricots was placed in a cylindrical plastic netting basket which was open along its length. Mite-infested leaves were stripped, leaving only the central rib region where the mites were usually concentrated, and placed face-down onto the fruit in the basket. Baskets were held at 20°C, 60% RH and a photoperiod of 16:8 (L:D) hours for two to three days before treatment to allow the mites to move from the desiccating leaves onto the fruit (approximately 20 mites per basket). Just before treatment, the leaves were removed and the baskets tied along their length with plastic twist wires. Ten 'treatment', two 'wet control' and two 'dry control' baskets were prepared in each trial. Treatment baskets were allocated over five to seven sample times, with samples in the upper mortality range tending to be represented by two baskets (~40 mites) and the remaining sample times by one basket (~20 mites). Each treatment basket was placed individually into the waterbath for the assigned duration (0.5-16 minutes) at the nominated temperature, then hydrocooled for 2 minutes. The

water in the cooling bath was changed between treatment of each sample to avoid potential contamination with live mites washed off from samples treated previously. Dry controls (20°C air) were kept to compare mite numbers with those in wet controls (20°C water) and thus quantify losses due to 'washing off'. A probe fruit was treated and hydrocooled along with each treatment basket (as described for 'adhered' trials).

A total of nine 'naturally infested' trials were conducted at temperatures of 46°C (3, n = 664), 48°C (3, n = 762) and 50°C (3, n = 745).

For 'on fruit' trials, all fruit were left to stand for 30-60 minutes following treatment until they were dry. Fruit were then transferred to plastic storage containers (22 x 13 x 9 cm), each with a perforated lid which secured a fine fabric liner, allowing air exchange.

Treated samples from all trials were stored at 20°C, 60% RH and 16:8 (L:D) for 24 hours. Mortality was assessed using a binocular microscope (20-40 X magnification) by scoring mites as 'live' or 'dead' by the presence or absence of movement when prodded with a pin.

A complementary log-log transformation was applied to the data in order to determine the mortality response versus exposure time at a particular temperature (Mairdondal 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

A representative temperature profile is given for apricots exposed to hot water at 46°C (Fig. 1). Temperatures at the fruit surface (where the mites were located) were considerably lower than the target temperature, which shows the temperature 'lag' when heating up fruit. Flesh and stone temperatures were a further 2-12°C below the temperature at the fruit surface.

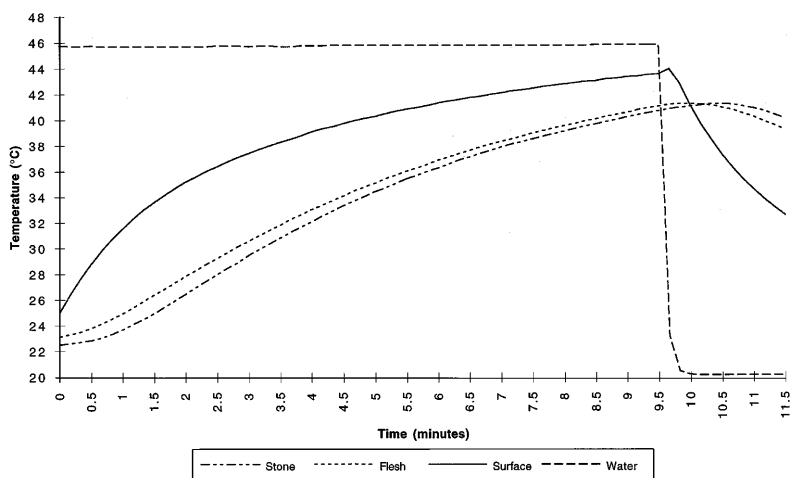


FIGURE 1: Temperature profile for apricots exposed to hot water at 46°C for 9.5 minutes followed by hydrocooling at 20°C for 2 minutes.

The overall response pattern of decreasing LT_{99} as temperature increased from 46 to 50°C was found in all cases, from 1.28 to 0.25 minutes, 2.93 to 0.95 minutes and 10.3 to 6.7 minutes for 'off fruit', 'adhered' and 'naturally infested' mites respectively (Table 1; Fig. 2). At all temperatures, the LT_{99} was lower for mites treated 'off fruit' than for 'adhered' mites, which was in turn lower than for 'naturally infested' mites. 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. The even longer LT_{99} s for 'naturally infested' (compared with 'adhered') mites, which represents the 'real' situation for disinfestation of the pest, is probably largely due to their ability to find protection in cavities and around the stem and suture of the fruit. Further, the 'naturally infested' mites were not 'washed off' the fruit since numbers of mites in air and water controls as well as in treatments were all very similar (mean 1.7, 2.0 and 1.9 per fruit respectively).

TABLE 1: Estimated times in minutes for 99% mortality (LT_{99}) of tydeid mite exposed to hot water at 46-50°C.

	Temperature (°C)			
	46	48	50	
'Off fruit'		1.32	0.53	0.28
		1.30	0.48	0.22
		1.22	0.53	0.23
	Mean ¹	1.28	0.52	0.25
	SEM	0.03	0.01	0.02
'Adhered' onto fruit		2.93	1.47	0.90
		2.90	1.47	1.05
		2.98	1.53	0.93
	Mean ¹	2.93	1.50	0.95
	SEM	0.03	0.02	0.04
'Naturally infested' onto fruit		10.1	5.4	6.6
		10.8	6.7	5.5
		9.9	6.4	8.3
	Mean ¹	10.3	6.2	6.7
	SEM	0.27	0.40	0.80

¹ Means calculated from log (LT_{99}) values and back-transformed to give the values shown.

When tested on apricots, tydeid mites have a relatively low tolerance to hot water at 46-50°C compared with other pests of quarantine concern. The LT_{99} of 6-7 minutes for tydeids at 50°C is considerably less than the times required for the leafrollers *Epiphyas postvittana* (Walker) (15 minutes) (Jones and Waddell 1994) and *Planotortrix octo* (Walker) (10 minutes) (McLaren *et al.* 1995). However, tydeid mites are more tolerant to hot water at 50°C than thrips (2 minutes) (McLaren *et al.* 1994).

Control of tydeid mites at 50°C appeared promising from studies carried out in the 1992-93 season, since the LT_{99} of 6-7 minutes was well within the tolerance limits of the fruit (9 minutes) (McLaren and Fraser 1993). However, similar trials carried out in the 1993/1994 season indicated that the fruit would only withstand 4 minutes at 50°C, probably because bad weather conditions prior to harvest caused the fruit to be of poor initial quality (McLaren *et al.* 1994). Control of tydeid mites in hot water at 50°C without apricot damage is therefore uncertain.

A novel hot water treatment system is now being used at HortResearch, Clyde to evaluate the efficacy of a 2 minute treatment at 50°C to control thrips 'on fruit' (predicted to cause complete thrips mortality without fruit damage), since it is the pest

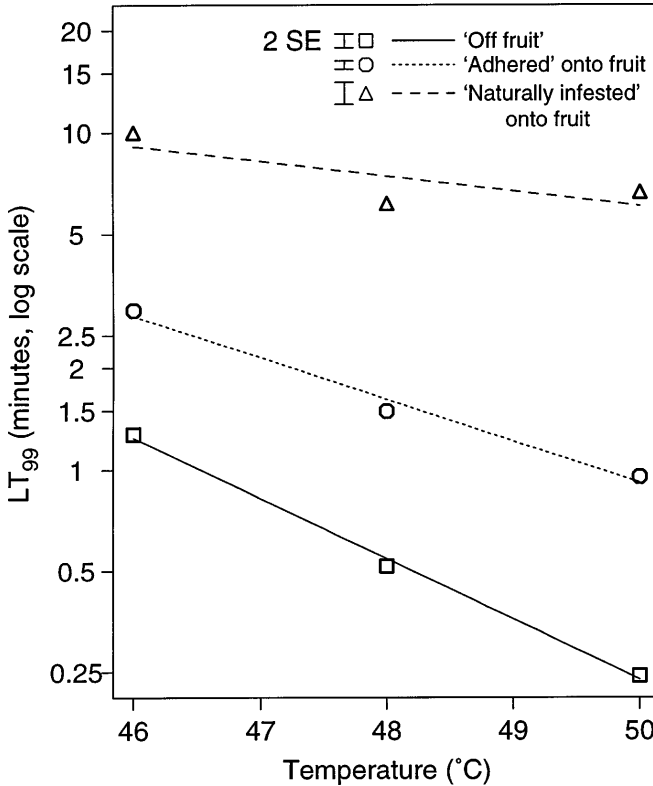


FIGURE 2: Estimated times in minutes for 99% mortality (LT_{99}) of tydeid mite exposed to hot water at 46-50°C. The error bars in the legend are the rms of the SEs at all points on the respective lines. Equations where t =temperature: 'off fruit' $\log y = 19.2$ [SE 0.789] - 0.413 [SE 0.016] t ; 'adhered' onto fruit $\log y = 14.0$ [SE 0.472] - 0.281 [SE 0.010] t ; 'naturally infested' onto fruit $\log y = 7.19$ [SE 1.332] - 0.108 [SE 0.028] t .

which causes the greatest number of export consignment rejections of apricots (G.F. McLaren pers. comm. 1996). While the 2 minute duration appears far too short to kill tydeid mites, 70-80% mortality was observed at this point in our trials of 'naturally infested' fruit. Thus while complete mortality of tydeids could not be ensured if the 2 minute treatment were implemented commercially, tydeid mortality would be greatly enhanced.

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