COMPARATIVE MORTALITY RESPONSES OF TWO SPECIES OF MITES FOLLOWING HEAT TREATMENT

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SUMMARY

Non-diapausing two-spotted mite (TSM, *Tetranychus urticae* (Koch)) and tydeid mite (*Orthotydeus californicus* (Koch)) are pests of quarantine concern on export summerfruit. Their relative tolerances to elevated temperatures were compared as part of a programme to develop a disinfestation treatment for summerfruit. TSM were more tolerant than tydeid mites when heated by direct dipping in water (41–51°C) or when exposed to heated air (37–45°C). A temperature 7–8°C warmer was required to give the same mortality for TSM as for tydeid mites. Mortality was higher in water treatments compared to air treatments of the same temperature. Pre-conditioning marginally increased the time taken to give 99% mortality.

Keywords: two-spotted mites, *Orthotydeus californicus*, dry-heat, summerfruit, disinfestation

INTRODUCTION

The main export market for New Zealand summerfruit is Australia. Currently most of the summerfruit is inspected in New Zealand prior to export by an Australian Quarantine Inspection Service inspector. Rejections for the past three summerfruit seasons have been due to the interception of thrips, leafrollers and mites. Of the mite species, tydeid mites are the pest responsible for the greatest number of export rejections of apricots.

Heat treatment has been under evaluation by HortResearch as a potential alternative for consignments failing pre-clearance inspection. Previous research used air treatments in the range 36–48°C. *Thrips obscuratus* (Crawford) has been shown to be relatively susceptible to heated air, and all life stages were killed within 12 h at about 40°C, 95% RH (Waddell *et al.* 1990). Third and fifth instars of lightbrown apple moth (*Epiphyas postvittana* (Walker)), placed on nectarines were more susceptible than non-diapausing TSM at 42°, and trial results gave estimated lethal times for 99% mortality of 12.7 and 13.3 h, respectively (Birtles *et al.* 1991). Diapausing TSM were shown to be more tolerant than non-diapausing TSM when infesting nectarines, and TSM are in general comparatively heat tolerant (Waddell and Birtles 1992).

In these trials in the absence of fruit, the responses of adult tydeid mites and non-diapausing TSM were evaluated at a range of temperatures over two summerfruit seasons. This research aimed to determine the relative susceptibility of the two species using heated air (1991/92 season) or water (1992/93 season).

METHODS

The non-diapausing TSM were reared in the laboratory using bean plants at 25°C, 60% RH, and L:D 16:8 (Singh and Clare, in press). Tydeid mites infesting apricot leaves were sourced from the Clyde Research Orchard, HortResearch, Central Otago and transported to Auckland overnight for use in the experiments the following day. Voucher specimens were deposited with the National Arthropod Collection Landcare Research New Zealand Ltd., Mt. Albert Research Centre.

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Water baths accurate to $\pm 0.01^\circ$ were used in all the trials to provide constant temperatures. A separate water bath was used for holding the controls at $25 \pm 0.5^\circ$, and as the cooling bath when the mites were cooled immediately after heat treatment. The treatment temperature was verified prior to the start of each trial with a digital reference thermometer (Fluke Model 2180-A) certified for accuracy by the Measurements Standards Laboratory of New Zealand, Wellington.

Heated air

Mites were placed in airtight containers and immersed in a water bath. Air temperatures in the range $37\text{--}41^\circ$ were initially chosen as these were unlikely to damage summerfruit. However, because of the greater tolerance of TSM to temperature, the range for this species was adjusted to $41\text{--}45^\circ$ to avoid very long treatment times.

Adult mites of both sexes were individually collected with fine paint brushes onto small pieces of paper and placed in plastic containers (80 ml internal volume) with airtight screw lids. Approximately 50 mites were collected in each container immediately prior to treatment. As a substrate a fresh bean leaf was included with the TSM and a clean apricot leaf with the tydeid mites. Ten to twelve containers with mites were prepared for each trial. Two were randomly selected as controls and the remaining eight to ten heat treated. All the containers were immersed in the water bath simultaneously and one container was removed after different exposure times (10 mins to 44 h depending on the species and temperature) to achieve a range of mite mortalities. Control mites were immersed in a 25° water bath for the duration of the longest treatment.

A total of 12 air trials were conducted. Six trials exposed tydeids at temperatures of 37° (1 replicate, $n=612$), 38° (1, 509), 39° (3, 1815) and 40° (1, 530), and six exposed TSM at 41° (2, 1104), 43° (2, 984) and 45° (2, 893).

Air temperatures inside the treatment containers were recorded on a data logger (Grant Squirrel data logger, Model 1206-14U/2L) using thermistor probes. Temperatures were recorded every 30 seconds.

Heated water

In the second season, high temperature water treatments were used. Twenty mites were placed dorsal-surface down onto double-sided tape on a microscope slide. Ten to sixteen slides were prepared for each temperature treatment, and two to four were randomly chosen and assigned as controls which were dipped in 25° water for the longest treatment duration. All the slides for a particular temperature treatment were immersed in the water bath simultaneously and one slide was removed after different exposure times (2 mins to 4 h depending on the species and temperature) to achieve a range of mite mortalities.

A total of 33 trials were conducted using the slide dipping method (Busvine 1980), 16 using tydeid mites at 41° (5, 1680) and 43° (11, 2513) and 17 using TSM at 45° (6, 1260), 47° (5, 1023), 49° (3, 618) and 51° (3, 580). Of the 11 tydeid replicates at 43° , three had a pre-treatment of 1 h in 38° air immediately prior to dipping (total $n=709$), while a further three consisted of pre-treatment, water dip, and then hydro-cooling in 25° water for 2 mins ($n=712$). The remaining five replicates consisted of water dips only ($n=1092$).

After air or water treatment, the mites were held for 12-36 h at 20° , 60% RH, L:D 16:8, then assessed as live or dead by the presence or absence of movement when touched with a pin. Control mites were assessed under the same conditions as the treated insects.

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).

RESULTS AND DISCUSSION

Increasing temperature in air and water resulted in substantially reduced treatment times needed to kill 99% of both insect species (Fig. 1). TSM were more tolerant than tydeid mites when exposed to either air or water and must be exposed to temperatures 7-8° warmer to achieve a similar level of mortality. The LT_{99} estimated for TSM in air at 45° was 10.9 h while in water of the same temperature the LT_{99} reduced to 3.5 h (Table 1). The same type of response was observed with tydeid mites as the LT_{99} was reduced from a predicted 89 mins in air to an observed 37.7 mins in water at 41°.

The delay in the mortality response for mites treated in air can partly be attributed to the warm-up period associated with air treatments. Air inside the treatment container took about 9 mins to equilibrate to the water temperature. In addition the slope for the response of TSM to hot water was significantly steeper ($P < 0.05$) than the slope for air treatments (Fig. 1) suggesting water transferred heat more rapidly than air. In contrast, the slopes determined for the tydeid response lines were not significantly different.

Figure 1. The estimated lethal times for 99% mortality (LT_{99}) for *Orthotydeus californicus* (Tydeid) and non-diapausing two-spotted mites (TSM) at a range of treatment temperatures. Equations where t = temperature: Tydeids in water $\log y = 35.26$ [SE 1.3] - 0.772 [SE 0.030] t ; Tydeids in air $\log y = 28.45$ [SE 4.4] - 0.584 [SE 0.114] t ; TSM in water $\log y = 30.69$ [SE 1.3] - 0.564 [SE 0.028] t ; TSM in air $\log y = 21.67$ [SE 0.7] - 0.337 [SE 0.017] t .

Pre-treatments and hydro-cooling were evaluated to determine if the tolerance of tydeid mites to high temperature increased, as apricots were reported to tolerate similar treatments (Lay-Yee *et al.* 1993). The response of tydeid mites when water dipped at 43° was altered by both pre-treatment alone and pre-treatment in combination with hydro-cooling (Fig. 2). The mean estimated LT_{99} following water dipping at 43° was 8.0 mins. This was increased to 10.6 mins ($P \leq 0.05$) when the mites were pre-treated

at 38° for 1 h in air immediately before dipping, and 10.7 mins ($P \leq 0.05$) when the mites were pre-treated, dipped and then hydro-cooled. The increased tolerance to heat after pre-treatment, although statistically significant ($P \leq 0.05$), was small. There appeared to be no additional effect from hydro-cooling post treatment.

Figure 2. The estimated lethal times for 99% mortality (LT_{99}) for *Orthotydeus californicus* heat treated at 43°.

TABLE 1: The estimated lethal time in minutes (m) and hours (h) for 99% mortality (LT_{99}) of two mite species following exposure to heated air and water at a range of temperatures.

Temp.°	<i>Orthotydeus californicus</i> (tydeid mites)				<i>Tetranychus urticae</i> (two-spotted mites)			
	Air		Water		Air		Water	
	m	h	m	h	m	h	m	h
37	1056	17.6						
38	456	7.6						
39	282	4.7						
40	186	3.1						
41	89*	1.5*	37.7	0.6	2526	42.1		
43			8.0	0.1	1368	22.8		
45					654	10.9	210	3.5
47							64.7	1.1
49							17.9	0.3
51							6.2	0.1

* Value estimated by extrapolation of mortality response line

Given the short treatment times possible at elevated temperatures, postharvest control of tydeid mites using heated air or water is promising. Longer times and/or higher temperatures will be required to kill TSM. Such time-temperature combinations may approach the limits of fruit tolerance. Further research is needed to investigate the response of mites treated on fruit. Pre-treatments and hydro-cooling also warrant investigation in on-fruit trials, linked to fruit quality assessment.

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