THE FEASIBILITY OF HOT WATER DISINFESTATION OF SUMMERFRUIT

G.F. McLAREN¹, J.A. FRASER¹ and R.M. McDONALD²

The Horticulture and Food Research Institute of New Zealand

¹ *Clyde Research Centre, R.D.1, Alexandra, Central Otago*

² *Ruakura Research Centre, Private Bag 3123, Hamilton*

ABSTRACT

A commercial-scale hot water bath was tested for the disinfestation of New Zealand flower thrips *Thrips obscuratus* from export summerfruit. Treatment in water at 50°C for 2 minutes removed approximately 98% of adults from nectarines and 90% from peaches. All adults and larvae were killed on nectarines in that time, but on peaches, just 1 minute (with a wetting agent) was required to kill all life stages, including eggs. Apricots, peaches and nectarines tolerated 50°C for 2 minutes. Pesticide residues were reduced by the hot water. This treatment could replace existing preharvest field insecticide applications for thrips control, as soon as international pressures for insecticide withdrawal requires it.

Keywords: disinfestation, hot water, New Zealand flower thrips, summerfruit, stonefruit

INTRODUCTION

The New Zealand flower thrips, *Thrips obscuratus* (Crawford), is an endemic quarantine pest of summerfruit. It occurs occasionally on summerfruit crops over the growing season, but is particularly attracted to ripening fruit, causing problems at harvest time. The insecticide, carbaryl, is currently applied up to one day before harvest, but prospects for its continued use in this manner are doubtful, based on World Health Organisation data (D. Lunn pers. comm.). A non-chemical method of control would provide a useful alternative, maintaining market access for New Zealand exports and reducing pesticide use in the field. An extended research programme has sought to minimise both damage to the fruit and delays in the packing shed, while optimising the control of all stages of thrips (McLaren and Fraser 1993; McLaren *et al.* 1994). Trials in 1993 investigated exposures over the temperature range 38–56°C and established that thrips were more heat tolerant than apricots in water at 38–44°C, but apricots were more tolerant than thrips at 48–50°C, with apricots tolerating 9 minutes and thrips just 3 minutes in a static bath (99% mortality). Subsequent work, using a purpose-built tumbler bath, established that all stages of New Zealand flower thrips were controlled in water at 50°C for 2 minutes, and that this treatment would not damage apricots, peaches or nectarines. However, it was also found in 1996 that the tolerance of rain-affected apricots could be as low as 3 minutes at 50°C (McLaren unpublished), which is much lower than had been found in the earlier trials, where rain had not been a factor.

In 1996 and 1997, a prototype hot water bath and drier was used to test the tolerance of summerfruit and New Zealand flower thrips to treatments in the 48–50°C range and to test the effect of the treatment on pesticide residues. This paper describes the final stages of the development of a commercial scale hot water treatment system, including a cost-benefit analysis.

METHODS

Insect mortality

(a) Thrips

Ripe peaches and nectarines, naturally infested with New Zealand flower thrips, were picked and then treated in 1400 litres water in a prototype commercial-scale bath at 50°C for 1 or 2 minutes. Some treatments included a wetting agent (10 ml/100 litres Citowett). All samples, including the untreated controls, consisted of approximately 130 peaches cv. 'White Lady' or 115 nectarines cv. 'Fantasia', with 3 and 5 replications respectively. Treated fruit were packed immediately after treatment into single layer plix trays and held at 20°C until inspection. Untreated controls were held in the laboratory in the nylon bags which had been used for their harvest (20 fruit per bag). All samples were inspected within 18–24 hours, when live and dead adults and larvae were identified under a binocular microscope. Confirmation of egg survival required a second inspection, 3 days later, after new larvae had hatched from eggs under the fruit's skin. Adults and larvae, which had been washed off the fruit, were collected in a bag in the bath. However, the number of larvae killed and collected in the bag was probably underestimated due to destruction of larvae by pressurised water compressing them against the cloth bag. This made it impossible to know the initial number of larvae present in each treatment. Therefore, percentage mortality of larvae was estimated by comparing survival in a treatment with that of the untreated control. The same approach was required when calculating percentage mortality of eggs. Since it was impossible to estimate how many eggs were present under the fruit's skin, the number of emerging larvae was compared with those in the untreated control.

Percentage mortality data were arcsine transformed for analysis but presented as raw means.

(b) Leafrollers

A few of the fruit being tested for thrips disinfestation were also naturally infested with leafrollers. The effect of the treatments on the survival of leafrollers was recorded from the samples of 115–130 fruit per treatment, with 8 replications. Surviving leafroller larvae were recorded and then reared to maturity on artificial diet before identification. Data for peaches and nectarines were combined for analysis.

Fruit quality

Over two seasons (1996 and 1997), two apricot ('Sundrop', 'Valleygold'), two peach ('Improved Flavourcrest', 'Flamecrest') and two nectarine cultivars ('Fantasia', 'Red Diamond') were treated in water at 50°C for 2 minutes, graded and packed in single trays, then stored for 3 weeks at 0°C followed by 5 days at 20°C. Between 300–432 fruit were tested per treatment, with 3 replications. After storage, 40% of each fruit sample was assessed for firmness and soluble solids (Effegi penetrometer with 8 mm tip and Atago refractometer); all fruit were assessed for external and internal disorders (visual assessments) and the presence and cause of fungal infections. Percentage rots were analysed after arcsine transformation, although raw means are presented.

Fruit flesh temperatures were monitored in five fruit per treatment after each treatment with a Digi-therm probe.

Residue analysis

Fruit samples were analysed for pesticide residues by solvent extraction, clean-up by partitioning or size-exclusion chromatography and determination by high resolution gas chromatography with dual electron capture and nitrogen-phosphorus detection (Holland and McGhie 1984; Rhoos *et al.* 1987).

RESULTS AND DISCUSSION**Insect disinfestation***(a) Thrips*

The majority of adults (98% on nectarines, 90% on peaches) were collected in the bath, rather than on the fruit. The addition of a wetting agent reduced the time required to control all stages of New Zealand flower thrips on peaches to 1 minute at 50°C, but left a few larval survivors on nectarines. The most effective treatment for nectarines was 50°C for 2 minutes, without a wetting agent (Table 1).

TABLE 1: Mean thrips per treatment killed and removed from fruit in water at 50°C after 1 or 2 minutes, with or without the wetting agent (WA),

Citowett 10 ml/100 litres.

Treatment	Adults			Larvae		Eggs	
	Alive	% mort.	% removal	Alive	% mort. cf. control	Eggs to larvae	% mort. cf. control
Nectarines cv. 'Fantasia'							
2 min	0 a	100 a	98.1	0 a	100	0.4 a	99.5
1 min + WA	0 a	100 a	99.7	0.3 a	98.3	0.57 a	99.3
2 min + WA	0 a	100 a	98.7	0.8 a	95.6	0.28 a	99.7
untreated	53.6 b	29 b	NT	34 b	-	86.6 b	-
Significance ¹	<0.01	<0.01	>0.05	<0.01	>0.05	<0.01	>0.05
Peaches cv. 'White Lady'							
2 min	2.3 a	99.2 ab	89.6	2.3 a	96.9	0 a	100
1 min + WA	0 a	100 a	89.3	0 a	100	0 a	100
2 min + WA	0 a	100 a	91.5	0 a	100	0 a	100
untreated	386 b	49.8 b	NT	341 b	-	1257 b	-
Significance ¹	<0.01	<0.01	>0.05	<0.01	>0.05	<0.01	>0.05

Significance¹: Means followed by the same letter in a column were not significantly different by Newman-Keuls test ($P < 0.05$).

NT = not tested

(b) Leafrollers

All the hot water treatments reduced leafroller numbers compared with the untreated (Table 2).

TABLE 2: Mortality of naturally infested leafrollers on peaches and nectarines (SE in parentheses) and percentage lost or killed.

Treatment	Fruit sample size	Number of damaged fruit	Live leafrollers	Mean number alive (SE)	Percentage killed or removed in water or handling
2 min	720	20	1	0.167 (0.17) a	95
1 min + WA	720	27	1	0.167 (0.17) a	96
2 min + WA	705	21	0	0 a	100
untreated	965	42	21	2.63 (0.99) b	50
Significance ¹					<0.05

Significance¹: Means followed by the same letter were not significantly different by Newman-Keuls test ($P < 0.05$). WA = 10ml/100 litres Citowett.

Equal numbers (7) of greenheaded leafroller (*Planotortix octo*) and lightbrown apple moth (*Epiphyas postvittana*) (7) were reared from the surviving larvae. Earlier trials on the control of these two species on fruit indicated that to achieve 99% mortality in 50°C water, 15 minutes would be required for *E. postvittana* and 7-10 minutes for *P. octo* (Jones and Waddell 1994; McLaren unpubl. data respectively). It is likely that the tumbling action of the fruit in the larger bath is responsible for increased water penetration inside leafroller tunnels, compared with that in a static bath (Jones and Waddell 1994) or in the small tumbler bath (McLaren unpubl. data). The level of mortality and removal of leafroller larvae, which was produced in the commercial prototype (95-100%), is likely to be seen as a useful contribution to the control of these quarantine pests.

Fruit Quality

Treated fruit stored as well as untreated fruit, with no detrimental effects on external

or internal quality (data not presented), but the level and cause of postharvest rots varied with cultivar and treatment. Peaches were particularly susceptible to postharvest rots mostly due to brown rot (*Monilinia* spp.) and grey mould (*Botrytis cinerea*). There were no differences between treatments in 3 of the 7 trials (Table 3). In the 4 trials where differences were found, hot water alone induced more postharvest rots than the untreated in 1 trial and decreased them in another. However, when the fruit were dried after the bath, fewer rots developed compared with the untreated control in 3 trials out of 4. Generally, the combination of hot water, followed by drying, produced fruit with a similar, or possibly lower, risk of developing postharvest rots than untreated fruit.

TABLE 3: Percentage postharvest rots in summerfruit (standard error in parentheses) after 3 weeks storage at 0°C followed by 5 days at 20°C following treatment in water at 50°C for 2 minutes.

Cultivar	Year	Percentage postharvest rots			Probability
		untreated	hot water	hot water then dried	
Valleygold	1996	50.7 b	45.7 b	15.7 a	<0.01
Sundrop	1996	11.7	17.0	12.7	>0.05
Sundrop	1997	3.6 a	10.53 b	6.79 ab	<0.01
Fantasia	1996	15.7 b	9.7 a	8.7 a	<0.01
Red Diamond	1997	2.2	4.6	4.5	<0.05
Improved Flavourcrest	1996	69.0 b	52.0 ab	33.3 a	<0.01
Flamecrest	1997	50.3	64.2	65.8	>0.05
Mean		29.0 (10.2)	29.1 (9.1)	21.1 (8.3)	>0.05

Means followed by the same letter were not significantly different by Newman-Keuls test ($P < 0.05$).

The internal temperature of the fruit was raised by 9°C in apricots and 6°C in peaches (larger fruit), irrespective of the initial fruit temperature. This temperature gain would

FIGURE 1: Pesticide residues (mg/kg) from sprays applied in the field on nectarines, peaches and apricots before and after treatment in water at 50°C for 2 minutes.

need to be recovered before transportation.

Pesticide residues

Hot water treatments reduced the residues of some pesticides on the fruit, particularly carbaryl, but iprodione and dicofol showed little change (except iprodione on apricots) (Fig. 1).

Cost benefit analysis

(a) Pesticide reduction

Hot water treatment offers an opportunity for pesticide reduction both in the field and postharvest. Most of the 3-6 field applications of carbaryl, currently applied before harvest and between picks, could be dispensed with. In addition, it is likely that if carbaryl were not being applied at 4 day intervals during harvest, the number of fungicide applications would be reduced and application intervals stretched to 7 days. We estimate, the average export grower would save 3 carbaryl and 2 fungicide applications, and two 'rounds' of the sprayer. This would represent savings of:

carbaryl at 2000 litres/ha:	\$92.40/ha x 3 applications	= \$277.20
iprodione at 2000 litres/ha:	\$147.40/ha x 2 applications	= \$294.80
application costs of tractor, sprayer and labour @ \$50/ha x 2		= \$100.00
	TOTAL	= \$672.00 / ha

(b) Capital Cost Estimates

The estimated cost of building a hot water bath and drier to fit into an existing packing shed and treat 4 tonnes/hour is approximately \$80,000 (G. Wansink, E.B McDonald Engineering, Dunedin). Some shed modification, including upgrading of electricity supply systems, may be required to accommodate the equipment (up to \$20,000). A system for disposal of waste water containing pesticide residues at the end of each day (data not presented) would also need to be considered. Planning approval will probably be required from the local authority for waste water disposal. Total cost of building and installing the equipment is, therefore, estimated to be approximately \$100,000.

(c) Market Access

Currently, there are poor prospects for continued market access for products treated with pesticides close to harvest. Consumers expect to buy 'safe' and therefore pesticide-free products. Carbaryl, in particular, is facing an increasingly uncertain future. A non-chemical treatment that reduces residues and avoids the use of preharvest insecticides would allow New Zealand producers to retain access to international markets without putting the importing country at risk of introducing new horticultural pests. The treatment shows promise for the control of thrips, and to some extent leafrollers; while thrips have consistently been the most common cause of rejection of export fruit, leafrollers are the second (C. Brown, MAF Qual. pers. comm). Therefore, this treatment would be a useful addition to a reduced field programme for the control of both pests, and would thus improve the environment for both orchard staff and beneficial organisms.

(d) Cost Benefits

Apart from the installation costs, the packhouse owner would need to evaluate the continuing costs and benefits. In a packing shed handling 3 tonnes/hour, working 6 days/week for 6 weeks, costs (including depreciation, loss of income (interest) on invested dollars, maintenance, electricity and general running costs) = 6.2 c/kg. Benefits accrued from spray savings = 4.5 c/kg and maintenance of market access = 70 c/kg. Therefore, operating costs are similar to benefits from saving sprays, so there would be little advantage in installing the equipment unless export markets were at risk. Should this situation arise, however, it would be easy to demonstrate the cost benefits of installing the equipment with a net gain of 68.3 c/kg fruit treated.

CONCLUSION

The use of field insecticides close to harvest has become increasingly undesirable and presents special problems for the control of a quarantine pest such as New Zealand flower thrips, which can fly into the crop within hours of harvest, attracted by ripening fruit. Hot water disinfection, being a non-chemical treatment, is an attractive alternative which is endorsed by the fruit growing community, but the cost of installing it in every export packhouse is an impediment to its adoption. The future of the system appears to depend

on the prospects for the continued use of carbaryl on export fruit.

ACKNOWLEDGEMENTS

This work was funded by a Technology for Business Growth grant number SFN501 from the Foundation for Research and Science Technology and Summerfruit New Zealand Incorporated. We thank Evan Blanch, Arlene Bradley and Sue Parker for excellent technical assistance and Colin Malcolm and Alistair Boyd for pesticide residue.

REFERENCES

- Holland, P.T. and McGhie, T.K., 1984. Multi-residue method for determination of pesticides in kiwifruit, apples and berryfruits. *J. Assoc. Offic. Anal.* 66: 1003-1008.
- Jones, V.M. and Waddell, B.C., 1994. Disinfestation of New Zealand summerfruit: mortality response of tydeid mite and lightbrown apple moth following hot water treatment. HortResearch Client Report No. 94/71.
- McLaren, G.F. and Fraser, J.A., 1993. Effect of hot water dips on quality of apricots and mortality of New Zealand flower thrips. *The Orchardist of New Zealand* 66 (11): 49-50.
- McLaren, G.F., Fraser, J.A., Rose, K.J. and McDonald, R.M., 1994. Tolerance of New Zealand flower thrips *Thrips obscuratus* (Crawford) and three apricot cultivars to hot water. In: Summerfruit Research 1993-94: Executive Summaries. *The Orchardist of New Zealand* 67 (11): 14-15.
- Roos, A.H., Van Munsteren, A.J., Nab, A.J. and Tuinstra, L.G.M. Th., 1987. Universal extraction clean-up procedure for screening of pesticides by extraction with ethyl acetate and size exclusion chromatography. *Anal. Chem. Acta* 196: 95-100.