SCREENING CHEMICALS TO CONTROL GREENHOUSE WHITEFLY ON TAMARILLO

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SUMMARY

Chemicals were sprayed on tamarillo (*Cyphomandra betacea*) leaves infested with greenhouse whitefly (*Trialeurodes vaporariorum*). The mortalities of the different whitefly stages were evaluated. Pyrethroids, alone or in mixtures, combined with oil or soap were effective at low rates against all whitefly stages. Soap, oil, organophosphates and mixtures of these chemicals were moderately effective against larval stages but ineffective against the egg and pupal stages, even at high concentrations.

INTRODUCTION

The greenhouse whitefly is one of the most difficult pests to control on greenhouse and outdoor plants. An understanding of the biology of this pest is necessary to appreciate why control is difficult to achieve. Adult females live 1-3 months and can lay a hundred or more eggs (Goodyer 1977, Martin 1985). The mobile first instar (crawler) settles and passes through three further instars or larval stages. The non-feeding pupa is enclosed in the exoskeleton of the fourth instar larva to form a puparium. The life cycle from egg to adult can be completed in 22 days at 27°C or 30 days at 22.5°C but takes longer at cooler temperatures (Madueke and Coaker 1984). The eggs and pupae jointly occupy 45% of the development time from egg to adult (Madueke and Coaker 1984) and are tolerant of many insecticides (Laska 1981). The short life cycle enables rapid infestation of crops by adults and all stages are continuously present. Control is extremely difficult as tolerant stages are present at the start and end of the life cycle. Whitefly has also developed resistance to some insecticides (Laska 1981, Elhag and Horn 1983).

Whitefly infested many tamarillo crops in Kerikeri in the 1984/85 season. In spite of numerous insecticide applications, fruit was contaminated with honeydew and black sooty mould. Growers have experimented with a wide range of insecticides but have been unable to obtain effective control. The objective of these trials was to screen a range of chemicals against whitefly to provide recommendations for growers at the start of the 1985/86 season.

MATERIALS AND METHODS

Four trials, screening a range of chemicals were carried out on mature blocks of tamarillos heavily infested with whitefly at Kerikeri (Tables 1-3).

Trial 1 investigated the effect of high rates of chemical on whitefly mortality (Table 1). Bunches of leaves were selected on which all whitefly stages were present. Whitefly stages occur on leaves of different ages, with eggs laid on the youngest leaves and a natural progression of stage maturity with increasing leaf age, with pupae being present on older leaves. Leaf bunches were tagged then sprayed on 24 April 1985 with a knapsack sprayer taking care to ensure all leaves, especially the undersides, were sprayed to run off. Spray coverage was more thorough than would occur using a commercial sprayer. Seven days after application, leaves were picked and adults present on the undersides of three-six of the youngest leaves in each replicate of each treatment were counted. Mortality of each larval stage and the pupae was assessed from two leaves per stage from each of the three replicates. Each leaf was examined under a microscope and mortality of the first 20 insects encountered was determined. Larvae and pupae were considered dead if they were dry, shrivelled or brown. Live insects were full

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TABLE 1: Trial 1. The effect of chemicals at high concentrations on reinvasion of adult whitefly on young tamarillo leaves 7 days after pesticide application, and on the mortality of larvae and pupae.

Chemical	g ai/100 litres	Adults /leaf	Larvae		Pupae	
			%Mort.	Rank	%Mort.	Rank
soap chips (Levers toilet soap)	1000	10	68	34	78	36
permethrin (Ambush 50 EC)	20	2	53	28	56	34
oil/methomyl	2000/50	2	61	28	30	28
oil/permethrin	2000/20	0	86	36	20	16
pirimiphosmethyl/ permethrin (Attack 47.5/2.5 EC)	95/5	5	53	28	17	22
fenvalerate (Sumicidin 10 EC)	20	3	40	21	8	16
oil (Sunspray 97 EC)	2000	3	35	20	14	19
diazinon (Basudin 80 EC)	96	30	34	17	8	14
omethoate (Folimate 58 EC)	116	12	30	16	18	19
detergent (Tepol)	2000	16	21	10	16	22
methomyl (Lannate 20 EC)	50	8	19	11	0	6
acephate (Orthene 75 WSP)	113	10	16	8	0	6
untreated		33	6	4	8	16
SED		5.7		5		6

TABLE 2: Trial 2. The effect of a range of chemical concentrations on mortality of whitefly larvae and pupae.

Chemical	g ai/100 litres	Larvae		Pupae	
		% Mort.	Rank	% Mort.	Rank
oil/permethrin	500/5 + 250/2.5	100 + 82	19 + 15	70 + 61	14 + 13
soap/permethrin	500/10 + 250/5	97	18	86 + 54	19 + 13
soap/diazinon	500/48 + 250/24	92 + 75	17 + 14	30 + 63	8 + 13
oil	1000 + 500	86 + 68	17 + 13	56 + 40	12 + 9
permethrin	10 + 5	81 + 70	15 + 13	78 + 28	16 + 7
oil/permethrin	1000/10	75	14	80	16
pirimiphosmethyl/ permethrin	47.5/2.5 + 23.8/1.3	73	13	68 + 66	14
detergent/ permethrin	1000/10 + 500/5	74 + 57	12 + 10	48 + 44	10
soap chips	500	54	9	59	13
detergent/ diazinon	1000/48 + 500/24	44 + 38	7	45 + 40	11 + 7
detergent	500 + 250	30 + 15	6 + 3	30 + 0	9 + 2
soap chips	250 + 125	16 + 8	3 + 2	14	5
untreated		6	2	1	2
SED			2.1		3.5

bodied, white or transparent with yellow markings on the abdomen of the larvae and red eyespots on the pupae. Pupae parasitised by *Encarsia* sp. were either yellow, purplish brown or black. Leaves were held at 4°C after sampling and mortality assessments in all trials were completed within 5 days.

TABLE 3: Trials 3 and 4. The effect of chemicals on whitefly larvae and pupae. A comparison of single (1 in table) or double (2 in table) cost equivalent rates.

Chemical	Rate g ai/ 100 litres	Cost equiv.	Larvae		Pupae	
			%Mort.	Rank	%Mort.	Rank
Trial 3						
soap flakes/ permethrin	500/3.5	1	96	50	100	58
soap flakes/ deltamethrin	500/0.6	1	94	45	100	58
alphanemethrin (Fastac 100 EC)	24.8	—	100	54	98	53
permethrin	14.3	2	96	52	97	51
buprofezin (IWD 50 WP)	12.5	—	100	59	83	44
oil/deltamethrin	300/0.6	1	77	35	100	58
soap flakes/ diazinon	900/90	2	89	40	87	45
oil/permethrin	300/3.5	1	91	43	94	43
permethrin	7.1	1	81	43	79	41
soap flakes/ permethrin	1000/7	2	66	34	55	46
deltamethrin (Decis 2.5 EC)	1.3	1	95	40	91	40
pirimiphos-methyl/ permethrin	3.1/0.2	1	66	31	98	52
oil	1000 + 300	—	74 + 93	24 + 37	88 + 89	39 + 41
soap flakes/ deltamethrin	1000/1.2	2	91	40	78	37
pirimiphos-methyl/ permethrin	6.3/0.3	2	60	35	59	26
oil/permethrin	600/7	2	73	32	65	29
soap flakes (Lux soap)	500 + 250	—	35 + 77	15 + 27	54 + 57	17 + 26
oil/deltamethrin	600/1.2	2	54	18	79	28
soap flakes/ diazinon	450/45	1	59	21	51	16
deltamethrin	2.5	2	40	13	77	32
oil/deltamethrin	150/0.3	—	48	18	69	24
liquid soap (Cascade)	500	—	43	17	53	16
untreated			6	6	13	2
SED				12		14
Trial 4						
oil/deltamethrin	300/0.6	—	67	21	54	14
soap flakes	1000 + 500	—	11 + 32	11 + 14	48	10 + 12
liquid soap (Safer Insecticidal Soap)	1000 + 500	—	21 + 9	12 + 7	20 + 14	6 + 9
untreated			5	5	28	10
SED				2.9		4.2

Trial 2 screened chemicals selected because of effectiveness (Trial 1) or low cost. Chemicals were applied (as for Trial 1) at two rates (Table 2) on 26 June 1985 and leaves were picked for larval and pupal mortality assessments 15 days later. Mortality was assessed from 10 of each stage/leaf and from two leaves per stage from each of the four replicates. In addition, young leaves were picked the day after spraying and sections of leaves, which contained at least 30 mature (black) eggs and no hatched or immature (green eggs), were incubated at 24°C on moist cotton-wool for 5 days, by which time eclosion of eggs on untreated leaves was completed. Mortality of the newly-hatched first instars was determined.

Trial 3 compared a group of chemicals at two cost equivalent rates (Table 3). Trials 3 and 4 also screened further chemicals, two liquid soaps, a bee-safe pyrethroid (alphamethrin) (Shires *et al.* 1984) and an insect growth regulator (buprofezin) (Table 3). Chemicals were applied on 2 and 10 December for Trials 3 and 4 respectively and mortality of 10 of each stage/leaf from three leaves from each of the four replicates was assessed after 19 days.

The mortality of each treatment was ranked relative to each other treatment in each replicate and a rank analysis used to compare treatment effects.

RESULTS AND DISCUSSION

Mortalities of each larval stage were similar for each chemical and hence combined mortalities are presented (Tables 1-3). Larval and pupal mortalities were higher in Trial 1 and Trial 3 compared to Trial 2 in spite of the higher concentrations tested in Trial 1.

The effect of chemicals on eggs was assessed in Trial 2 with some egg eclosion observed from all treatments. Hatched nymphs were alive in the untreated, soap, pirimiphosmethyl/permethrin and tepol/diazinon treatments. In the other treatments, nymphs may have hatched but were usually found dead close to the egg shell.

The efficacy of chemicals against adult whitefly was not investigated in these trials. Adult whitefly have been shown to be readily killed by a wide range of insecticides including most of those tested in these trials (Laska 1981). Soap has been shown to be effective against adults at concentrations above 0.1-0.5% (Puritch *et al.* 1982). Buprofezin does not kill adults directly but suppresses egg production and prevents eggs hatching (Naba *et al.* 1983). In these trials it was of interest that the oil and pyrethroids, either alone or as mixtures, reduced the reinvasion of adults after 7 days, suggesting that chemical residues were still actively killing or repelling adults (Table 1).

The main differences in whitefly mortality between chemical groups over all trials was in a crude order of effectiveness: oil or soap/pyrethroid > pyrethroid > oil or soap/organophosphate > oil = soap > organophosphate = detergent. Pyrethroids are known to be more effective than organophosphates against whitefly (Oetting and Morishita 1980, Laska 1981, Collmann and All 1982) but the use of oil or soap mixtures with pyrethroids does not appear to have been evaluated previously.

Multiple applications of chemicals are generally required to control whitefly outbreaks and hence the cost of chemicals is an important consideration. Two of the more effective groups of chemicals, pyrethroids and oils, are considerably more expensive than the other chemicals when used at recommended rates. It was therefore of interest that low rates of many treatments were as effective as high rates (Tables 2 and 3). Increases in mortality due to higher rates were generally of little practical significance. A number of treatments were equally effective at killing whitefly when tested at the lowest cost equivalent rates (Table 3). These included permethrin and deltamethrin alone or in mixtures with other chemicals.

Tamarillos flower for long periods over the spring and early summer. Although self-pollinating, the flowers are attractive to bees and the use of bee-safe materials may be advantageous. Further work on the bee-safe pyrethroids, such as alphamethrin, and insect growth regulators, such as buprofezin, may be warranted.

Pyrethroids, either alone or mixed with oil or soap at approximately a third or quarter of recommended rates, would be the first choice for control of whitefly on tamarillo, particularly because of the good control achieved with the difficult-to-kill eggs and pupae. However, clearance of pyrethroid residues on export tamarillos must

first be obtained. The use of some pyrethroids can cause mite outbreaks in apple orchards (Hull *et al* 1985). A potential problem from using pyrethroids on tamarillo is the risk of inducing mite outbreaks on adjacent shelter or weeds and subsequent contamination by 'passenger' mites of tamarillos or adjacent crops such as kiwifruit. These trials thus endeavoured to find a treatment which excluded pyrethroids. Soap chips were effective against larvae and pupae at 1% and partially effective at 0.5%, but were difficult to dissolve at these concentrations. Lux flakes, which are made from soap chips (less 7% moisture), in addition to the two liquid soaps, were easier to dissolve but did not give consistently high levels of mortality. Safers Insecticidal Soap (0.5%) has been shown in topical application tests to be effective against all whitefly stages except for eggs and has been registered in Canada for control of whitefly (Puritch *et al* 1982). *Encarsia formosa* parasites, within the whitefly scales, were tolerant of the soap which is recommended for use in integrated control programmes in glasshouse crops in Canada. A pupal parasite, *Encarsia pergandiella* (identified by Dr N. Martin, DSIR) was found in approximately 30% of overwintering pupal cases on tamarillo. Further work would be required to determine if soap, in combination with these parasites, might control whitefly on tamarillo. At this stage, however, there appears to be no obvious alternative to the use of pyrethroids.

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REFERENCES

- Collmann, G.L. and All, J.N., 1982. Biological impact of contact insecticides and insect growth regulators on isolated stages of the greenhouse whitefly (Homoptera: Aleyrodidae). *J. Econ. Entomol.* 75: 863-867.
- Elhag, E.A. and Horn, D.J., 1983. Resistance of greenhouse whitefly (Homoptera: Aleyrodidae) to insecticides in selected Ohio greenhouses. *J. Econ. Entomol.* 76: 945-948.
- Goodyer, G.J., 1977. Greenhouse white-fly. Entomology Branch Insect Pest Bulletin 60, NSW Department of Agriculture: 5 pp.
- Hull, L.A., Beers, E.H. and Meagher, R.L. 1985. Integration of biological and chemical control tactics for apple pests through selective timing and choice of synthetic pyrethroid insecticides. *J. Econ. Entomol.* 78: 714-721.
- Laska, P., 1981. Screening of 62 pesticides used against glasshouse whitefly *Trialeurodes vaporariorum* (Homoptera, Aleyrodinae). *Acta Ent. Bohemoslov* 79: 7-13.
- Madueke, E.N. and Coaker, T.H., 1984. Temperature requirements of the whitefly *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae) and its parasitoid *Encarsia formosa* (Hymenoptera: Aphelinidae). *Entomol. Gener.* 9: 149-154.
- Martin, N.A., 1985. Greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), life cycle. DSIR Information Services No. 105/41.
- Naba, K., Nakazawa, K. and Hayashi, H., 1983. Long-term effects of buprofezin spray in controlling greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), in vinylhouse tomatoes. *Appl. Ent. Zool.* 18: 284-286.
- Oetting, D.D. and Morishita, F.S., 1980. Potential of pyrethroid insecticides for greenhouse whitefly control. *J. Georgia Entomol. Soc.* 15: 272-280.
- Puritch, G.S., Tonks, N. and Downey, P., 1982. Effect of a commercial insecticidal soap on greenhouse whitefly (Hom: Aleyrod.) and its parasitoid, *Encarsia formosa* (Hym: Euloph.). *J. Entomol. Soc. Brit. Columbia* 79: 25-28.
- Shires, S.W., Murray, A., Debray, P. and Le Blanc, J. 1984. The effects of a new pyrethroid insecticide WL-85871 on foraging honey bees (*Apis mellifera* L.). *Pestic. Sci.* 15: 491-499.