EVALUATION OF ORGANIC PEST CONTROL AGENTS

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SUMMARY

Several chemical compounds of natural origin were tested on four insect genera in an orchard and a greenhouse. The conventional pesticides, Applaud, Enstar, Malathion and Target were included in the greenhouse trials. Seven chemical compounds were tested for control of apple leafcurling midge (*Dasyneura mali* Kieffer). Only Yates Pyrethrum and vegetable oil + Sunlight gave a significantly lower proportion of infected shoots than the untreated control. Four chemical compounds were tested against Froggatt's apple leaf hopper (*Typhlocyba froggatti* Baker). Defender + Oil treatment resulted in the highest percentage of dead nymphs. Thirteen chemical compounds were tested for control of greenhouse whitefly (*Trialeurodes vaporariorum* Westwood). After two sprays no nymphs were found on the plants treated with Natures Way Insect Spray, Safers Natural Concentrate and Target. Nine compounds were used on the longtailed mealybug (*Pseudococcus longispinus* Targioni-Tozzetti). All except Neem were better than the untreated control but Malathion was a significantly better treatment than the rest.

Keywords: *Dasyneura mali* Kieffer, *Pseudococcus longispinus* Targioni-Tozzetti, *Typhlocyba froggatti* (Baker), *Trialeurodes vaporariorum* Westwood, organic pesticides.

INTRODUCTION

An increasing demand for organic produce overseas has caused a general interest in organic production in New Zealand. Local processors are now asking for a supply management service for organic produce (Springett 1992). Apart from those transferring from conventional methods to organics there are also growers who wish to spray less and use more environmentally friendly chemical compounds, preferring a more integrated pest control approach. Soaps, oils and *Bacillus thuringiensis* are not successful against a wide range of insects and mites. Pyrethrum is the only other chemical compound which is allowed by the organic production specifications in New Zealand. It is the most dependable organic insecticide, but is regarded as a last option, since it kills both pests and beneficial insects. Others such as Naturgro (Ryania) are potentially useful because they are selective, sparing a range of beneficial insects (Wearing 1991) but these preparations lack registration.

Rather than continually testing newly 'discovered' or 'rediscovered' organic mixtures, we included in our trials only commercial, readily available chemical compounds (Table 1). The chemical compounds tested are in most cases approved for use by organic growers under New Zealand Biological Producers Council Standards for organic production (NZBPC 1988) or have been reported to be useful (Yepsen 1984; Anon. 1990; Graff 1990). Two insect growth regulators, Applaud and Enstar, were included in the whitefly trial as they are important chemicals used in integrated pest control.

Four pests, apple leafcurling midge, Froggatt's apple leaf hopper, greenhouse whitefly and the longtailed mealybug can cause problems on various crops.

Apple leafcurling midge increases dramatically when a full spray programme is suddenly stopped (van Epenhuijsen and Carpenter 1990). This midge can cause serious defoliation of terminal shoots despite high levels of parasitism by *Prosactogaster demades* Walker (Todd 1959; Collyer and van Geldermalsen 1975). Froggatt's apple leaf hoppers are normally abundant in unsprayed orchards, causing discolouration of

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TABLE 1: List of chemical compounds used in the four experiments.

Product	Description	Active ingredient
Applaud	insect growth regulator	250 g/kg buprofezin
Bettacrop	botanical extract	12 g/litre pyrethrum oil 18 g/litre garlic extract
Conqueror Oil, Protector Spraying Oil, and Sunspray Oil	mineral oil	970 ml/litre mineral oil
Defender and Natures Way Insect Spray	saponified fatty acid	250 g/litre potassium salts
Enstar 5 EC	insect growth regulator	65.3% kinoprene
Lux	soap flakes	sodium salts of mutton tallow >90% and coconut oil
Malathion 25W	organo-phosphate	250 g/kg maldison
Naturgro R-50	botanical extract	0.11% ryanodine
Naturgro Triple Plus	botanical extract	0.1% pyrethrins 0.055% ryanodine 0.75% rotenone
Neem	neem seed oil extract	5% azadirachtin
Quassia	botanical extract	Quassin
Red Devil Sabadilla	botanical extract	0.8% sabadilla alkaloids 40% diatomaceous earth 40% Fuller's earth
Safers Natural Concentrate	ethanolic saponified fatty acid	477 g/litre potassium salts
Sebon	“ “ “	50% potassium salts of fatty acids
Sunlight	dishwashing liquid	
Target	organophosphate + synthetic pyrethroid	95 g/litre pirimiphos methyl + 5 g/litre permethrin
Vegetable oil	sunflower oil	63.1% linoleic acid
Yates Pyrethrum	synergised botanical extract	14 g/litre pyrethrum + 56.5 g/litre piperonyl butoxide

foliage in the flower clusters from early in the season. Heavy foliage infestation may cause fruit discolouration when specks of excrement are deposited on the fruit (Penman 1984). Sprays have to be applied before the first generation of adults start to fly. Monitoring with yellow sticky traps (Teulon and Penman 1984; van Epenhuijsen 1990) shows the flights of two generations per year.

Greenhouse whitefly is regarded as a glasshouse pest but also attacks outdoor plants such as tamarillo (Blank *et al* 1986). Plants lose vigour and exude honeydew on which sooty mould grows. Major problems with longtailed mealy bugs arise when a sooty mould develops on the honeydew. The late apple variety 'Granny Smith' is particularly susceptible (van Epenhuijsen 1990) as are persimmons. Grapes are also lost to sooty mould infestation and light crops can be expected the following year. Mealy bugs also cause problems in greenhouse crops such as orchids. Although mealy bugs are always present, they do not seem to cause serious problems in all organic orchards (Carpenter *et al* 1991).

This paper reports attempts to control these pests in an orchard managed under the Biogro registration, and a greenhouse, at Levin Horticultural Research Centre.

METHODS

Apple leafcurling midge

Two experiments were carried out on the 1-year old apple variety 'Spartan' with seven chemicals (Table 2) and an untreated control. A randomised complete block design was used with three replicates and two trees per plot. Eggs were counted weekly from 1 October until 1 April. Apart from the first very small egg deposits on 15 October, eggs occurred on more than 10% of tips only on the recording dates of 17 December and 11 February. The major egg deposit periods were similar to that described before (van Epenhuijsen and Carpenter 1990). Sprays were applied to run off with a hand pump action sprayer 2 days after 7-10% of the tips were found to contain eggs. One day prior to spraying all visibly affected leaves were removed.

In Experiment 1 sprays were applied on 10 and 18 December and in Experiment 2 on 7 and 12 February. The total numbers of non-affected and affected tips and leaves per tree were counted in Experiment 1 on 31 December 1991 and 7 January 1992. Experiment 2 was assessed in the same way on 27 February.

Frogatt's apple leaf hopper

Two experiments were carried out with four chemicals (Table 3) and a water control, the first on the apple variety 'Cox's Orange' and the second on 'Granny Smith'. A randomised complete block design was used with 10 replicates and one tree per plot. For both experiments flower clusters with at least four or more nymphs on the lower side of leaves were selected and tagged the day before treatments were applied. These marked clusters were individually sprayed to run off from below and above, with a Cambrian CSP/15 compressed air sprayer.

In Experiment 1, clusters were tagged on 1 October and treatments were applied on 2 October. The numbers of dead and alive nymphs were counted on 3 October.

In Experiment 2, clusters were tagged at petal fall on 14 October and sprayed on 15 October. The same treatments as in Experiment 1 were used except that Conqueror Oil was replaced by Protector Oil. To prevent the nymphs from leaving, treated clusters in this experiment were covered with organza bags and tied with twistems immediately after spraying. On 16 October all bags containing clusters were pruned off and taken to a cooler (4°C). Over the next 2 days nymphs from each bag were shaken into a petri dish and the number dead and alive were counted.

Greenhouse whitefly

A randomised complete block design was used with 14 treatments including a water control and a conventional standard (Table 4). There were two replicates and three pots per plot. Egg plants cv. 'Black Beauty' were sown in boxes and transplanted singly into 120 mm diameter pots containing bark mix on 12 November 1991. From 28 November the plants were trimmed regularly, leaving three leaves per plant, to reduce the leaf area for future egg deposits. All pots were placed on benches in a greenhouse and kept at 24°C. Approximately 2,000 third instar whiteflies, reared by DSIR, arrived on 20 November. On 29 November the adults were released on to the pots and allowed to lay eggs for 5 days. Twice a day the plants were shaken to redistribute the adult whiteflies.

On 5 December all adults were vacuumed off and plants covered with organza, supported by 300 mm sticks. The organza was removed for spraying and replaced afterwards. The first spray was applied on 16 December when most of the nymphs had reached the second instar. The second spray was applied on 22 December. Treatments were applied to run off to individual plants, from above and below, using a Cambrian CSP/15 compressed air sprayer.

On 19 December and 23 December the number of dead and live nymphs on one 20 mm diameter punch sample per plant, taken from leaves containing the most nymphs, was counted under a microscope. More samples were taken when the total number of dead and live nymphs was less than 20. The samples were collected in petri dishes and kept in a cooler at 10°C till counting which was carried out over a period of 2 days. Larvae and pupae were considered dead if they were brownish, partly shrivelled and/or dry.

Longtailed mealybug

A randomised complete block design was used with nine chemicals, including a conventional standard, (Table 5) and an untreated control. There were nine replicates with 1 PB bag per plot. Potatoes cv. 'Rua' were cut in four pieces, dried for 2 hours, and planted in a bark mix in PB8 bags on 5 December. The plants were placed in an unheated greenhouse.

Up until 2 January 1992 mealy bugs, raised by DSIR on potato tubers, were laid out on the sprouting potatoes in the PB8 bags with aid of a small brush. An attempt was made to spread them as uniformly as possible.

By tip-pruning the plants twice to three times a week the plants were kept to a reasonable size while the mealybug population increased from 2 January until 29 January. The tipped parts were left lying on the plants in order to allow the mealy bugs present on these parts to return to the living material. The mealy bugs preferred to stay on the slowly decaying cut off tips, which did not dry up quickly enough to force them to look for fresh food. A number of mealy bugs were lost in this way at the end of the "tipping" period when all the dead loose material was removed before spraying.

At the beginning of February the first new crawlers were noticed on the plants. However, fungi appeared on some of the tipped plants at this time and the experiment had to commence before their condition began to deteriorate.

On 12 February plants were sprayed from above and below with a Cambrian CSP/15 compressed air sprayer to run off.

On 14 February three tips (30 mm long) and three older compound leaves were taken from each plant, placed in paper bags, and stored in a plastic bag in a cooler at 4°C until assessed. The number of dead and alive mealy bugs were counted under a microscope between 14 and 18 February.

Statistical methods

All data were analysed, using a generalised linear models approach with binomial error model and standard logit link function to produce analysis of deviance.

RESULTS AND DISCUSSION**Apple leafcurling midge**

The untreated control trees showed similar infection rates early (40% in Expt 1) and late (38% in Exp 2) in the season. The effectiveness of the chemical sprays, as measured by the mean percent infected shoots, is given in Table 2. Although the best time for spraying was chosen by monitoring the egg deposits, the efficacy of the chemical compounds is disappointing and would certainly not help if a higher population of the midge occurred.

TABLE 2: Percentage of shoots ($\pm$ standard error) on apple trees infected by apple leafcurling midge after early and late season application of seven chemical compounds.

Treatment/Solution	Mean % infection ¹ ($\pm$ SE)			
	Early		Late	
Control	40a	(6)	38a	(6)
Red Devil Sabadilla 1.2%	33ab	(8)	26ab	(7)
Bettacrop 2.5%	25abc	(8)	14b	(5)
Naturgro R-50 0.8%	22abc	(8)	31ab	(8)
Quassia ² + Defender 2%	22abc	(9)	25ab	(8)
Neem ³ + Defender 2%	20abc	(7)	24ab	(7)
Yates Pyrethrum 0.5%	12bc	(7)	7b	(5)
Vegetable oil 4% + Sunlight 0.25%	7c	(5)	17b	(6)

¹ means followed by the same letter are not significantly different at P=0.05 level

² 23 g of Quassia chips boiled for 40 mins in 1.0 litre water, then water loss is replaced and diluted 1:3

³ Early 0.025%, and late 0.05%

Only Yates pyrethrum and vegetable oil + Sunlight produced a significantly lower infection rate than the untreated control in the early season evaluation. In the late season experiment Bettacrop also gave a significantly lower infection rate. The amount of infection within the shoot, as measured by number of infected leaves per infected shoot, was not significantly affected by the sprays. For early and late experiments the mean values were 2.9 and 1.6 respectively.

In our orchard the number of curled leaves was only slight to moderate, but never severe. The degree of infestation is measured by the quantity of terminal growth present. This in turn is determined by irrigation, nutrition and the presence of other insects. In Levin many tips were eaten by *Melanchnra* sp. during January and February and no fertiliser or compost had been applied during the previous year. For efficient control when a reduced spray programme is used it is essential that the egg laying periods of the five generations are determined.

Froggatt's apple leafhopper

All four sprays were effective in killing the Froggatt's apple leaf hopper (Table 3). In Experiment 1 Defender + Oil gave a significantly better kill than the other three sprays while in the second experiment both Defender and Bettacrop surpassed the other two treatments. The ability of chemicals containing ryanodine to control the Froggatt's apple leaf hopper has been noted before (Collyer and van Geldermalsen 1975).

TABLE 3: Mean percent mortality ($\pm$ standard errors) of Froggatt's apple leaf hopper one day after application of four treatments in two experiments. Experiment 1 on Cox's Orange, Experiment 2 on Granny Smith.

Treatment/Solution	Mean % mortality ¹ ($\pm$ SE)	
	Experiment 1	Experiment 2
Water control	20a (3)	20a (4)
Naturgro R-50 0.8%	73b (5)	55b (6)
Natures Way Insect Spray 2%	84b (3)	52b (5)
Bettacrop 2%	86b (5)	80c (4)
Defender 2% + Conqueror Oil 2%	96c (2)	
Defender 2% + Protector Oil 1%		88c (3)

¹ Means followed by the same letter are not significantly different at $P=0.05$ level.

Results of this trial clearly showed that the organic grower would be able to control a serious outbreak of this insect without having to use pyrethrum which is harmful to beneficial insects. Timing of the application is important with good results obtained early in the season, when the canopy of the fruit trees is not so dense. In Levin the first adult was caught in a "Rebell" trap around 17 November 1991 after which date the numbers in the trap sharply increased, reaching a peak on 10 December. A second period with suitable numbers of nymphs occurred between 21 January and 18 February 1992.

Greenhouse whitefly

The ranking order of the treatments remained very consistent across first and second sprays (Table 4). Lux changed position, but was still very effective. Bettacrop, Applaud and the control were not significantly different and least effective at both spray times. Although these were not different from Sunspray Oil the first time, they were inferior to all other materials at the second spray.

At the first spray, Target was not different from Safers Natural Concentrate, Natures Way Insect spray, and Sebon but better than the rest, but at the second spray it was only better than the water control, Applaud and Bettacrop. A large group of treatments including the insect growth regulator Enstar were effective after two sprays and there was no reinfestation.

As found by other research workers (Blank *et al* 1986; Lindquist and Casey 1990), oils and soap showed good to excellent results against whitefly.

TABLE 4: Percent mortality ($\pm$ standard error) of greenhouse whitefly on egg plants after one or two applications of 13 chemical compounds.

Treatment/Solution	Mean % mortality ¹ ($\pm$ SE)			
	1st Spray (+ 3 days)		2nd Spray (+ 1 day)	
Water control	7a	(5)	20a	(7)
Applaud 0.05%	9a	(6)	32a	(8)
Bettacrop 2%	11a	(5)	39a	(8)
Sunspray Oil 1%	24ab	(9)	78b	(7)
Naturgro Triple Plus 1%	38bc	(11)	83b	(6)
Neem 0.02% + Sunlight 0.3%	42bc	(12)	84b	(6)
Vegetable oil 4% + Sunlight 0.3%	62bcd	(15)	95b	(4)
Enstar 5EC (0.16% 1st 0.08% 2nd)	68cd	(9)	98b	(2)
Yates Pyrethrum 0.5%	80de	(8)	99b	(1)
Lux 0.6%	83de	(7)	92b	(5)
Sebon 1%	92def	(6)	100b	(1)
Natures Way Insecticide Spray 2%	94ef	(5)	100 ²	(0)
Safers Natural Concentrate 3%	95ef	(4)	100	(0)
Target 0.5%	99f	(1)	100	(0)

¹ Means followed by the same letter are not significantly different at P=0.05 level

² Total kill treatments not included in analysis.

Longtailed mealy bug

All sprays except Neem performed better than the untreated control (Table 5). Malathion was better than all other treatments. Natures Way Insect Spray and Quassia were significantly less effective than the rest.

TABLE 5: Percent mortality of longtailed mealy bug (crawlers and nymphs) on potato plants after application of nine chemical compounds.

Treatment/Solution	Mean % dead ¹ ($\pm$ SE)	
Untreated control	3a	(1)
Neem 0.05%	3a	(1)
Quassia ² + Sebon 0.7%	11b	(2)
Natures Way Insect Spray 2%	17b	(3)
Safers Natural Concentrate 2%	26c	(3)
Sunspray Oil 1%	28c	(3)
Sebon 2%	28cd	(4)
Bettacrop 2%	33cd	(4)
Yates Pyrethrum 0.5%	39d	(4)
Malathion 25W 0.3% + Sunspray Oil 0.3%	72e	(5)

¹ Means followed by the same letter are not significantly different at P=0.05 level.

² See Table 1.

Yates Pyrethrum was not different from Bettacrop and Sebon but was better than Sunspray Oil and Safers Natural Concentrate. This group of five was the most effective apart from the standard Malathion treatment.

CONCLUSIONS

We tested several botanical pesticides and compared them with conventional pesticides and insect growth regulators. Pyrethrum was the most effective of the botanical pesticides. The Naturgro has some efficacy, at least against Froggatt's apple leaf hopper. Soaps and oils have a wide range of activity. The two insect growth

regulators tested against greenhouse whitefly had rather different effects. Enstar was the most effective.

We have shown that across a range of insect pests several organically acceptable pesticides are effective. Use of other appropriate measures such as predatory insects and screening of greenhouse vents in combination with targeted spraying should enable growers to keep insect problems below manageable thresholds. Some problems are unresolved. Neem appears to vary in efficacy. We have never found it to be as effective as reported by other workers (Lindquist and Casey 1990). In a preliminary trial Lux (2% solution) killed tomato plants and caused the floor to become dangerously slippery. Naturgro and Sabadilla blocked spraying systems and left a powdery deposit quite visible on the plants.

It is possible that some of the compounds shown to be effective in our research will have attributes attractive to conventional growers. The lack of effective control of an intractable pest (apple leafcurling midge) shows that growers turning to organic production will face problems from such secondary pests and will need to develop strategies to minimise their effects on production.

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REFERENCES

- Anon., 1990. Green Growers Guide. The Worldwide Directory of Agro-biological 1990/91 CPL Press, Newbury U.K. 304 p.
- Anon., 1991. Biological control for custard apples proves a success. *Country Living Magazine* 1 (15): 19.
- Blank, R.H., Balgrove, M.J. and Waller, J.E., 1986. Screening chemicals to control greenhouse whitefly on Tamarillo. *Proc. 39th N.Z. Weed and Pest Control Conf.*: 148-152.
- Carpenter, A., Wood, P., Stocker, A., and Butts, C., 1991. Mealy bugs and grapes in Poverty Bay. Rep. Gisborne Grape Growers Soc. MAF Technology Levin/Manutuke.
- Collyer, E. and van Geldermalsen, M., 1975. Integrated control of apple pests in New Zealand. 1. Outline of experiments and general results. *N.Z. J Zoology* 1: 101-134.
- Graff, D., 1990. Pest control you can live with. Gardens Alive, Sunman USA, 78 p.
- Lindquist, R.L. and Casey, M.L., 1990. Evaluation of oils, soaps, and natural product derivatives for leafminer, foxglove aphid, western flower thrips and greenhouse whitefly control. *Ohio Florist Association Bull.* 727: 3-5.
- Mead, R., 1990. The Design of Experiments. Cambridge University Press, Cambridge.
- N.Z. Biological Producers Council, 1988. Production Standards of Organic Foods. NZBPC Auckland. 24 pp.
- Penman, D.R., 1984. Deciduous Tree Fruit pests. In: D.M. Ferro (ed.) New Zealand Insect Pests p. 38. Lincoln University College of Agr. Canterbury, New Zealand.
- Springett, J., 1992 MAF Technology Agroecology Programme 199/91. Annual report. p.6
- Teulon, D.A.J. and Penman, D.R., 1984. Spray timing for control of Froggatt's apple leafhopper in Canterbury. *Proc 37th N.Z. Weed and Pest Control Conf.* 145-247.
- Todd, H.D., 1959. The apple leafcurling midge, *Dasyneura mali* Kieffer, seasonal history varietal susceptibility and parasitism 1955-1958. *N.Z. J Agr. Res.* 2 (5): 859-869.
- van Epenhuijsen, C.W., 1990. Pest monitoring in organics 1989-1990. Levin Horticultural Research Centre. *Techn. Bull No. 14.* 28 p.

- van Epenhuijsen, C.W. and Carpenter, A., 1990. Pearslug and apple leafcurling midge: observations on their biology and control in an organic orchard. *Proc. 43rd N.Z. Weed and Pest Control Conf.*: 119-122.
- Wearing, C.H., 1991. Ryania for organic control of apple and pear pests. *The Orchardist of N.Z.* 64 (4): 35-37.
- Yepsen, R.B., 1984. The Encyclopedia of Natural Insect and Disease Control. Rodale press, Emmaus, Pennsylvania. 490 p.