PRELIMINARY TRIALS OF MATING DISRUPTION OF LIGHTBROWN APPLE MOTH IN NELSON

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SUMMARY

Synthetic sex pheromone was released in four commercial blocks of pipfruit orchards in Nelson from 1000 polyethylene dispensers per ha to disrupt mating of lightbrown apple moth during the 1987/88 and 1988/89 seasons. Standard insecticide programmes were used on these and equivalent areas of orchard not treated with pheromone. No lightbrown apple moth were trapped in blocks with pheromone dispensers. Fruit from blocks treated with pheromone and insecticide generally had the same or less leafroller damage than blocks treated with insecticide alone. The release rate of pheromone at harvest in April from pheromone dispensers applied in November was half that of dispensers applied in January.

INTRODUCTION

Insecticides are the main means of controlling leafrollers in New Zealand pipfruit orchards. Regular applications of azinphos-methyl and chlorpyrifos currently effectively control a range of pests. However, the use of organophosphate insecticides on pipfruit faces problems in the medium term, including the potential for insecticide resistance and increasing consumer opposition to insecticide use. Alternative control tactics are unlikely to be as cheap or broadly effective as insecticides, yet will be needed in order to maintain market access and meet increasingly stringent criteria for environmental acceptability. In Nelson, *Epiphyas postvittana* Walker (lightbrown apple moth, or LBAM) is the dominant leafroller species, and typical insecticide programmes on late varieties use 10-12 applications per annum for sufficient control to meet export quarantine criteria. Work on the use of mating disruption to control LBAM began with the two-fold aim of managing for resistance (Hide and Suckling 1988), and reducing insecticide use (Suckling *et al* 1990a).

Complete suppression of LBAM catch in pheromone traps using synthetic sex pheromone was first achieved in 1984. This was despite the release of nearly 2000 marked males into treated blocks (Suckling *et al* 1990a). Comparison of pheromone blends for mating disruption of LBAM released from polyethylene dispensers indicated that even a modification of the natural blend was satisfactory to disrupt mating at 1000 dispensers per ha (Suckling and Clearwater 1990). In subsequent field trials on an area affected by insecticide-resistant LBAM at Mouere Bluffs, leafroller damage in cv. 'Sturmer Pippin' dropped from >1% in 1985/86, down to 0.007% after 3 years of pheromone use, accompanied by a reduction by three in the number of insecticide applications applied annually (Suckling *et al* 1990b). A few cases of mating disruption have been successfully commercialised and there are now registered systems for use against several orchard and vineyard pests (Campion *et al* 1989).

Mating disruption trials differ from insecticide trials due to the considerably greater potential for interference between treated and untreated blocks. Mating disruption is most effective on large blocks (>3 ha) with limited secondary pest pressure, and adequate shelter to reduce pheromone losses from wind. Suitable orchards have large areas of late season cultivars (e.g. 'Granny Smith' and 'Sturmer') in two similar blocks (treated with pheromone plus insecticide and a control treated with insecticide alone) and a history of leafroller control difficulties under the standard

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insecticide programme. Orchards meeting these criteria are found in Lower Moutere and Mariri, Nelson, where these trials were located.

The aim of the trials reported here was to assess control of LBAM under a combined pheromone and insecticide programme. We concentrated on the late season variety 'Granny Smith' because it is exposed to leafroller pest pressure for the longest period, and can return a high premium which would assist the economics of pheromone use.

MATERIALS AND METHODS

Locally manufactured triangular ('delta') sticky traps (28 cm long x 20 cm base x 15 cm x 15 cm) were baited with 100 µg ((E))-11-tetradecenyl acetate (E-11-14:0Ac) and 5 µg (E,E)-9,11-14:0Ac on rubber septa for *E. postvittana* (Bellal *et al* 1983). For the native leafrollers, 21 µg (Z)-8-14:0Ac and 9 µg (Z)-5-14:0Ac was used for *Ctenopseustis obliquana*, 100 µg (Z)-5-14:0Ac for *C. herana*, and 100 µg 14:0Ac for *P. excessana* (only in 1988/89) (S.P. Forster pers. comm.). Traps were placed at 1.5 m height in apple trees inside orchards or up to 50 m outside the perimeter of orchards to monitor moth populations. Four LBAM traps were located near the perimeters of the blocks, and two in the centre of each block. Two replicate traps were set for each native leafroller species near each block. Caps were changed six-weekly, and sticky bases were changed monthly or more often if needed. In 1987/88, pheromone traps for LBAM and native leafrollers were operated from 1/12/87 (commencing 4 weeks prior to placement of mating disruption pheromone dispensers on 8/1/88), through to the end of May. Trapping in the 1988/89 season commenced on 3/10/88 (prior to placement of pheromone dispensers on 8/11/88), through to the end of May. The traps were only operated for 1 month prior to the commencement of the pheromone treatment, as this was considered an adequate indication of LBAM populations within both treatments inside the orchards.

Apple trees were treated with 1000 polyethylene tubing dispensers per ha (Shin-Etsu Chemical Co. Ltd., Tokyo) containing (E)-11-tetradecenyl acetate and (E,E)-9,11-tetradecadien-1-yl acetate (56.5 mg and 2.8 mg per dispenser, on 18/1/88 and 51.7 mg and 2.8 mg on 8/11/88). Dispensers also contained (Z)-11-tetradecenyl acetate as an impurity (15.2 mg and 20.9 mg for each season respectively). Two dispensers were hand applied per tree, (1000/ha) with 75% of dispensers at 1.5 m, and 25% at 3 m canopy height.

Trial 1 (1987-88) Pheromone dispensers were placed in a 2 ha block of 'Granny Smith' apples and a full insecticide programme was also applied. The comparative block treated with insecticides alone (11 applications) was 50 m away across a stream. It was smaller (1.5 ha) and exposed to pasture on two sides. The blocks were located on completely flat land.

Trial 2 (1987-88) Dispensers were placed in 2 ha of 'Granny Smith' apples exposed on one side to pasture, and with considerable native vegetation at one end. This block also received a full insecticide programme (8 applications). An insecticide only block was also near sources of native leafrollers. Both blocks were on completely flat land.

Trial 3 (1987-88) This trial, on contoured hillsides, involved one 'Granny Smith' block (1 ha) receiving the standard insecticide programme, and another (2 ha) receiving the same insecticide programme (7 applications) and pheromone.

Trial 4 (1988-89) Treatments from Trial 2 were reversed between the blocks used in the previous year, in order to minimise the bias in probability of leafroller damage. The area treated with pheromone was increased to 10.6 ha, consisting of the block treated with insecticides alone in 1987/88 in Trial 2. Dispensers were applied on 8 November 1988, 2 months earlier than previously, due to an extended period of efficacy demonstrated in other trials (Suckling and Shaw unpublished data).

Packhouses recorded the number of bins of fruit harvested from each trial, and saved all fruit rejected for the suspected presence of leafroller damage. The cause of the damage and number of fruit in the packhouse samples was checked, and the total fruit volume estimated, assuming 100 fruit per case and 25 cases per bin. This provided a conservative estimate of fruit damage.

Numbers of damaged fruit over the total number of fruit harvested were compared using a chi-square test with correction for continuity. The mean numbers of moths caught weekly were log transformed and compared between treatments using t-tests.

The meniscus of pheromone in 10 dispensers was measured weekly from applications one month apart in November, December, and January in order to investigate the impact of different application times on the pheromone rate over the fruit harvest period.

RESULTS AND DISCUSSION

There was considerable variation in the relative population levels of native leafrollers near trials in different parts of Nelson. Care had been taken to balance predicted leafroller pest pressure between treatments during trial layout (from land use), and this aim was largely achieved for native leafrollers, which were generally rare (data not presented).

The weekly catches of male LBAM in Trials 1-3 in the 1987/88 season are shown in Fig. 1. The comparison in catch between internally and externally located traps indicates the effectiveness of the pheromone dispensers which completely prevented catches by traps within treated blocks in all four trials. In contrast, traps placed internally in blocks treated only with insecticide continued to catch LBAM (although

Fig. 1: Mean catch per trap.day of light-brown apple moth in pheromone traps in Trials 1-3 in the 1987/88 season. Apple orchard blocks were untreated (left) or treated (right) in January 1988 with synthetic sex pheromone for mating disruption. Both blocks received insecticide applications from November to March. Traps were placed either inside (internal, $n = 2$) or outside (external, $n = 4$) orchard blocks in each trial. Note differences in scale between graphs.

less than external traps, which were not treated with insecticide). Traps placed outside pheromone-treated blocks also continued to catch moths throughout the season, indicating flight activity nearby. Some weekly differences in the level of LBAM activity between matched blocks receiving the pheromone/insecticide and insecticide alone treatments are apparent from the differences in the y axis scales of Fig. 1. There was no significant difference between treatments in mean catch of male LBAM either before the application of pheromone in the case of internal traps, or during the entire season for external traps (Table 1) ($P > 0.05$, t-tests on log transformed mean catch per trap/day). This indicates that LBAM pressure was similar in the pheromone/insecticide and insecticide alone treatments. The nil trap catch inside pheromone-treated blocks persisted over the harvest period to the following spring. Such interference has often continued for at least 10-12 months following the application of dispensers (Suckling and Shaw unpublished data).

TABLE 1: Mean daily trap catch of male LBAM in pherotraps at Trials 1-3.

Location Block	4 Scrub Traps		2 Orchard Traps	
	Ph	No Ph	Ph	No Ph
Mean Catch Per Trap/Day (4 weeks) SEM	Before Pheromone Dispensers (1/12/87-4/1/88)			
	0.065	0.093	0.048	0.072
	0.020	0.037	0.021	0.045
Mean Catch Per Trap/Day (13 weeks) SEM	After Pheromone Dispensers (23/1/88-11/5/88)			
	0.115	0.772	0.000 ¹	0.223
	0.063	0.265	0.000 ¹	0.113

¹ All values were zero due to disruption of trap catch

Trapping commenced in October in Trial 4, and the traps located in the block which had been pheromone-treated in the previous season failed to catch LBAM, demonstrating that sufficient pheromone was still being released to disrupt trapping. Numbers caught in this treatment were low throughout the trapping period (0.003 average daily trap catch from November on). Application of dispensers to the other block in the first week of November 1988 prevented further catches inside that block throughout the season. Numbers of LBAM trapped outside the orchard blocks were variable. Those near the pheromone block trapped fewer males than did those near the untreated block. This represented a decrease in numbers compared to numbers trapped before pheromone application. These results were not significant.

There was generally less fruit damage recorded in the pheromone-treated blocks, compared to the untreated blocks, ($X^2 = 52.86$, $P < 0.01$, 6 df). However, there was significant heterogeneity between harvest results (X^2 for heterogeneity = 36.9), indicating that block effects were important to the outcome (Table 2). For example, in Trial 1, a very small amount of leafroller damage was detected on the border of the pheromone-treated block, near a stream. This damage may have been due to the movement of native leafrollers, which are not affected by the pheromone used, from the host plants near the waterway separating the blocks. Block size, location, and geographical context (e.g. host plants, topography, wind, neighbouring land use, etc.) are critical factors affecting the success of mating disruption. At 2 ha in size, Trials 1-3 were at the lower limit of area over which mating disruption could be expected to operate, and represent relatively rigorous tests of this approach. Only Trial 2 could be considered a success for disruption, but even in this case some leafroller damage was evident.

The problem of block size was addressed the following season. Trial 4 was large enough (10.6 ha) to expect the mating disruption technique to make an improvement in fruit quality, if it was capable of doing so. There was a significant reduction in leafroller damage in two of the four cultivars (Table 2), although some leafroller damage was still evident. This may have been partly a function of the location of cultivars within the block, with some closer to boundaries than others.

TABLE 2: Harvest assessment of apples from Trials 1-4.

	Pheromone + Insecticides			No. Fruit	Insecticides Alone		X ²
	No. Fruit	% Leafroller Damage	No. Sprays		% Leafroller Damage	No. Sprays	
1987/88 'Granny Smith'							
Trial 1	1125000	0.0009	11	630000	0.0019	11	2.56
Trial 2	750000	0.0045	8	250000	0.0540	8	67.90**
Trial 3	150000	0.0107	7	105000	0.019	7	2.53
1988/89 Trial 4							
Cox' Orange Pippin	125000	0.0016	6	260000	0.0023	6	0.54
Gala	175000	0.0000	6	75000	0.0040	6	4.06*
Red Delicious	1542500	0.0125	8	850000	0.0113	8	0.64
'Granny Smith'	2100000	0.0028	12	1042500	0.0059	12	12.07**

The application of pheromone in November resulted in a weekly release rate over harvest about half that of the application made in January (Fig. 2). The earlier application would appear to have the advantage of extending the period of cover whilst still maintaining a release rate above the threshold required for disruption. Further work is underway to determine the threshold of atmospheric pheromone required for mating disruption of LBAM.

It has been demonstrated elsewhere (Suckling *et al* 1990b) that damage from insecticide resistant *E. postvittana* can be reduced by supplementing the insecticide with mating disruption, and that the number of insecticide applications also can be reduced as a result of pheromone use, at least at Moure Bluffs. Insecticides will continue to be needed for control of other New Zealand orchard pests, with the result that continued selection pressure for resistance will occur. In the presence of pheromone, survivors of insecticide selection would presumably have a decreased likelihood of successfully producing progeny. Mating disruption therefore seems a suitable proactive resistance management solution, if it can be readily integrated into standard orchard practice.

Fig. 2: Average release rates of synthetic LBAM sex pheromone from three application times during the season. The meniscus in polyethylene tubing dispensers was measured weekly to estimate the release rate.

Because of a nil tolerance, any contribution to reducing leafroller feeding injury in export apples would be desirable. However, the additional cost of the pheromone over that of a standard insecticide programme would require the benefits to growers to be substantial. A reduced insecticide programme would make the technique more economically viable, and up to three sprays have been saved with pheromone use at Mouere Bluffs without negative effects on fruit quality (Suckling *et al* 1990b). Whether sufficient savings can be made to render the mating disruption technique financially competitive with the standard programme of insecticides remains to be established. The increasing consumer concern over insecticide residues on fruit could also assist the adoption of this technology, although a reduction in insecticide residues has yet to be achieved. Mating disruption will therefore require further development and testing, but this is justified in view of the potential benefits to the industry.

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