A RECOMMENDED SPRAY PROGRAMME FOR LEAFROLLER AND CODLING MOTH CONTROL IN CENTRAL OTAGO APPLE ORCHARDS

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ABSTRACT

Apple orchards in Central Otago are attacked by a complex of three leafroller species and codling moth (CM), *Cydia pomonella*. The relationship between pheromone trap catches, crop damage, and insecticide spray programmes was investigated on commercial orchards and the Clyde Research Centre from 1990-94. The leafrollers are bi- (or partially tri-) voltine and the generations of all species are well synchronised. A post-bloom organophosphate spray programme is recommended comprising three sprays against the first generation, supplemented by 0 to 2 further sprays against the second respectively for early to late harvested cultivars. CM rarely requires an additional spray and only where pheromone trap catches are above the spray threshold. The most damaging species in the region is greenheaded leafroller, *Planotortrix octo* (OCTO).
Keywords: phenology, leafroller, codling moth, pheromone trap, organophosphate

INTRODUCTION

The tortricid pests of apple orchards in Central Otago are CM, OCTO, lightbrown apple moth, *Epiphyas postvittana* (LBAM), and brownheaded leafroller, *Ctenopseustis obliquana* (BHLR). Organophosphate (OP) use has varied widely between orchards from three to eleven post-bloom applications, with no consistent relationship between spraying frequency and efficacy (Wearing 1991). This has been due in part to the presence of OP-resistant OCTO (Wearing 1995a) at Dumbarton and also because some growers have discovered by trial and error how to use well-timed sprays. Other growers have used a calendar spray programme of two-weekly spraying. This paper summarises four seasons of research (1990-94) on pest phenology which aimed to rationalise insecticide use through improved spray timing. This work included extensive investigations of the relationships between crop damage, spray programmes, pheromone trap catches, cultivars, orchards and districts; reduced spray programmes based on pest phenology were tested from 1991-94 and codling moth control was investigated in 1993-94 in districts affected by this pest (Wearing 1991, 1992, 1993, 1994). Only an outline of the programme and key conclusions can be presented in this paper.

METHODS

Orchards (1990-91, 20; 1991-92, 10; 1992-93, 16; 1993-94, 5) were selected for the study from throughout the region and representing all districts (Cromwell, Alexandra, Roxburgh, Dumbarton, Ettrick).

Pheromone trapping

Four pheromone traps were monitored weekly for each of CM, OCTO, LBAM and BHLR on the margins of a designated apple block (2 to 10 ha) within each orchard using standard procedures (HortResearch 1992) and lures (McLaren and Suckling 1993). After the first two seasons, BHLR was not monitored due to very low catches and synchrony with OCTO/LBAM in all districts, and CM trapping was confined to orchards where the pest was found to be present. The traps for all species were used to determine male flight phenology as a basis for the design of spray programmes, including for CM up to 1992-93. In 1993-94, CM catches in traps placed *within* the blocks were used as thresholds for spraying as described by Wearing and Charles (1978).

Harvest samples

Harvest samples of fruit were examined in the field for leafroller and CM damage using 100 fruits per tree on 15 trees per cultivar per treatment on each orchard. Representative cultivars were selected for the early-, mid-, and late-season harvest periods (usually three cultivars per treatment per orchard), especially including short-stemmed and late cultivars more prone to leafroller damage. The same blocks of the same cultivars were sampled each season if possible, to enable comparison between seasons. Sample bins of apples from the same plots were also labelled and sent to the packhouse where damaged fruit was recovered for assessment. Fruit size data from ENZA New Zealand each season enabled calculation of the number of fruits per bin and hence the percentage damage by pests recorded from the bins. The larger packhouse samples permitted the detection of much lower levels of leafroller and CM damage than could be recorded in the field samples. For example, the packhouse damage estimates were based on total samples of 6.8 million apples in 1991, 2.5 million in 1992, and 6.4 million in 1993. Although infection by other insect pests (eg. scale insects) was recorded, this was below economic damage levels in all samples.

Spray programmes

All growers supplied details of their spray programmes each season, including the products, rates, dates and volumes of sprays applied. A small number of orchardists were already applying only 3-4 sprays at the start of the research and they continued their minimal spray practices. All other orchardists modified (by timing) or reduced their spraying after 1990-91, and in 1992-93, reduced and standard spray programmes were also compared directly on matching cultivars in four orchards.

Clyde Research Centre trial

The 1 ha apple block at the Clyde Research Centre was monitored using similar methods to those used on the commercial orchards except that the CM traps were operated *within* the block every season. The objective of this trial was to design a timed, minimal and effective spray programme. Beginning with no OP sprays in 1990-91, the number was increased to two in 1991-92 and then to three-four in the following two seasons. In 1993-94, spray thresholds for CM were based on trap catches (Wearing and Charles 1978). Samples of harvested fruit (500-2000/cultivar from 5-20 randomly selected trees) were examined for insect damage. A 'control' block could not be used in this trial and the test of the efficacy of the spray programme is by replication over several seasons.

Statistical analysis

Percentage damage data were subject to angular transformation before analysis of variance and multiple regression to determine whether the following factors contributed significantly to leafroller and CM damage (field and packhouse) at harvest: year (1991-93), season (early, mid, late), orchard (grower), cultivar, total post-flowering spray applications (with and without thinning sprays), and mean catches of moths in pheromone traps. These analyses also provided data for the 4 years on the mean interval between sprays, mean maximum interval between sprays, mean withholding period, and mean numbers of sprays applied. Paired t-tests were also used to compare results from the paired standard and reduced programmes in 1992-93. Data from Dumbarton are not presented in this paper because the presence of OP-resistant OCTO required additional control measures (Wearing 1995 a, b).

RESULTS AND DISCUSSION

Trap catches, fruit damage and the timing of flights

Leafroller damage in the field and the packhouse each season was dependent on OCTO populations as measured by trap catches ($P<0.05-0.01$). No such relationship could be consistently demonstrated for LBAM (or BHLR) (Wearing in prep.). The pheromone trapping showed the occurrence of two periods of male leafroller moth activity associated with the two generations of these pests each season, with peak catches in mid-December to mid-January and in March/April. There is a distinct trough in trap catches separating the two generations and this is well synchronised between the different leafroller species (McLaren and Suckling 1993). The timing of the peaks and troughs in any season is temperature-dependent (Wearing and Hayes unpublished) but the synchrony facilitates spray timing for the whole leafroller complex (Fig. 1). If a partial third generation occurs, the extension of the male flight period in autumn is too late to cause crop damage.

CM damage in the field was significantly dependent on pheromone trap catches ($P<0.05$) and varied between districts ($P<0.001$) and orchards ($P<0.001$). The latter reflected the presence of unsprayed apple trees close by, and damage also increased ($P<0.05$) where less than four sprays were applied over the season. Male flight of CM occurred mainly in December/January, and extended through February. In the 1993-94 trials, no sprays were required specifically for CM because thresholds were exceeded only at times when leafroller sprays were scheduled.

Spray practices and fruit damage

The mean number of post-bloom insecticide sprays (excluding carbaryl for thinning) applied varied between districts from four to six (range three to ten) outside Dumbarton. There was no significant increase in economic damage from leafroller on any orchard associated with modified timing or reduced applications during the four seasons (Wearing in prep., data summarised in Table 1). Economic damage by CM occurred occasionally in individual orchard blocks under standard or reduced programmes (Cromwell and Alexandra) from 1990-91 to 1992-93. This was related to poorly timed spray applications which caused long spray intervals during the period of risk in January. This did not occur in the 1993-94 commercial and Research Centre trials where CM was specially monitored and CM spray thresholds were applied.

TABLE 1: Mean percentage of apples damaged by leafrollers and codling moth, recorded in the field and at the packhouse, from standard and reduced/modified spray programmes, 1990-91 to 1993-94 (districts outside Dumbarton).

Year Treatment	n[1]	Mean no. of sprays (range)	Leafroller		Codling moth	
			Field	Packhouse	Field	Packhouse
1990-91						
Standard	16(48)	5.85 (3-10)	0.066	0.0041	0.259	0.0108
1991-92						
Standard	4(12)	5.25 (4-8)	0.008	0.0015	0.058	0.0035
Red/Mod	4(12)	4.25 (3-5)	0.016	0.0020	0.000	0.0248
1992-93						
Standard	4(12)	5.82 (4-8)	0.007	0.0058	0.004	0.0007
Red/Mod	10(27)	4.18 (3-5)	0.018	0.0004	0.006	0.0024
1993-94						
Red/Mod	5(14)	4.00 (3-5)	0.007		0.004	

[1] No. of orchards (cultivar blocks)

From 1991-93, the reduced/modified programmes removed an average of two sprays from standard spray programmes (six to four, $P<0.001$). An effect of this was to extend the mean spray interval from just over 2 weeks in a standard programme to just over 3 weeks when modified and/or reduced ($P<0.05$). Whereas standard sprays were routinely applied at two-weekly intervals from late November to late January, there were only three sprays applied (at three weekly intervals) in December/January of the reduced programmes. Similarly, the mean maximum spray interval was increased by the restructured spray programme from 25 days to 33 days ($P<0.05$). This was achieved without increasing the mean length of the withholding period (38-40 days) by timing sprays in relation to the two generations of leafrollers. Many orchards/cultivars had no detectable damage.

These results were supported by the trial at the Clyde Research Centre in which sprays were applied based on pest phenology (and CM thresholds in 1993-94) (Table 2).

TABLE 2: Mean percentage of apples damaged by leafrollers and codling moth recorded in the field in the Clyde Research Centre apple block, 1990-91 to 1993-94.

Year	Cultivar	No. of post-bloom sprays[1]	Leafroller	Codling moth
1990-91	Cox	0	0.52	0.30
	Royal Gala	0	0.10	0.97
	Red Delicious	0	0.18	0.22
	Braeburn	0	1.17	3.03
	Fuji	0	2.64	2.64
1991-92	Cox	2	0.06	0.37
	Red Delicious	2	0.09	0.28
1992-93	Cox	3	0	0
	Royal Gala	3	0	0
	Red Delicious	4	0	0
	Fuji	3	0	0.10
1993-94	Cox	4	0	0
	Royal Gala	4	0	0
	GS2085	4	0	0
	Braeburn	4	0	0
	Fuji	4	0	0

[1] excludes carbaryl thinning sprays

The absence of damage in 1992-93 and 1993-94 confirmed that four sprays of OP insecticides are sufficient for effective control of leafrollers and CM at Clyde. Similarly in 1994-95, only three fruit damaged by leafroller were found in a total of 3500 apples sampled at harvest from Royal Gala, Fuji and Braeburn which had received 3-4 post-bloom sprays. A simple solution to the problem of very low but detectable CM damage, if it is needed, is to apply a minimum of four timed sprays for leafroller control, and monitor for CM to detect flight activity which may require extra spraying. As on the commercial orchards, no specific sprays were required for CM control in 1993-94.

A recommended spray programme for Central Otago

This research provided the basis for a recommended post-bloom OP spray programme (azinphos-methyl, chlorpyrifos) for leafroller and CM control in Otago apple orchards (Fig. 1). A pre-bloom oil + OP spray should continue to be applied as in normal commercial practice for scale and woolly aphid control and the post-bloom programme should include at least one product, such as chlorpyrifos, which is particularly toxic to these pests as well as CM and leafrollers.

1. *Apply three OP sprays at three-weekly intervals against the first generation of leafrollers.* The timing of these sprays will normally be early December, late December and mid January, and this will also provide control of codling moth. These sprays are the core of the control programme and should be applied regardless of the numbers of moths caught in traps. The timing of the first spray may vary with spring temperatures, and pheromone traps should be used to provide information on the start of leafroller moth flights, especially OCTO which usually begins at the start of December. A temperature-driven phenology model of these events is being developed.
2. *Apply 0 to 2 (normally 1) OP sprays against the second generation of leafrollers depending on (i) cultivar, (ii) timing of the second generation, and (iii) local experience of spray requirements.* The need for these sprays has been found to vary between orchards and the experience of each orchardist. Early- and mid-season cultivars may require 0 or 1 spray against the second generation, and late-season cultivars may require 0-2 sprays. The normal timings for these sprays are early February (because of withholding periods for early cultivars), and late February/March based on phenology. In late seasons, such as 1992-93 and 1993-94, the early February spray would be unnecessary, occurring during the trough between the first and second generations (Fig. 1). Pheromone traps can be used to determine the timing of the trough, which will also be included in the phenology model. Larval sampling in 1994-95 has shown that, as temperatures fall in late summer, there is an increasing lag between pheromone trap catch data and subsequent larval phenology (Wearing unpublished). This suggests that a spray against larvae of the second generation will be required rarely on early-harvested apple cultivars.
3. *If CM is known from trapping or past experience to be a risk to the crop, monitor for CM with pheromone traps and apply extra sprays only when the spray threshold is exceeded.* This is most likely in the Cromwell and Alexandra districts. It is advisable to test CM pheromone traps in a number of sites around the orchard to find localised populations of this pest. This may require internal or margin trapping depending on location.

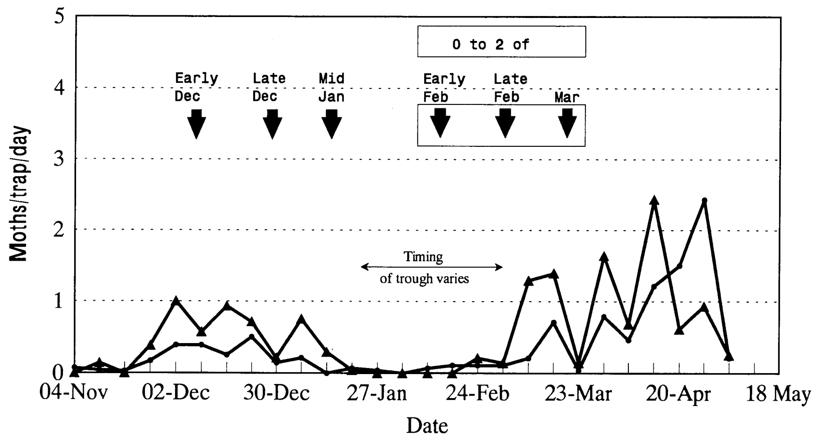

FIGURE 1: A recommended post-bloom OP spray programme (🠇) for Otago apples superimposed on leafroller trap catch data typical of the 1992-93 season (▲ OCTO; ● LBAM). The need for no, one or two late season sprays is determined by the harvest date of the apple cultivar and the moth phenology in a given season (see box and text).

In contrast to CM, the absence of a relationship between LBAM (and BHLR) trap catches and crop damage in this study confirms that leafroller pheromone traps must not be used for timing sprays based on the number of moths caught. This does not provide a reliable indication of the level of risk. Further research is required to determine whether the demonstrated relationship between OCTO trap catches and crop damage is sufficient for the development of spray thresholds for this leafroller species in Otago.

ACKNOWLEDGEMENTS

The skilled technical assistance of Helen Ogle, Nina Smeets, Carol Burke, Andee Barrie, and Ross Marshall is gratefully acknowledged. Thanks to NZAPMB staff at Alexandra for their assistance with spray programmes and fruit size data. I thank all growers and packhouse managers for their collaboration, especially for the operation of pheromone traps and the provision of harvest samples. Thanks to Fred Schild and Sue Muggleston, HortResearch, Auckland, for supplying pheromone traps. This research was funded by The Foundation for Research Science and Technology and ENZA New Zealand (International).

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