INTEGRATED FRUIT PRODUCTION FOR NEW ZEALAND PIPFruit: EVALUATION OF PEST MANAGEMENT IN A PILOT PROGRAMME

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ABSTRACT

A pilot Integrated Fruit Production (IFP) programme for pest and disease management was evaluated on approximately 88 apple orchards throughout New Zealand. Insect control was based on increased use of biological control, monitoring and threshold-based applications of insecticides. The insect growth regulator tebufenozide was used for control of codling moth and leafrollers, while homopteran pests and apple leafcurling midge were controlled by oil, buprofezin and organophosphate insecticides. The frequency of post-bloom insecticide use was reduced by 40-60% when compared with conventional programmes, and organophosphate use decreased to 0.5-1.0 applications. Insect control is discussed together with the cost of pest management under integrated and conventional fruit production.

Keywords: integrated fruit production, apple, pest management, tebufenozide

INTRODUCTION

The New Zealand Integrated Fruit Production - Pipfruit (NZ IFP-P) programme is a new approach to pipfruit production which aims to address increasing consumer concern over pesticide residues in food, and the impact of crop production practices on the environment (Batchelor *et al.* 1997). The underlying pest management philosophy within this IFP programme is to place greater emphasis on the use of biological control through reduced use of pesticides and greater adoption of more selective and environmentally benign products, such as tebufenozide (Walker *et al.* 1991). Implementation of the pilot NZ IFP-P programme required the development of monitoring procedures for pest and beneficial species, and action thresholds for the key pests. Initial thresholds were derived from a combination of previous research and the best estimates of researchers. The phytosanitary requirements in our international markets were reviewed to ensure that these requirements would be met by the new procedures, which are presented in the ENZA New Zealand Integrated Fruit Production Pipfruit Manual (Anon. 1996).

The key pests of New Zealand's apple crop are leafrollers and codling moth and these have been most important in formulating control recommendations for export crops. IFP control strategies were also required for other pests, such as mealybugs, scale insects, woolly apple aphid (WAA) and apple leafcurling midge (ALCM). These have differing regional importance, but have previously been suppressed by the organophosphate (OP) insecticide programme applied to control key pests. Mites have been a significant problem in apple orchards but with the widespread adoption of Integrated Mite Control (IMC) programmes based on *Typhlodromus pyri*, miticide use has declined substantially (Manktelow *et al.* 1997).

The challenge in the development of an IFP programme was to integrate individual pest control strategies into a comprehensive pest management programme for each region. We needed to ensure that growers incurred little, if any, increase in fruit damage and that fruit did not exceed MAF phytosanitary tolerances for pest infestation. This paper evaluates insecticide use, fruit quality and programme costs associated with a pilot NZ IFP-P programme which was commercially evaluated in the 1996-97 season.

METHODS

Eighty-eight orchards were registered with ENZA to operate the pilot IFP pest management programme (Batchelor *et al.* 1997). Most of the orchards were from Hawkes Bay (53), Nelson (12) and Central Otago (19) with just four and two orchards in Canterbury and Waikato respectively. Growers were asked to follow the IFP pest management guidelines published in the ENZA NZ IFP-P Manual (Anon. 1996).

Pest management thresholds and treatment responses

Some treatments were recommended based on pest phenology. These included mineral oil at 'green-tip' for the control of scale insects, and tebufenozide at the start of spring leafroller flights and again 14-21 days prior to harvest. In all other instances, growers were required to monitor for pests and respond with insecticide only if one of the pest thresholds was exceeded. Some of thresholds were justified on the basis of pest presence in the block during the previous harvest. The thresholds and recommended treatment responses are summarised in Table 1.

TABLE 1: The treatment thresholds and recommended insecticidal responses for orchards following IFP guidelines.

Pest (and time)	Threshold	Products
Apple leafcurling midge	>20% egg infested shoots	diazinon
Codling moth	Either 5 moths in a trap in one week or >2 moths/trap/week or 10 moths in a trap since last spray	tebufenozide ¹ or diazinon, chlorpyrifos
Leafroller	One infested/damaged shoot in 200 One infested/damaged fruit in 200	tebufenozide ¹ or diazinon, chlorpyrifos
Mealybug (September)	Presence on fruit last harvest	oil + either buprofezin ¹ or chlorpyrifos
Mealybug (November)	2% fruit infested last harvest	chlorpyrifos
Scale (September)	>2% fruit infested last harvest	oil ± either buprofezin ¹ or chlorpyrifos
Woolly apple aphid	Colonies on •10% of shoots	chlorpyrifos

¹ preferred treatment

Harvest assessment procedures

At harvest, 2000 fruit (200 from each of 10 bins) per cultivar were assessed by IFP consultants (or their assistants) in the field for any pest damage or infestation. Damaged or infested fruit were examined by HortResearch and the incidence of pests, or damage, was recorded. Twelve apple and three pear cultivars were included in this programme, with a maximum of four cultivar blocks examined per orchard. Approximately 300

cultivar blocks were examined nationally, but this analysis was limited to 219 blocks (Hawkes Bay = 144; Nelson = 31; Otago = 44) from the four main apple cultivar groups; Cox, Gala strains, Braeburn and Fuji. Regions with fewer than 10 blocks were excluded from the main analysis but are discussed. Some growers withdrew from the programme (due to hail or frost damage) or were eliminated from the analysis because they had invalid, or missing, spray programme information. In Hawkes Bay, additional fruit assessments were completed for 10 growers in the programme who had also grown crops following conventional fruit production (CFP) methods based on OP insecticides (ENZA's USA Code of Practice). Matched pairs of 15 cultivar blocks formed the basis of a simple economic analysis of comparative programme costs based on insecticide use and fruit losses between IFP and CFP.

Spray diary information

Insecticide use on each cultivar block was obtained through an analysis of ENZA's Pest Control Record Books as completed by the participating growers. As similar pre-bloom insecticide programmes were followed in IFP and CFP blocks, the analysis of pest control programme differences was limited to post-bloom insecticide use. Insecticides applied to each block were classed as Insect Growth Regulators (IGRs), which included tebufenozide, buprofezin and limited use of lufenuron, or OPs which included chlorpyrifos, diazinon and restricted use of azinphos-methyl. Carbaryl, used for fruit thinning in both IFP and CFP programmes, was excluded from this analysis.

RESULTS

Leafrollers and codling moth

A regional analysis of leafroller damage at harvest and post-bloom insecticide use is shown for the four apple cultivars (Table 2). In Hawkes Bay, leafroller damage in IFP blocks was minimal in early season cultivars (Cox and Gala) and increased in later cultivars (Braeburn and Fuji). At least two generations of leafrollers attack the crop in this region. In contrast, in Otago where almost all damage is from the first generation, the short-stemmed early season 'Cox' apples suffered more damage than longer-stemmed later cultivars. Despite increased insecticide use in Nelson, leafroller damage there was more variable and generally higher for all cultivars than in either Hawkes Bay or Otago blocks.

TABLE 2: Regional analysis of leafroller damage and respective post-bloom OP and IGR insecticide use on four apple cultivars. Leafroller damage is shown as the percent of orchards in each district with crops in one of three fruit damage categories.

District	Cultivar	No. of blocks	Leafroller damage class			Mean no. applications		
			<0.5%	0.6-2.0%	>2%	IGRs	OPs	Total
Hawkes Bay	Cox	19	89	11	0	1.9	0.5	2.4
	Gala	50	96	4	0	2.5	0.9	3.4
	Braeburn	48	84	14	2	2.6	0.7	3.3
	Fuji	27	77	17	6	2.7	0.8	3.5
Nelson	Cox	10	50	20	30	2.4	0.8	3.2
	Gala	8	63	37	0	2.5	1.5	4.0
	Braeburn	8	12	63	25	3.3	1.0	4.3
	Fuji	5	20	80	0	3.0	0.3	3.3
Otago	Cox	8	63	37	0	3.0	0.5	3.5
	Gala	10	80	20	0	2.8	0.5	3.3
	Braeburn	13	92	8	0	2.9	0.4	3.3
	Fuji	13	92	8	0	2.8	0.5	3.3

The only orchards where leafroller damage was >0.5% in Otago (Table 2) or >2.0%

in Hawkes Bay, were from localised areas where either *Planotortrix octo* (Otago and Hawkes Bay) and *Ctenopseustis obliquana* (Hawkes Bay only) are known to be resistant to OP insecticides (Wearing 1995a; Lo 1997). In both districts, resistance management programmes based on mating disruption were under evaluation in the 1996-97 season. In an attempt to reduce the cost of mating disruption, lower rates of pheromone release than used previously (Wearing 1995b) were tested in Otago, and this contributed to the higher fruit losses reported for Cox blocks from this region.

Within each district, a proportion of the leafroller damaged fruit reported here was acceptable for export under ENZA grade standards. In Nelson, this inconsequential damage accounted for 43% to 64% of total damage Cox and Fuji blocks respectively. Growers in Nelson generally had slightly higher average levels of OP use within IFP blocks (required for ALCM control) while average use of IGRs was similar among districts.

Total pest infestation levels

In Hawkes Bay, fruit from 9% of blocks (13/144) had total pest infestation levels which potentially exceeded the MAF Maximum Pest Limit (MPL) of 0.5%, which rejects crops from export when insect infestation exceeds 12 fruit in a sample of 600. Although standard fruit grading procedures should remove most infested fruit, these blocks of fruit were potentially unacceptable for export. The relative importance of the pests contributing to these potential downgradings are shown in Table 3. In all Hawkes Bay blocks with greater than 2% total fruit infestation there was some presence of either mealybug or ALCM. Mealybug was the most common contaminant, but ALCM and scale insects were important secondary contaminants which could increase the frequency of blocks being downgraded from export.

TABLE 3: The relative importance of pests in Hawkes Bay blocks where the MAF Maximum Pest Limit of 0.5% was exceeded.

Pest	Mean incidence (%)	Range	No. of blocks where pest was:	
			Primary problem	Secondary problem
Leafrollers	0.03	0 - 0.30	0	2
Codling moth	0.00	0	0	0
Mealybugs	2.07	0.10 - 3.55	10	3
Leafcurling midge	0.60	0.05 - 1.40	1	12
Woolly apple aphid	0.26	0 - 2.50	1	2
Scale insects	0.09	0 - 0.75	0	5
Mites	0.33	0 - 4.30	1	1
TOTAL PEST	3.38	2.05 - 6.45		

Leafroller and codling moth larvae were not primary factors threatening the export suitability of IFP blocks; codling moth damage was inconsequential in all three districts and occurred in just 8% of cultivar blocks examined. In Otago, leafroller damage was minor except in the area with OP resistance. Very low levels of fruit infestation were experienced from WAA, scale insects and ALCM, the most widespread being scale (range 0 - 0.45% infested fruit). In Nelson, ALCM was the most significant contaminant of fruit, averaging 0.7% and 0.9% on Cox and Gala cultivars respectively. Scale was present at low levels in some properties in all three districts. There was strong evidence that fruit infestation from scale insects came from windblown crawlers dispersing from shelter belts in mid and late summer.

Economics

The cost of pest management on a selected group of Hawkes Bay orchards is shown in Table 4. Fruit damage by insects is divided into that from leafrollers and other pests. Leafroller damage was 3-10 fold higher in IFP programmes than in CFP programmes,

while losses due to other insects were approximately three-fold higher in the IFP programme. However, IFP blocks received fewer post-bloom insecticides with an average reduction of approximately 60% compared to CFP blocks. The reduction in insecticide use was reflected in lower insecticide costs, but this was substantially offset by the loss of fruit value in the IFP blocks. This analysis shows that the IFP blocks incurred a marginal financial benefit with respect to the total cost of pest control. However, this analysis does not include potential benefits of reduced pesticide application costs and improved market access for IFP fruit, nor the additional cost of crop monitoring. This was estimated to range from \$150-250 per hectare in Hawkes Bay orchards.

TABLE 4: The cost of insect pest management in selected Hawkes Bay orchards following both integrated and conventional fruit programmes.

Programme and cultivar ¹	Fruit damage (%)		Mean no. insecticides	Insecticide \$/ha ²	Fruit loss \$/ha ³	Total cost of pests (\$/ha)
	Leafroller	Other				
Integrated						
Cox	0.10	0.25	2.5	268	86	354
Gala	0.10	0.47	2.8	283	218	501
Braeburn	0.32	0.34	3.4	328	207	535
Conventional						
Cox	0.03	0.10	6.0	400	32	432
Gala	0.04	0.13	8.0	527	65	592
Braeburn	0.03	0.10	8.7	573	41	614

¹ Blocks of matched programme pairs Cox (n=2), Gala (n=7), Braeburn (n=6).

² Based on 1996 recommended retail prices of respective insecticides

³ Using estimates of fruit yields and fruit values taken from the MAF 1995-96 Farm Monitoring Report

DISCUSSION

Growers in each region participating in this pilot NZ IFP-P programme generally produced excellent fruit quality with low levels of pest damage. They achieved a 35%, 53% and 60% reduction in post-bloom insecticide applications when compared with conventional programmes in Otago, Nelson and Hawkes Bay respectively. Similar reductions were also achieved in Canterbury and Waikato orchards. With the shift to IGRs in NZ IFP-P, the decrease in OP insecticide use was even greater, 88%, 89% and 93% for Nelson, Otago and Hawkes Bay respectively. Typically, 2-3 IGRs were applied, principally for leafroller control and still lower use may be possible (e.g. Otago and Canterbury) without compromising fruit quality. However, codling moth may increase in importance as pesticide use declines, and this may limit these opportunities.

Some pest difficulties were encountered with the programme. Small increases in scale infestation in each region were associated with the close proximity of host shelter trees. The most serious difficulties occurred in Hawkes Bay where unacceptable levels of fruit damage (>2%) occurred in 10% of blocks due to mealybugs, leafrollers or Fuller's rose weevil. The high level of mealybug infestation was biased because some growers entering the IFP programme were previously unable to meet grade standards set for this pest by ENZA despite an intensive OP-based pest control programme. WAA and ALCM populations in orchards can also be expected to rise in IFP programmes. WAA has been readily controlled by natural enemies after two seasons under IFP in several regions (Shaw and Walker 1996; Wearing unpubl. data), but limited use of diazinon may be required for ALCM control.

The IFP programme contains the desirable elements of worker and environmental safety, with significant potential consumer and marketing benefits. Feedback from growers indicated that many liked IFP because they considered its safety better for

themselves and their families. Although the programme produced fruit which was generally impressive for its freedom from pests, damage occurred in a few blocks at unacceptable levels. It will be essential that this risk of fruit loss is managed through an appropriate revision of the threshold responses for these 'escaping' pests. The risk of unforeseen crop loss may also require ENZA to ensure that growers are rewarded for producing fruit to this new environmental standard. There is strong interest for wider adoption of the programme, particularly amongst Hawkes Bay and Central Otago growers. This will require an expansion of support services and personnel to address the needs of growers entering the programme.

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