DEVELOPMENT OF AN IPM PROGRAMME FOR AVOCADOS IN NEW ZEALAND

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Summary
The key pests of avocados in New Zealand are a complex of leafrollers, greenhouse thrips, armoured scale insects and six-spotted mites. As naturally-occurring levels of biological control are not sufficient to prevent pests causing unacceptably high levels of fruit loss, active control, through the use of insecticides, is essential. Until recently sprays have been applied on a calendar basis, generally using broad-spectrum products. However, in 1997 a first-stage IPM system known as 'AvoGreen' was implemented on five avocado blocks in New Zealand. Since that time the programme has been extended to cover blocks on 150 orchards. The AvoGreen programme is a first-stage IPM programme providing pest monitoring services and spray recommendations through field scouts from a commercial company. Specific pest monitoring systems for each of the key pests have been developed and refined over time. Research into the ecology of key pests, biological control and the use of selective insecticides has complemented the IPM programme and new control options will progressively be available to growers in the future.

The pest control challenge and the IPM opportunity

As the avocado industry in New Zealand is predominantly focused on producing fruit for export, growers face the challenge of balancing the potential conflict between meeting stringent phytosanitary standards and internationally acceptable Maximum Residue Levels (MRLs). While some countries are able to produce avocados with very little active intervention in terms of insecticide applications (e.g. Israel and California prior to the introduction of the persea mites and the avocado thrips), it is essential for New Zealand avocado pests to be actively managed. Naturally occurring biological control is not sufficient to meet the phytosanitary standards or to prevent high numbers of fruit being rejected from export due to insect-caused blemishes. Historically, avocado pests in New Zealand have been managed by broad-spectrum insecticides that are applied on a calendar schedule. However, the current pest management approach is far from ideal as the timing of insecticide application is increasingly determined by withholding period requirements rather than periods of pest activity. There is a clear need to develop improved systems for managing pests in New Zealand avocados and the development of an Integrated Pest Management (IPM) system is seen as the most effective way of controlling pests in the longer term.

The term IPM has been used for at least 25 years and most people have a general understanding of the concept. Kogan (1998) defined IPM as 'a decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy, based on cost/benefit analyses that take into account the interests of and impacts on producers, society, and the environment'. Although the concept of IPM includes management of insects, plant diseases and weeds, generally the initial

emphasis is on insect control. There is a continuum of adoption of IPM systems from very simple to advanced. However, all IPM programmes generally have basic components in common irrespective of crop, including pest scouting and action thresholds so that pesticides are only used when scouting indicates a need. As the IPM programme becomes more advanced, there will be a shift towards using selective insecticides to minimise impacts on natural enemies, as well as use of non-pesticide methods of control (e.g. augmentative releases of biological control agents, mating disruption, habitat manipulation etc.). At a more advanced level, IPM systems may incorporate a community-level understanding of the ecology of pest and beneficial insects, predictive models, multi-crop interactions etc.

In 1997 a first-stage IPM programme known as 'AvoGreen' was implemented on a trial basis in New Zealand avocado orchards. Implementation of the IPM system has been a stepwise process with gradual commercialisation of pest scouting systems and control methods, as they become available. This paper describes the key pests of avocados in New Zealand and briefly describes the implementation of a first-stage IPM system.

The pest complex of avocados in New Zealand

The key pests of avocado in New Zealand are leafrollers, greenhouse thrips, armoured scale and six-spotted mites. Pest status of the insects and mites varies from those that are quarantine pests, those causing cosmetic defects and those affecting tree health (Table 1). The significance of the key pests varies depending on geographic location and season, for example, six-spotted mite is only a serious problem in the Whangarei production area. Historically, the focus of spray programmes has been built around different key pests in different regions, for example armoured scale insects have been the key target in the Far North, and leafrollers have been the key target in the Bay of Plenty.

Table 1. The key pests of avocado in New Zealand and the basis of their pest status.

Pest species	Fruit blemish	Quarantine	Tree health

Leafrollers			
Ctenopseustis obliquana (Walker)	✓	✓	✗
C. herana (Felder and Rogenhofer)			
Planotortrix excessana (Walker)			
P. octo Dugdale			
Cnephasia jactatana (Walker)			
Epiphyas postvittana (Walker)			
Greenhouse thrips			
Heliothrips haemorrhoidalis Bouché	✓	✓	✗
Armoured scale			
Hemiberlesia lataniae (Signoret)	✓	✗	✗
Hemiberlesia rapax (Comstock)			
Six-spotted mite			
Eotetranychus sexmaculatus Riley	✗	✓[1]	✓

[1]Although six-spotted mites are classed as a quarantine pest, these mites are not generally found on fruit.

Steps towards IPM

Prior to the early 1990s very little entomological research on avocados had been carried out. Unlike other IPM programmes in New Zealand that have been able to build on many years of underpinning ecological research, the process for avocados had to start with gaining very basic information. The first priority in terms of moving from a calendar-based spray programme towards IPM was undertaking research to gain an understanding of the basic ecology of the key pests in relation to avocados. Information on the seasonal population trends and location of the pests within the avocado environment has been determined as a basis for recommending appropriate spray timing, pest monitoring systems and spray thresholds. Preliminary pest monitoring systems and spray thresholds needed to be developed to allow improved timing of sprays and potential reductions in the numbers of spray applications. Information on the efficacy of selective products needed to be obtained to create orchard environments where biological control had a chance to be successful. The routine use of broad-spectrum insecticides is a serious constraint to future improvements in naturally occurring biological control. There is a logical sequence followed in the development of the components making up an IPM programme (Figure 1). However, the components in the development pathway to IPM are not independent and there is an interaction between the various stages. The boxes in Figure 1 represent the very basic steps and additional boxes could have been drawn to cover habitat manipulation, physical barriers to pests and other influencing factors.

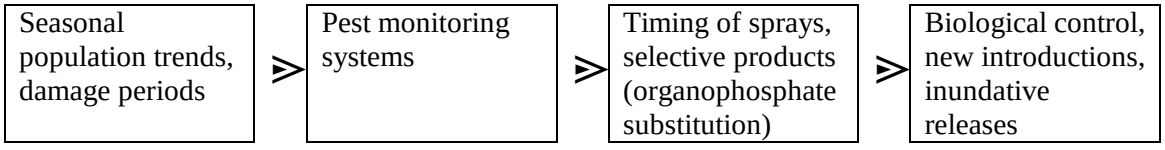

Figure 1. The sequence used to develop an IPM system for avocados in New Zealand.

Although the implementation of AvoGreen initially covered pest monitoring systems for leafrollers, scale insects and thrips, the underpinning research focused on each pest individually. The research initially focused on the leafroller complex as the pest group responsible for most spray applications, and then the emphasis shifted to greenhouse thrips and is now directed at six-spotted mites. Little research on armoured scale has been carried out at this stage.

Leafrollers

The predominant leafroller species damaging avocados in New Zealand is the endemic brownheaded leafroller *Ctenopseustis obliquana*. Most damage to fruit occurs between fruit set in December and early winter and this is the critical time for control measures. While eggs and larvae are parasitised by a range of natural enemies, naturally occurring levels of biological control are not able to keep damage to acceptable levels. Up to 30% of fruit can be rejected from export because of caterpillar damage in unsprayed orchards (Stevens *et al.* 1995). Larval parasitism levels range between 13-17% in unsprayed orchards. The main parasitoids are *Doligogenidia* spp. (Hymenoptera: Braconidae) and *Trigonospila brevifacies* (Diptera: Tachinidae). Both these species are of Australian origin but the feasibility of introducing additional biological control agents from overseas for a native pest species is extremely low. A limited amount of research into the two species of egg parasitoids that have been found attacking leafrollers has been carried out with a view to evaluating the feasibility of inundative releases (Stevens 2000). However, in the short to medium term, control of leafrollers will still be reliant on insecticide applications. However, there is potential to improve the timing of sprays and to substitute the broad-spectrum organophosphates for more selective products.

Under the IPM system being implemented, the optimal timing of sprays for control of leafrollers is determined by a scouting system. Growers are provided with regular information so that they can make informed decisions about the need for a spray application. If a spray is required, the product used will depend on the time of year and the need to control other types of insects. Selective sprays such as *Bacillus thuringiensis* products, the insect growth regulator tebufenozide (Mimic® 70 W), and spinosad (Success™ Naturalyte™) are available for control of leafrollers in avocados.

Greenhouse thrips

Greenhouse thrips (*Heliothrips haemorrhoidalis*) feed on the surface of fruit causing fruit to be downgraded because of scarring. Individual growers may lose as much as 20% of export fruit due to greenhouse thrips damage. Adult thrips begin to be appear on new season's fruit in January and most damage occurs between January and June. It is essential to control adult thrips as these cause approximately six times more damage than larval thrips (Stevens *et al.* 1999). As with leafrollers, AvoGreen scouts provide growers with information on greenhouse thrips populations over the critical part of the growing season. However, there was a need to develop solutions for growers with high thrips populations as there were no selective products available for control. A research programme evaluating new 'soft' products for control of greenhouse thrips in avocados was begun in 1999 (Stevens *et al.* 2000). There has also been a greenhouse thrips

biological control research programme in place since 1992. Initial surveys of greenhouse thrips in New Zealand found no parasitoids so a programme of importation and release was begun. In 1995 a larval parasitoid, *Thripobius semiluteus* Boucek, (see Figure 2) was introduced into quarantine in New Zealand for evaluation of its suitability for release (Froud *et al.* 1996). To release new biological control agents in New Zealand, approval must be gained from the Environmental Risk Management Authority (ERMA). In May 2000 permission to release the *T. semiluteus* was gained and releases were begun in February 2001 in the North Island.

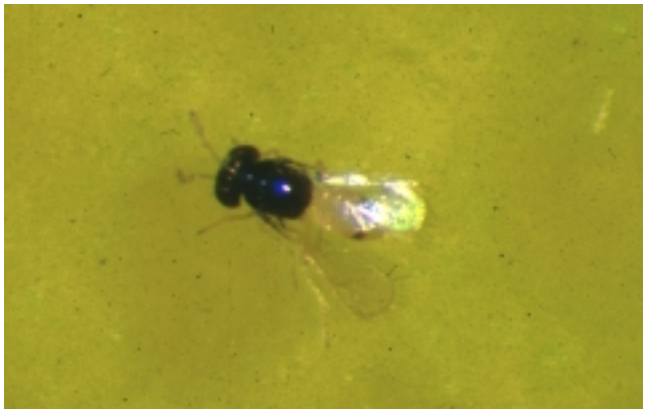

Figure 2. The larval parasitoid of greenhouse thrips introduced into New Zealand.

Six-spotted mites

The six-spotted spider mite (*Eotetranychus sexmaculatus*) is mainly a problem in the Whangarei growing region, although the mite is present throughout the other avocado growing regions. The mites feed on the underside of leaves and in severe outbreaks defoliation can occur. Avocados appear to tolerate only low populations of six-spotted mite feeding before defoliation occurs (Bailey and Olsen 1990). As mite outbreaks in many situations are induced by insecticide applications targeted at other pests, the further development of selective chemicals for other key pests of avocado may help to reduce the significance of six-spotted mites. However, the spray practices used by growers cannot account for the pest status of six-spotted mites in Whangarei when compared to those in other regions. Currently there are no miticides registered for control of six-spotted mites on avocados and, in the short term, there is an urgent need to develop solutions for growers. A number of pesticides are being evaluated in the laboratory for activity against six-spotted mites. In the longer term research will aim to develop biological control of six-spotted mites.

Armoured scale

Latania scale (*Hemiberlesia lataniae*) and Greedy scale (*Hemiberlesia rapax*) are both found on avocados in New Zealand. In the far north growing regions scale insects are the most important pests. The pest status of scale insects has been reduced through negotiations between New Zealand and Australian quarantine authorities. In 1995 the status of latania scale was modified so that no action is taken if present on New Zealand fruit being exported to Australia. However, the presence of scale insects on fruit remains as a cosmetic blemish. In 1987 a research programme evaluating predators for control of scale insects on Kiwifruit in New Zealand was begun. Kiwifruit and Avocado are hosts to the same species of armoured scale so the smaller avocado industry has been able to benefit from information from the more established kiwifruit industry. In 1987 the predatory mite *Hemisarcoptes coccophagus* was released into New Zealand orchards. While it appears that these mites have established in New Zealand, they are susceptible to insecticides being used in avocado orchards. There are no selective sprays registered for control of armoured scale insects on avocado. In the future it may be possible to substitute narrow range mineral oil sprays for organophosphate sprays in some situations, although the effects of mineral oils on tree performance needs to be studied.

Implementing a IPM programme for avocados in New Zealand

A review of essential components in the successful implementation of IPM programmes suggests that success can be improved by institutional cooperation (Norton, 1994). The development of AvoGreen involves a cooperative effort by the New Zealand avocado industry and growers, entomologists, Agrichemical companies, and a company providing pest scouting services. Entomological research into insect ecology commenced in the early 1990s and provided a basis for the development of preliminary pest scouting systems. At the commencement of the 1997-98 season a commercial pest monitoring system was implemented by Fruitfed Supplies Ltd. Initially, HortResearch entomologists provided input into training pest scouts and assisting in the development of a scouting instruction manual. The first season involved monitoring leafrollers, armoured scale and greenhouse thrips on five properties. Since that time the programme has expanded to include 150 properties and the methods used to monitor pests have been refined as experience has been gained. There is a high level of interest amongst growers in the programme and some growers now wish to do their own scouting. Other parties are interested in providing commercial pest scouting services. Although the avocado industry and the commercial scouting company subsidise some of the sites for the purposes of developing and testing new techniques, the programme is provided to growers on a cost-recovery basis. Quick communication of scouting results is a key component of the system with growers being provided with a carbon copy of results and a fax report within 24 hours. To complement the development of a commercial pest scouting service, new more selective products have become available to growers through the investment of Agrichemical companies and the Avocado Industry Council.

In the future it is planed to set up an accreditation system for AvoGreen. Auditing will ensure that commercial operators wishing to provide commercial scouting services for growers under the AvoGreen name maintain minimum operating standards.

The IPM programme currently being implemented in New Zealand avocados consists of using pest scouting to ensure timely applications of insecticides, rather than a fully integrated programme utilising multiple tactics. The programme also focuses on pests within categories (i.e. insects only) with little consideration of multi-pest categories. However, these limitations are common criticisms of many IPM programmes throughout the world (Kogan 1998). Importantly, the system implemented by the avocado industry provides a platform for further developments in the future. The gradual expansion of AvoGreen in a controlled manner allows the system to be further refined and developed without causing serious economic risk to participants. Failure of AvoGreen at an early stage would undermine any confidence in the IPM concept. There will need to be an ongoing process of grower education as well as a period of infrastructure development.

In the future it is envisaged that there will be increased use of selective chemicals and biological control agents. Although there are a number of companies supplying biological control agents in New Zealand, these mostly only supply natural enemies for pests of greenhouse crops. New and innovative systems for providing avocado growers with access to appropriate biological control agents in a cost-effective way need to be developed.

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