9. Smart technologies used to control pests on outdoor vegetables

Outdoor vegetable producers spray their crops with agrichemicals to kill pests that would otherwise reduce the yield and quality of their produce. In the past these crops have been sprayed at regular intervals according to a schedule based on the calendar rather than need. Increasing production costs, and the ability of some pests to adapt to the chemicals used, have caused the growers to adopt smarter and more innovative ways of controlling pests. Equally important over recent years, has been the consumers' desire for an assurance that both fresh and processed vegetables are safe to eat.

Diamondback moth & larva

During the 1970s science became concerned that pests appeared to be developing resistance to pesticides, particularly synthetic pyrethroids and organophosphates. Scientists studied the life cycle of pests and identified the factors that determined their numbers on the target crops. Using this information they were able to construct specific integrated pest management (IPM) technologies to control pests on these crops:

- Vegetable brassicas (cabbages, cauliflowers, broccoli) that suffer frequent pest attacks. Continual use of broad-spectrum pesticides eventually led to poor control of diamondback moth. The sustainability of brassica crop production was threatened.
- For process tomatoes, production costs were the initial driver to reduce pesticide use, but the threat of pests developing resistance to pesticides was also present.

Science has developed integrated approaches to pest control in brassicas and process tomatoes that have enabled growers to adopt innovative practices that:

- reduce the applications of agrichemicals by spraying only when prescribed threshold numbers of pests are exceeded on the crop,
- alternate applications of the different pesticide groups and minimise the risk of the target pest adapting to the sprays,
- use pesticides that will not harm the natural predators of the target pests,
- monitor the resistance of the target pests to pesticides, and
- require regular monitoring of the presence of pests and diseases on the crops.

Diseases are considered in the development of integrated programmes for outdoor vegetables but their control is usually secondary to the need to control insect pests.

Heinz Wattie Ltd. and Cedenco Ltd. have made the IPM programme mandatory for their process tomato growers. Pesticide use is now 90% below the quantities used during the1980s. The IPM programme for brassicas has resulted in an average 50% saving in pesticide use, compared with crops grown under conventional practices. The programme is now used by 80% of growers in the main brassica growing region around Pukekohe, and 96% of growers are using crop scouting to monitor pests.

Failure of New Zealand growers of outdoor vegetables to use IPM systems would have placed the sustainability of process tomatoes and brassica crops at risk. These IPM technologies will reduce the risk of pests becoming resistant to pesticides - something that is causing major problems overseas.

The case study illustrates how the science and industry partnership has resulted in ownership of the outcomes by the brassica and process tomato sectors of the industry. The development of the IPM programmes was begun by science and subsequently led by industry. In future, IPM programmes for these crops will continue to be refined and the technology will be extended to other crops, based on further science information.

1. Background

The most sustainable solution for controlling pests such as insects, mites, disease pathogens, and weeds in vegetable crops is the development and implementation of Integrated Pest Management (IPM) programmes by growers.

The IPM programmes have several common principles:

- a combination of control methods involving biological, cultural, and chemical technologies are used to prevent pests causing unacceptable damage to crops,
- an essential ingredient is for the pest and disease status of the crop to be regularly monitored by the grower and/or consultant scout,
- the grower must be able to supply produce that meets the quality standards of the intended market,
- IPM systems provide an additional benefit of producing vegetables (and fruit) with nil or minimal pesticide residues.

These attributes make IPM technology a unique and valuable option for growers. Adopting IPM, rather than conventional pest and disease control, requires a commitment by the growers, but presents them with a range of control options.

Tomato fruitworm larva

The vegetable industry first adopted IPM technology for growing process tomatoes in Gisborne and Hawke's Bay, and in vegetable brassicas around Pukekohe. For vegetables, the initial benefits of the IPM systems were recognised by the growers and subsequently by the local domestic markets for vegetables. This contrasts with fruit crops, where the driver for adoption of IPM systems was primarily the requirements of the export markets.

IPM programmes have been developed for greenhouse crops, process tomatoes, sweetcorn, vegetable brassicas and potatoes. Development of IPM programmes for lettuces and onions have also started. Problems in these crops have originated from calendar spraying which increases production costs and is compounded by threats to sustainability that arise from the build up of resistance to the pesticide chemicals within the population of pests. The development of IPM programmes takes over 10 years from inception to successful implementation.

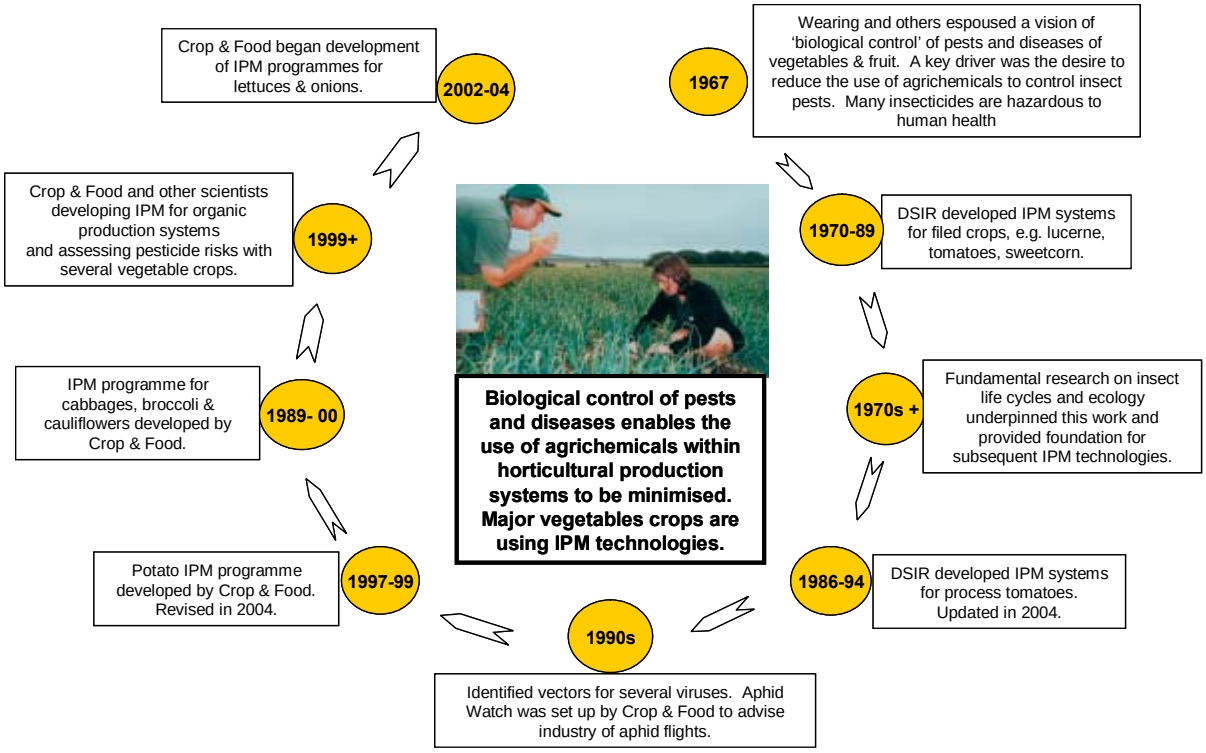
Crop monitoring is a key to the success of the IPM programmes. This practice ensures that growers and/or crop scouts monitor the pests and their numbers on each vegetable crop. The optimum pest control method is selected depending on the presence of natural enemies of the target pest, the cultural control options for that crop, and the prevailing environmental factors that may determine the future activity of the pest. A prescribed pest threshold is determined for each crop species and this value is used as the basis in deciding whether or not to spray. In selecting the pesticide to be used the grower must take account of the need to preserve natural enemies of the target pest, and the requirement to alternate certain pesticide groups in order to minimise the build up of pest resistance.

Introduced parasitoids have increased the success of IPM programmes with vegetable crops. The parasitoids provide a focus that encourages growers to reduce spraying and use selective agrichemicals – a strategy that integrates well with some resistance management practices. In some sectors, such as brassicas, the recognition that

pesticide resistance is a threat to sustainable production has been slow, and a "crisis" had to occur before the development of resistance management strategies were adopted.

Demonstration trials have been a key part of IPM implementation. The adoption of IPM programmes by process tomatoes (1995) and brassicas (2000) growers was assisted by sector launches and the release of grower manuals, industry publications, grower meetings, and access to specifically trained industry consultants.

2. Timeline



The development and implementation of IPM systems for vegetable crops has enabled useful experience to be gathered on the performance of these systems which will be applied to IPM technologies developed for other crops.

3. Science and innovation features:

IPM programmes have initially focused on the most important insect pest problems associated with outdoor vegetable production in New Zealand, i.e. tomato fruit worm (*Helicoverpa armigera*) in process tomatoes, and diamondback moth (*Plutella xylostella*) and white butterfly (*Pieris rapae*) in vegetable brassicas.

These innovative decision support systems for pest management are based on:

- the use of cost-effective field monitoring of the target pests and their natural enemies,
- using previously validated pest thresholds as a key determinant as to the nature and timing of the pest control intervention to be used, and
- strategic use of selective pesticides that will maximise the impact of introduced larval parasitoids.

In process tomato production *Cotesia kazak*, the dominant parasitoid of tomato fruit worm, is well synchronised with the host and kills larvae while still small, preventing

major fruit damage. Other parasitoids have been introduced to complement *C.kazak*. When used in combination with an action threshold that estimates larval parasitism, these parasitoids have led to a 90% reduction in pesticide use.

Vegetable brassicas are sprayed for pests and the frequent applications of pesticides have lead to the development of pesticide resistance. By 1997, the levels of resistance to recommended synthetic pyrethroid and organophosphate pesticides in the diamondback moth had reached a level where pest control failures were experienced in several regions. This over-reliance on pesticides threatened the sustainability of brassica production. To overcome this failure Crop and Food Research scientists were able to develop a successful IPM programme for brassicas. This programme involved

- an pesticide management strategy that required different chemical groups to be used in different seasonal windows, and
- use of selective pesticides that do not harm the beneficial populations of natural enemies of the target pest.

The use of this IPM programme by growers (eg. 80% in Pukekohe) has resulted in an average 50% saving in pesticide applications compared with the former production systems.

Parasitoids are also used in the control of pests on brassicas. New parasitoids are continually being found, such as the recent introduction of the white butterfly parasitoid, *C. rubecula,* which is proving to be superior to the earlier introduced parasitoid, *C. glomerata.* Together with *Diadegma semiclausum* which attacks diamondback moth, these parasitoids attained high levels of parasitism. When used in combination with well-timed applications of larvicides, pesticide applications can be reduced by 75%.

IPM programmes have been developed for potatoes. These aim to overcome the failure of calendar spraying practices to control potato tuber moth, and the development of pesticide resistance in aphids which transmit pathogenic viruses, as well as introducing control measures for powdery scab and late blight. The adoption of IPM systems by potato growers is limited to the exploratory trial areas at present.

Continual innovation is a key element of these IPM systems which have a significant biological control component.

4. Benefits:

Smart use of pesticides in the management of process tomato crops has led to an approximately 90% reduction in pesticide use. Over 90% of the process tomato growers have adopted IPM production systems. Several benefits ensue:

- pest damage is reduced and the quality of the vegetables improved by applying pesticides only when there is a recognised pest problem. Customers pay better prices for quality vegetables with low pesticide inputs.
- using less pesticide reduces the risk of pests developing resistance to a specific chemical.
- spray operators are less likely to develop health problems from pesticides when they work within the IPM programme, because of reduced pesticide use.
- negative effects on beneficial insects (e.g. bees and natural enemies) are minimised under IPM programmes.
- the risk of pesticide residues becoming an environmental hazard is reduced under IPM programmes.

Similar benefits apply where IPM systems are used for growing vegetable brassicas. Growers have benefited from an improved image in their vegetable markets, as well as the gains from reducing pesticide application costs that are estimated to be $125/ha per year.

Reduced pesticide pollution of the environment, less risk of pesticides affecting the health of workers and their families, and value added to the vegetables in the market, are significant benefits, but they are more difficult to estimate.

5. Return on R&D investment:

The return on investment was not evaluated for the IPM programmes on outdoor vegetables because of the difficulty in determining accurately the causal relationship between the IPM innovation and the returns in the New Zealand marketplace.

Key information on outdoor vegetables:
Vegetable brassicas are produced on 3,750 ha and the produce has a farm gate value of over $80 million.

Process tomatoes are produced on 600 ha has domestic sales of $5 million and exports of $2 million.

Onions are grown on 5,500 ha with domestic sales of $25 million and exports of $100 million.

Lettuces are grown on 1,300 ha with domestic sales of $39 million and exports of $1 million.

Sweetcorn is produced on 6,400 ha with domestic sales of $28 million and exports of $54 million, primarily in a frozen of canned form.

Potatoes are grown on 10,600 ha with domestic sales of $300 million and exports as fresh ($12 million)and processed ($57 million) potatoes of $69 million.

Research funding for the development of IPM programmes has been provided by several industry and government agencies: New Zealand Vegetable & Potato Growers Federation Inc. (Vegfed), DSIR, FRST, Agmardt, Heinz Wattie Ltd, Cedenco Ltd, TBG and agrichemical companies.

6. Quotes:

- *"this (IPM) manual is the best thing to happen to the Brassica growing industry in 30 years"* – grower at VegFed launch of the *Integrated Pest Management Manual for Brassicas*, Oamaru 2001.
- IPM has resulted in a *"90% reduction in broad-spectrum pesticide use in process tomatoes."* Alan Kale, formerly Process Tomato Research Manager, Heinz Wattie Ltd.
- *"IPM was cutting edge technology for sustainably managing plant pests and diseases in a way that minimised economic, environmental and health risks."* John Mangan, of Freshco, an Auckland-based produce exporter, who also said *"the issue of chemicals in food was critical to export markets."*

7. Related activities:

Vegfed has combined with the New Zealand Fruitgrowers Federation to implement the NZ Fresh Produce Approved Supplier Programme, which is a proactive move by New Zealand growers to address consumer concerns relating to food safety and quality. An Approved Supplier must be able to demonstrate to customers that their vegetables and fruit are safe to eat, of an acceptable quality and produced in a sustainable manner.

The IPM programmes are an essential management tool for vegetables growers who wish to be Approved Suppliers.

Several other vegetable sectors are developing IPM systems. Many are able to benefit from the experiences of the process tomatoes and vegetable brassicas systems. Although the vegetable IPM systems have focussed on pest management there will be future opportunities to incorporate disease management into many of these programmes.

Future developments of IPM in the vegetable sector are likely to see issues such as soil and water management and fertiliser practices being included within the overall management packages.

IPM for greenhouse tomatoes has been developed to overcome problems associated with routine spraying, and toxicity of the available chemical sprays. The greenhouse whitefly is controlled by the introduced parasitoid, *Encarsia,* caterpillars are controlled by using *Bacillus thuringiensis,* and botrytis is controlled by manipulating the greenhouse environmental conditions.

GROWSAFE® is a training programme which aims to educate users in the safe and responsible use of agrichemicals. It addresses the management, application, transport, storage, disposal and modes of action of all agrichemicals. The programme is overseen by the New Zealand Agrichemical Education Trust.

8. Information sources:

Information supplied by:

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- Graham Walker, Crop & Food Ltd, Auckland.

Other references:

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- '*Implementing of an IPM programme for vegetable brassicas in New Zealand*'. G.P.Walker, P.J.Cameron, 4th International Workshop, 2001,Melbourne.
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This case study is one of a 21-part case study series aimed at demonstrating the value of science and innovation in New Zealand's leading edge bio-science industries... and their significance to New Zealand.

Martech Consulting Group is a strategic consultancy based in New Zealand. The growing**futures** case study series was in part based upon Martech's extensive work with sector representative groups, science providers and organisations that interact with science providers to achieve consensus on co-ordinated actions, improve governance, develop sector-based strategies and improve innovation processes.

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