A decade of integrated pest management (IPM) in brassica vegetable crops – the role of farmer participation in its development in Southern Queensland, Australia

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Abstract
In the mid 1980’s, management of Diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), in brassica vegetable crops was at crisis level with spray failures prevalent across the industry in Southern Queensland. Insecticide resistance to synthetic pyrethroids was identified in 1986, and resistance monitoring between 1988 and 1992 showed that problems also existed with carbamates, organochlorines and some organophosphates.

A resistance management strategy was implemented in 1988 with the widespread support of industry. This strategy resulted in a summer production break, improved spray application, an understanding of resistance and the need for insecticide rotation on farm. Development work with *Bacillus thuringiensis* (Bt), crop scouting, shelterbelts and natural enemies of pests expanded the emerging integrated pest management (IPM) system over the next few years.

A joint project between Australia and China to improve IPM in brassica vegetable crops commenced in 1995. The aim of the project is twofold; to expand the tools base available to growers by investigating critical areas within the IPM system (pest forecasting, monitoring, action thresholds, spray application, natural enemies, decision aids); and to continue industry participation in the development of practical IPM systems, using action learning and adult education principles.

This paper gives an overview of the research, development and extension work with pest management in brassica vegetable crops in Southern Queensland over the last ten years. In particular it discusses the evolution of Integrated Pest Management (IPM) systems in the region and examines the changing role of farmers in developing these systems for managing and avoiding insecticide resistance in *P. xylostella*.

Key words: IPM, implementation, brassicas, Australia

Introduction
The brassica industry of Queensland is worth Aus$24 million, which is 19% of the Australian industry. Eighty percent of the crop is sold on the domestic market, with the remainder exported to Hong Kong, Singapore and Japan (Australian Bureau of Statistics, 1993). The major brassica vegetable crops grown are cabbages, cauliflower and broccoli with Brussels sprouts, Chinese cabbage and other Chinese leafy vegetables being minor crops. A total of 2 300 hectares of brassicas are produced per annum (Australian Bureau of Statistics, 1993). The average property size is 50 hectares.

The major production region is the Lockyer Valley, a river system about 100 km inland. Planting of crops begins in February (late summer) and weekly or fortnightly plantings are made until early spring (September) with last harvests in late spring (end of October). Summer production occurs at higher altitudes further inland in the Granite Belt region. Limited areas of brassica vegetable crops are also grown near the coast, north and south of Brisbane.

A suite of lepidopterous pests attack brassica vegetable crops in Queensland. These include the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), cabbage white butterfly, *Pieris rapae* (Linnaeus) (Lepidoptera: Pieridae), centre grub, *Hellula hydralis* (Guenee) (Lepidoptera: Pyralidae), cabbage cluster caterpillar, *Crocidolomia pavonana* (Fabricius) (Lepidoptera: Pyralidae), cluster caterpillar, *Spodoptera litura* (F.) (Lepidoptera: Noctuidae), and *Helicoverpa* spp. (Lepidoptera: Noctuidae). Aphids can be pests of seedlings or a contaminant of produce but generally do not cause severe damage to the crop.

*P. xylostella* is the most difficult pest to manage, largely due to its resistance to a range of commonly used insecticides, however *C. binotalis* and *H. hydralis* have the potential to cause more significant damage if not controlled in early season crops.

Traditionally, brassica vegetables were grown year round in the Lockyer Valley and growers schedule sprays for pests once per week throughout the production season. Since the mid 1980s when *P. xylostella* resistance to pyrethroids was first reported (Wilcox, 1986) and resistance in carbamate, organophosphate and organochlorine insecticides was identified (Hargreaves, 1994, pers. comm.), Queensland growers have gradually included pest monitoring, *Bacillus thuringiensis* var. *kurstaki* (Bt),
a production break, rotation of insecticides and improved spray application in their pest management regime.

Several factors facilitated this change in pest management practice. Spray failures and crop plough-outs were the trigger for developing and implementing alternative methods of pest management as scheduled applications of insecticides were no longer reliable. Up until the late 1980’s, growers were largely interested in research focussed on efficacy of insecticides, however the control crisis mobilised industry and government to search for alternative approaches to DBM management and all sectors of the industry participated in implementation. The opportunity was also taken to develop an alternative approach to research and extension which did not rely on the transfer of technology extension model (Chambers and Jiggins, 1987). Continued participation by all sectors of the industry was seen as a key to successful implementation of research and development results within the farming system and extension activities were structured using the concepts of action learning (Kolb, 1984; McGill and Beaty, 1992; Heisswolf, 1995) and adult education (Brookfield, 1986; Tennant, 1991).

The progression of IPM in brassicas in Queensland can be divided into three discrete but overlapping projects.

- **1988 to 1990** – Development and implementation of an insecticide resistance management strategy based on rotation of insecticide groups by exclusion. Techniques which developed from this strategy included a production break, pest monitoring and improved spray application.
- **1990 to 1995** – A project designed to reduce reliance on conventional insecticides by focussing on the cropping systems level of pest management and introducing Btk into the developing IPM system.
- **1995 to 1998** – This project builds on the existing IPM system and includes research, development and extension components.

**Materials and Methods**


The initial response to the crisis caused by insecticide resistance in *P. xylostella* was the development of a resistance management strategy based on rotation of insecticide groups. It was used in three valleys in South East Queensland, hence its name, the 3 Valley Strategy. The strategy was launched in August 1988. It was developed by a small group of people from various organisations and the concept for the strategy received widespread support from all sections of the industry including local growers, agrichemical companies, pesticide resellers and crop consultants. Its primary objective was to reduce the rate of increase of insecticide resistance in *P. xylostella* and *Helicoverpa* sp. by asking growers to voluntarily exclude a particular insecticide group from use in particular months of the year. The strategy was aimed at all primary producers in the region (Deuter, 1989).

A logo for the strategy was developed and pesticide resellers were asked to colour-code insecticide containers according to insecticide groups. A series of articles was published in the local media and extensive publicity about the strategy was maintained for two years after its launch. (Deuter and Twine, 1988; Deuter, 1989). Growers meetings and insect identification workshops were held to encourage grower adoption of the strategy (Deuter, 1989).

Operating costs for activities were shared by industry and organisations involved in promoting the strategy.

A survey to determine the level of adoption of the strategy was conducted in 1990. Data was gathered using a questionnaire to interview four groups of people; broccoli growers, local pesticide resellers, crop consultants and company field officers (Heisswolf, 1992).

**Reducing reliance on conventional pesticides (1990 to 1995)**

The second project aimed to further reduce reliance on conventional insecticides by developing alternative pest management techniques within an IPM framework and focussing on the cropping systems level rather than the individual pest level. Research and extension activities involved a series of demonstration plantings at a local research station and on commercial farms in the Lockyer Valley. This work was funded by the vegetable industry, state and federal governments. Unsprayed plantings of brassica vegetables were also established to collect data on the abundance of pests and beneficials over three seasons and insecticide resistance levels in *P. xylostella* continued to be monitored.

Thirty-six demonstration plantings were established between 1990 and 1993 at the local research station and over 50 commercial brassica plantings were assessed on farm from 1992 to 1995. Data collected included pest activity, yields and quality of harvested product. Results were used to recommend improvements to the farmer’s pest management regime with particular emphasis on spray decision making. Apart from the intensive work with grower cooperators, farm walks and field days were used to demonstrate results in commercial crops. Numerous articles were also published in local media and industry publications describing project progress and recommendations from this work.


The third project aims to build on the existing IPM system. It includes a research and development component which focuses on problem areas such as insecticide spray coverage, pest monitoring protocols, action thresholds, natural enemies particularly parasitoids, and development of decision-making tools. The project also includes an implementation component with emphasis on extension methodologies useful to IPM implementation.
The project commenced in July 1995. It is a collaborative research and development project between Queensland and China funded by the Australian Centre for International Agricultural Research (ACIAR). Objectives for the Queensland component of the project evolved from a problem definition workshop (Deuter and White, 1995) held by the Cooperative Research Centre for Tropical Pest Management (CTPM) at which farmers, consultants, scientists, extension staff, industry, chemical company staff were represented.

A team approach was adopted with team members holding skills in entomology, taxonomy, pesticide application methodology, extension and IPM development. The broad skills base of the team should contribute towards a systems approach to IPM in brassica vegetables. The process also encourages considerable grower contribution to the project with their views playing a significant role in determining the direction of research. Industry participation is encouraged through on farm trial work, collaborative planning and conduct of trial work and field days using adult education and action learning principles. These principles have also been used to structure six monthly review meetings of the project team.

Results
The Resistance Management Strategy
An evaluation of the 3-V strategy two years after development revealed that within the first year, 70% of broccoli growers had used the strategy; but 12 to 18 months later this implementation rate had dropped to 35%. Key factors for achieving a relatively high rate of adoption were extensive publicity and industry support. Factors leading to the decline of the strategy included a perceived inflexibility of the strategy, and a lack of continuing publicity. It is important to point out that of the 35% of farmers who continued using the strategy, most had adapted the strategy to suit their particular farming enterprise (Heisswolf, 1992).

The evaluation also showed that by 1990, farmer and industry awareness of responsible insecticide use and pest management techniques such as a break in production over summer, improved spray application, pest monitoring and strategic applications of Btk had increased (Deuter et al., 1992).

Reducing reliance on conventional pesticides
Monitoring of resistance of a range of insecticides from 1988 to 1992 showed that *P. xylostella* was relatively insensitive to methomyl, carbaryl and endosulfan and as a result the organochlorine and carbamate groups of insecticides were no longer recommended. An apparent stabilisation of resistance levels occurred in permethrin after the introduction of a summer break in 1990 (Heisswolf and Hargreaves, 1994).

Demonstration plantings showed that brassica vegetable production with significantly reduced input of conventional insecticides was possible using pest monitoring and Btk. This system minimised hazardous effects on natural enemies and farmers became more aware of predators and parasites in their crops. Since 1990, the use of monitoring and Btk by Southern Queensland brassica vegetable growers has increased substantially (Deuter et al., 1992) indicating that demonstration plantings, field days, on farm trial work, availability of decision aids and continued publicity about IPM have been successful tools for implementing new pest management practices.

By 1995, the focus had changed from scheduled spraying of conventional insecticides to a more complex system which combined a range of pest management techniques. These include:
- cultural control methods (production breaks, crop hygiene),
- crop monitoring to improve decision making,
- strategic applications of insecticides (biological and conventional),
- protection of local natural enemies by using pest specific insecticides whenever possible

Improving IPM in brassicas
The successful implementation of IPM techniques discussed above has led to a receptive environment for integrating research results from the ACIAR project into the existing pest management system. Close interaction with farmer cooperators will continue to be critical in refining IPM systems at the farm level and for highlighting specific research needs and implementation constraints. Grower cooperators are more proactive in their approach to pest management and are actively involved in assisting the ACIAR team realise project milestones.

Discussion
Much has been written in the past few years about the transfer of technology (TOT) model of extension and its limitations in implementing complex systems or concepts such as IPM. Tait (1983), Chambers and Jiggins (1988), Vanclay and Lawrence (1994) state that the traditional TOT model relies on a top down approach in which scientists develop methods and technologies which are disseminated by extension agencies for adoption by farmers; and that this extension model is inappropriate in many instances. Petty (1994) argues that participative methods of enquiry are required to develop sustainable farming practices so that local people are able to develop farming systems which suit their particular needs and conditions. A respect for knowledge, experience and expectations of farmers is considered critical for participatory research and extension (Chin et al., 1992; McDonald and Glynn, 1994).

Traditionally the main barriers to adoption were considered to be farmer attitudes and lack of knowledge rather than logical decision making by farmers on the usefulness of a particular technology (Vanclay and Lawrence, 1994) but it appears that that the reasons for non adoption are more complex.

A recent survey of crop consultants in the United States indicates that lack of viable nonchemical tactics, potentially lower yields and quality, higher costs, need
for higher management skills and lack of information are the major limitations of IPM adoption (Ferguson et al., 1996). Tait (1983) suggests that poor marketing of research products is a contributing factor in non adoption of IPM and survey work by Wearing (1988) showed that an IPM program must be marketed and adapted to suit local conditions in an effort to compete with pesticides.

Lack of a crisis with existing pest management techniques is also listed as a major obstacle to IPM implementation by Wearing (1988) and Vancclay and Lawrence (1994) outline several additional factors which lead to resistance or reluctance to change including conflicting information, loss of flexibility, complexity and/or incompatibility with other aspects of farm management and personal objectives.

Over the past decade, our approach has been to actively encourage industry participation in combating the insecticide resistance problem. The process of developing IPM systems and appropriate extension processes has been evolutionary and highlight the importance of the issues discussed above.

The development of insecticide resistance in DBM and resultant spray failures and crop plough-outs in the late 1980's provided the necessary crisis and accelerated the search for alternatives to insecticides. Resistance management became a priority not only for government but industry and farmers who were unable to rely on their usual pest management technique; scheduled applications of insecticides. Resistance management became a priority not only for government but industry and farmers who were unable to rely on their usual pest management technique; scheduled applications of insecticides. This, combined with industry and farmer involvement in developing the strategy provided a receptive environment for implementation.

The review of the strategy in 1990 highlighted the importance of marketing. Widespread support of the strategy combined with an aggressive publicity campaign placed additional pressure on farmers to consider the strategy as an appropriate part of their pest management system. As publicity and industry support for the strategy decreased, farmer usage also decreased, with lack of flexibility given as a major factor in discontinuing use of the strategy (Heisswolf, 1992).

By this time, additional techniques which evolved from the strategy were being utilised, including a summer production break, improved spray application and pest monitoring. Industry and farmers had adapted the strategy to fit their farming systems. IPM technology is not static but must be modified and improved as new management tools become available (Chin et al., 1992).

The demonstration plantings and on farm trial work from 1990 to 1995 promoted the strategic use of Btk and pest monitoring under commercial conditions. From a farm management point of view, Btk use is not radically different from conventional insecticides – both are applied through spray equipment – although Btk requires higher managerial skills to achieve comparable results. Btk was in a good position to compete with conventional insecticides. A concerted marketing effort by Btk suppliers and participatory on farm trial work demonstrating the Btk/monitoring system were key elements in achieving adoption of these two techniques. With reduced input of conventional insecticides, natural enemies were seen more frequently in crops and farmers became more receptive to methods which would help protect natural enemies and further decrease insecticide use.

The participatory problem specification workshop (Deuter and White, 1995) in 1995 assisted in the development of the ACIAR project and utilised farmer and industry knowledge and experience. Farmer participation will continue through the use of adult education and action learning to plan and conduct on farm trial work and field days. This will ensure that a two way flow of information and ideas between the project team and industry occurs throughout the life of the project.

The future holds many challenges for IPM in brassica vegetables in Southern Queensland. Research and extension efforts are seen as one source of information for improving IPM systems and participatory processes will enable the project team to tap into farmer and industry experience and so remain responsive to changes in farmer needs. Participatory processes ensure ownership of problems and opportunities and provides a mechanism for contributing towards solutions.

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References


