IPM Overview –the key elements of sustainability

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What is IPM?

Perhaps the best way to answer this question is to firstly define what is meant by an integrated pest management (IPM) program. Basically an IPM program should;

1. Provide effective control of the pest complex
2. Reduce reliance on synthetic insecticides
3. Be economically viable
4. Be simple and flexible
5. Utilise compatible control measures
6. Be sustainable
7. Have minimal harmful impact on the environment, the producer and consumer.

Agriculture continues to change in response to the needs of society (Dent, 1995). The development of IPM is often explained as a response to problems facing farmers that result from overuse of insecticides, such as pesticide resistance and secondary pest outbreaks. However, increasingly the development of IPM reflects the expectation of society for pest management systems that do not degrade the environment or cause health problems. *The primary aim therefore of IPM systems is to reduce reliance on synthetic insecticides.*

There are relatively few well-documented highly effective IPM systems. Those that do exist have behind them a strong incentive – usually economic, but sometimes social, that has provided the catalyst for change. The economic incentive can come from a high cost of control, relative to the value of the crop, or due to resistance and the two are often linked. Social incentives often come in the form of strict legislation to prevent off-farm movement of pesticides, in response to community concerns, or could come in the form of consumer demand for a particular type of produce, ie organic.

What makes an IPM program successful

A review of all of the factors that contribute to the development of a successful IPM program would be very long and take into account a wide range of issues such as research paradigms, socio-economics, psychology, modelling and much more. In this short review however the focus is at a more practical level, with emphasis on the Australian cotton system. There are perhaps two foundation components to a successful IPM system. The first is the development of the system itself, that is the tools and techniques and the ways they are combined, and secondly the implementation of the system within the farming community.

The development of an IPM system requires intensive research to define the problem pests, to investigate their ecology and population dynamics and to develop or test options for control. Such research is most effective when undertaken by a scientist with specific training or experience in the relevant area, who is in turn part of a multi-disciplinary team. However, as most crops experience a myriad of interacting pest problems it is essential that the research be put in context of the farming system. This requires inter-disciplinary research where each scientist also has to be aware of the work of others so that it is integrated into the solution of the problem (Dent, 1995). It is possible for a scientist or small group of scientists to development the foundation of an IPM system, but they will need to call on the expertise of others to integrate it into the farming system.

The second vital element is to have the system implemented in the field. This requires a good team of extension personnel with effective links to both farmers and research. At this point it is pertinent to ask "who is the system for?". It is vitally important that the implementation of IPM is grower driven, as this is the group paying the bills and ultimately making the decisions about what pest management approach they want to use. IPM tends to be more complex, and a "participatory research/ participatory implementation" model for implementation is appropriate (Dent, 1995). In this model the on-farm trials are used by the grower, extension personnel and scientist to provide constant feedback, in both directions, to identify and correct problems within the system.

Is IPM achievable in Australian Cotton

In the Australian cotton system there are a number of very strong drivers for the adoption of more sustainable pest management approaches. These include;

- Community concerns over the impact of pesticide spraying on their health and that of the environment
- Legislation to prevent off-farm movement of pesticides, contaminating cattle and waterways
- Increasing costs and decreasing efficacy due to resistance in pests, both primary (Helicoverpa) and secondary (mites and aphids)

The common theme in these drivers is the over-reliance on synthetic pesticides as the primary means of pest control. Can we use IPM systems to reduce reliance on synthetic pesticides? The short answer to this question is yes. The first fundamental component, the development of an IPM system, is already available and documented in the Integrated Pest Management Guidelines of Australian Cotton and associated supporting documents (Mensah and Wilson, 1999). These guidelines emphasise a systems approach to IPM, especially focusing on 'off-season' activities that can influence the success of IPM through the growing season. The guidelines are derived from both research and on-farm experience of growers and consultants. The basic tools and techniques to achieve IPM are available now, although there is a need for more tools and techniques to give a greater choice for growers in

some situations. The guidelines are a living document which will be revised and improved as more information becomes available, for instance the recent publication of the 'Spring Trap Crop Management Guidelines' (Ferguson et al., 2000).

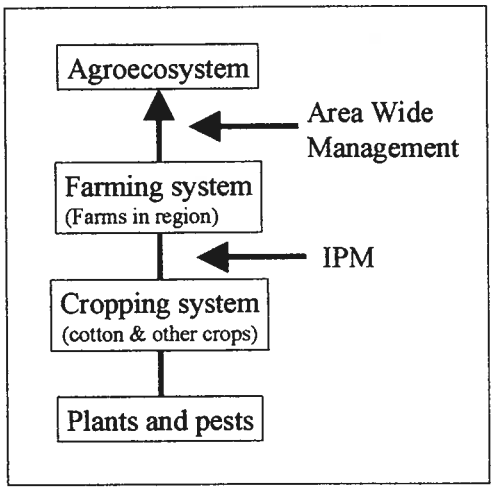
The second fundamental component, implementation, is gradually improving. Industry development officers are testing out components of IPM such as damage and pest thresholds. Many growers are conducting their own IPM experiments, in conjunction with their consultants, to gain confidence in the concept. There are already clear examples of IPM approaches that have significantly reduced reliance on synthetic insecticides. The IPM system developed by Dr Robert Mensah puts reliance on natural mortality factors and biological pesticides with intervention using synthetic insecticides as a last resort (see paper by Mensah and Singleton elsewhere in these proceedings). Dr Mensah's system uses lucerne strips inter-planted in cotton as a nursery for beneficials and a trap crop for the green mirid (Mensah and Khan, 1997). He uses a predator to pest ratio to determine if predators will provide control of *Helicoverpa* spp or if supplementary action is required. Envirofeast® food sprays and/or manipulation of the lucerne (by mowing) is used to attract or to force predators into the cotton crop, thereby adjusting the predator to pest ratio (Mensah, 1997). Selective biological or synthetic sprays are used as a backup.

Increasingly there are also success stories emerging from industry where innovative growers and consultants have adopted elements of the IPM guidelines. A recent example of this is the IPM system being established in the South Burnett by Matthew Holding and the growers he works with. By adopting a range of IPM tactics, especially preservation of beneficial insects these growers reduced insecticide costs from $700/ha in 1997-98 to $350/ha in 1998-99 (Holding, 1999). Such success has also occurred in the larger cotton regions. The area wide management group set up in the Bates Scheme south of Goondiwindi has achieved considerable success using a 'soft insecticide' approach, which has generally resulted in higher profit with less hard synthetic insecticide use over the past two seasons (See paper by Hoque, Farquharson, Dillon and Kauter in these proceedings).

Are IPM and area wide management compatible

IPM is an approach that a grower uses to manage pests on their own farm. For pests that are more mobile and particularly those with a broad host range such as *Helicoverpa armigera*, an area wide approach may also be appropriate. Area wide management (AWM) allows co-operation between growers to address the pest problem in a way that would not be effective if each grower did their own thing. Essentially, area wide management has focussed on *H. armigera* because this species is resistant to most older chemical groups and becoming resistant to some newer groups, and is the major pest of cotton and other crops in the regions. The two concepts are therefore complementary of

each other (see paper on AWM by Murray, Miles and Ferguson elsewhere in these proceedings). A conceptual model of the position of AWM is given below.



What are the main challenges for IPM in Australia's cotton areas

There are a number of challenges that confront the industry. Some of these relate to the need for new technology to assist the development of IPM. For example the availability of bio-pesticides and selective insecticides to support IPM has been quite limited until recently. However, in reality no matter how many tools and techniques are available there will always be a demand for more. The provision of tools and techniques is very important, but alone will not increase adoption of IPM. Growers need to gain confidence in the tools and techniques. To achieve this they need to give IPM a try, which means a change in mind-set from seeing insecticides as the core of pest management to seeing them as one tool in the system. A significant challenge for the cotton industry to make a change in mind-set from viewing IPM as a researcher concept that is not the mainstream, to viewing IPM as the mainstream industry standard. This would foster commitment to the concept of IPM.

The issue of IPM adoption within the industry has been raised many times and researchers and extension personnel have reviewed reasons for poor adoption. In reality these groups can foster an environment where IPM can be tried, by providing information and working with growers, but no-one can enforce adoption. In the short term the easiest way to manage pests is just to spray with insecticide, but is this sustainable. Ultimately it is up to the grower to decide that they are not satisfied with their current management and want to try an IPM approach. Some growers have made this decision and are committed to it. This is what is needed throughout the industry – a deeper understanding and commitment to the principles of IPM. Education can go a long way to fostering this change (see below). The current implementation of Best Management Practice (BMP) throughout the industry provides a timely vehicle or framework to assist this shift in attitude. As BMP moves

progressively towards an environmental management systems approach, more and more elements of IPM can be incorporated and formalised as industry best practice.

At present our pest management system does embrace many components of IPM, including sampling, thresholds, pupal control, compensation and use of selective insecticides. However, our basic pest management strategy still largely revolves around the use of insecticides as the basis for control. Apart from the environmental and community concerns that this approach raises, there are problems emerging with resistance to newer chemistry. For instance resistance to Tracer has emerged after three seasons of use with a restriction of 3 applications per season! How long will Tracer last, how long will other new chemistry last?

IPM and integrated resistance management (IRM) are highly complementary. IPM seeks to reduce use of synthetic pesticides, which is one of the most effective ways used in IRM to manage resistance. However, IPM and IRM are quite different in their primary aim. IPM seeks to reduce use of synthetic insecticides and incorporate as wide a range of other tools as possible to manage pests. IRM seeks to manage insecticide resistance, but does not account for impacts on beneficial insects or environmental risk. What is our goal, to build a sustainable pest management system or to manage resistance?

The two concepts are however not mutually exclusive, an outcome of IPM is reduced use of insecticides which is a primary means of reducing selection pressure, so in a sense both IPM and IRM have some common goals. A major objective in the development of IRM is that it should not be an impediment to IPM. The recent removal of pyrethroids and carbamates from Stage 1 of the Insecticide Resistance Management Strategy is a move in this direction (Holloway et al., 2000b).

A range of new products is coming along in the next few years. Are we going to see this as a sign that the chemical pipeline is never-ending, though increasingly expensive, or do we see the situation with Tracer as a cautionary story about how quickly our current system selects for resistance? Are we simply going to substitute the new chemistry for the old, or are we going to reduce the need for intervention with insecticides in the first place? Many of the newer insecticides offer greater selectivity than the old chemistry. Are we going to make use of beneficials in the system and include them in decision-making, or simply continue to spray on thresholds that are often significantly below the levels that cause economic loss? These are hard questions but we need to ask them. Researchers and extension personnel can talk about IPM until they are blue in the face but this will not convert growers to IPM unless the growers have the will to change.

Those growers and consultants practicing IPM often say that the greatest hurdle is to keep IPM going once pyrethroid use begins in the region. Where growers and consultants have been able to delay or avoid application of a pyrethroids and have not been affected by drift from neighbours they have been able to extend IPM further into the season. This has been one of the main drivers for establishment of

area wide management groups; delaying the use of pyrethroids across an area for greater impact in terms of preserving beneficials. It is ironic that we have put so much effort into preserving the efficacy of this insecticide group, yet they are represent one of the most significant impediments to IPM systems.

What is needed to have a sustainable IPM program

Support – education and training

Education of growers about the principles of IPM will undoubtedly improve understanding of the concept in theory and practice. Greater understanding could then provide more confidence to increase adoption. In a real sense the adoption of IPM is probably easier for newer growers or consultants than for those who have experienced the earlier era of highly effective insecticide based pest management. The development of the IPM Short Course for growers (to be launched next winter) will go a long way to achieving this goal. Similarly the Australian Cotton CRC's Cotton Production Course, run by the University of New England, is providing formal training in IPM for consultants and agronomists.

Tools and techniques

Although the components of IPM systems are already available there are a number of tools that would provide greater choices for growers and consultants at decision points. These include the availability of more selective efficacious control options, especially those that are relatively benign in the environment. In recent years much has been made of the selectivity of the new chemistry. In reality most of the new chemistry is more selective than the older chemistry (carbamates, organophosphates and pyrethroids), but nevertheless most of these compounds do have a significant negative effect on some elements of the beneficial fauna (Mensah and Wilson, 1999 & Lytton-Hitchins, 1999 #41). Provision of information on such impacts is an ongoing and essential component of IPM. Complementary to this we need to continue to develop our understanding of the role of beneficial insects in managing pests and to understand the ecology of the beneficials so that we can manipulate the system to enhance their contribution to IPM (see paper by Schellhorn, Manners and Fitt elsewhere in these proceedings). Access to cotton crops that are not affected by insecticides or insecticide drift in which to conduct basic ecological research is an issue for researchers.

Among the options for selective controls is Ingard® cotton. In the portion of the industry in which this technology has been used (10-25%) this technology has so far led to reductions of 40 to 60% in insecticide use compared with conventionally managed cotton – by far the biggest impact of any single technology to date (Pyke and Fitt, 1998). The use of the improved Ingard® varieties available in the 2000-2001 cotton season will provide an improved platform on which to build IPM. In the future the two-gene Ingards will significantly extend this trend as discussed in detail in a paper by Dr Gary Fitt elsewhere in these proceedings. Recent research also suggests that the efficacy of selective biological and synthetic insecticides may be more robust on Ingard varieties than on conventional

cotton (Holloway et al., 2000a). Ingard® is not essential to IPM, but it makes the process a lot easier to manage (Wilson et al., 1998).

Area wide management and the use of trap crops is an area with much promise for improving management of *H. armigera*. This is an area of burgeoning interest within the industry and has been embraced by groups in several areas as a mechanism for improving communication and collaboration between farmers, both from cotton and other industries.

Understanding the capacity for compensation in the cotton plant is also crucial in development of IPM. The cotton plant has a remarkable capacity to recover from damage. Often the degree of recovery has to be seen to be believed. Work by Dr Tom Lei is extending the boundaries of our understanding of compensation (see paper elsewhere in these proceedings). Experiments run by the Cotton CRC Industry Development Officers are extending compensation research to all major regions. In the future the capacity to predict compensation using crop models will provide greater confidence in allowing some pest damage to occur and to reduce insecticide use.

The industry needs to continue to invest in new tools that can assist with IPM. This can involve new approaches including semiochemicals (long and short range behaviour modifying compounds, such as the attractants being developed by Prof Peter Gregg and Dr Alice Del Socorro of the CRC), petroleum spray oils, myco-insecticides or foodsprays. Innovation is sometimes also a matter of serendipity. The recent research using wheat stubble to reduce erosion and transport of insecticides off-farm, undertaken by Dave Walters at DNR Emerald, has had an unexpected side effect of reducing early season pest pressure from *Helicoverpa* spp.. Growers in some areas have been quick to test and develop this concept and research is helping to define the fit of this technology into IPM.

Risk and attitude

At a recent industry meeting a leading cotton grower (who shall remain nameless to protect the innocent – me) remarked that the industry perceives IPM as more risky than current practice (pesticide reliant). However I would argue that risk depend largely on your perspective. For instance a grower may apply an insecticide early in the squaring stage to control tipworm. This he/she perceives as reducing the risk of yield loss or delay which may in turn increase late season pest control costs. However, experiments over the last 10 years have shown repeatedly that the control of tipworm with a broad-spectrum insecticide will reduce beneficial abundance. This increases the survival rate of *Helicoverpa*, increasing the risk of yield loss and need to control this pest. It also increases the risk of outbreaks of spider mites and associated risk of yield loss and control costs. For both *Helicoverpa* and mites there is then increased risk of selection for resistance and off farm movement of insecticides. So, what is most risky, tolerating some tipworm damage, or controlling the tipworm? The IPM guidelines address issues such as these by looking at both pest abundance and plant growth – in this case tip damage and fruit retention levels.

Another issue for the cotton industry is the emphasis on yield as the final measure of success of a pest management approach. This is truly shortsighted and is at the heart of some of the folklore that IPM is more risky. In fact, even if we take such a short-term view, we should emphasise and focus on returns (gross margins or profit). A grower may yield less than his neighbour, but also spend less on pest control and come out ahead in terms of gross margin per ha. The recent analysis of the inputs and returns for the AWM group south of Goondiwindi amply demonstrates this point (see paper by Hoque, Farquharson, Dillon and Kauter elsewhere in these proceedings).

The future

The tools and incentive to shift the industry to more strongly IPM focussed systems are there and the framework for progressive adoption through BMP is also there. Increasingly there are reports of growers undertaking an IPM strategy on all or parts of their farms, almost always with positive results. The cotton industry is characterised by its cohesiveness, good communication, fast uptake of new technology and innovation. There is no reason why IPM should not become the future for pest management in our industry.

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