ALTERNATIVES AND CONSEQUENCES

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INTRODUCTION

The problem of the high reliance on the use of synthetic insecticides for the control of *Heliothis* in Australian agriculture has led to a number of attempts to investigate the feasibility of alternative control technique. These problems have traditionally centred around the issues of insecticide resistance, environmental contamination and the adverse effects of the insecticides on a number of non target species, namely the beneficials, pollinators and wildlife. In recent years however, there has been a further change in society's acceptance of the use of insecticides in general.

Numerous alternative control techniques have been available in various forms for many years. Unfortunately none of these alternatives have been regarded as practically or economically viable. Obviously such a statement results from a comparison of these alternatives to the extremely effective, quick and cheap control provided by insecticides. Now that the resistance situation is beginning to develop further and the acceptance of insecticide use is being questioned, the comparison between insecticides and the alternative techniques becomes much closer.

POSSIBLE CONTROL TECHNIQUES

The following alternative control techniques are discussed in terms of their applicability to the control of *Heliothis* in agricultural and horticultural crops:-

1. Microbial control

There are quite a number of organisms which have been recorded as infecting the *Heliothis* group and some of these have been developed as commercially available options for *Heliothis* control. Most noted amongst these are the viruses, bacteria and (to a lesser extent), the fungi. Commercial formulations of the virus and *Bacillus thuringiensis* have been available for over 20 years in Australia and their acceptance in most cropping situations has been extremely disappointing. Several of the earlier formulations of these products definitely lacked the stability that was regarded as an essential characteristic of a good insecticide.

They also lacked an acceptable speed of kill. More recent formulations have not only addressed the specific infectivity of the organism but have paid more attention to the stability of the formulation.

The future for microbial control lies in the manipulation of the agent itself. Through a range of techniques a number of companies are looking at the production of strains of the organisms with potencies above those of the earlier materials. Such an increase in potency obviously should help in the limitation caused by the rapid decline of the organism under field conditions. Further options are provided by the addition of the synthetic insecticides to the microbial insecticides so as to overcome the problems often encountered with the significant delay to kill, or the size of the target larvae.

Not the least issue to be addressed in the use of microbial insecticides for *Heliothis*, must be the problem of farmer education in the use of these products. Microbial insecticides probably offer the next best alternative to the use of synthetic insecticides for *Heliothis* control. They provide a comparatively quick kill and are comparable to the traditional "squirt gun" approach. For this reason alone they should not be dismissed. Unfortunately these products differ dramatically in their critical characteristic to the traditional insecticides and an appropriate educational programme will be required for their successful development in our cropping systems.

2. Host Plant resistance

The traditional techniques of host plant resistance have been employed in the development of a number of plant types conferring some degree of resistance to the *Heliothis* group. These plants include tomatoes, cotton and some of the grain legume species. Whilst sources of resistance to the *Heliothis* group have been identified in each of the crop species, and appropriate bioassay techniques have been developed, there is still a considerable way to go in the application of this research to commercially viable plant types.

Another opportunity with this work lies in the manipulation of the toxins associated with microbial agents into the genetic structure of the plant host. The advancement in the technologies available to this approach is leading to the realisation that, the development of plant types offering an enhanced inherent resistance to the *Heliothis* complex is not too far away.

Several arguments have been developed in the literature as to the problems of pursuing such a course of action. Data gathered to date using the *B. thuringiensis* toxin in tomatoes has clearly indicated the development of a 80 - fold resistance to the toxin after only 12 generations of selection on appropriately engineered tomato plants.

Obviously the retort to such work can propose a multitude of strategies to minimise such resistance developing. The grim reality is that the target species group has an excellent track record of compensating for the action of the many xenobiotics which have been placed in its way. It would be comforting to believe that the manipulation of such seemingly "natural" agents would render the system immune from these concerns. Such proposals should not be developed without appropriate debate.

The use of plant types conferring a significant level of inherent mortality is an ideal option on which other ecologically sound and economically attractive alternatives can be superimposed. For this reason alone further advances in host plant resistance work, particularly where the resistance characteristics are based on morphological and non preference types, should not be underestimated.

3. Pheromones

The use of the male confusion techniques for the control of the *Heliothis* complex has been addressed on a number of occasions. Historically however, the work has not been very productive. There are a number of measures for this, not the least of which is the accurate identification and understanding of the functionality of the numerous components of the pheromone system of the *Heliothis* species.

The real value of this technique is only realised in a situation where the migratory activity of the target species is somewhat limited, and the controls can be developed over a significant portion of the target area involved. The problems of dispensing the pheromone have been addressed by a number of workers in the field. There are an array of delivery systems available and their appropriateness to specific cropping systems would have to developed for each.

4. Autocidal control

The success of the inherited sterility factor defined between *H. subflexa* and *H. virescens*, has opened the way for the investigation further of such options for the autocidal control of other species in the complex group. To date no other such crosses have been established although the array of reciprocal crosses (perticularly between *H. armigera, H. punctigera* and *H. zea*) needs to be completed after appropriate quarantine arrangements have been finalised.

Very little data have been developed in the search for alternative sterilisation options. However, despite the method of sterilisation, the technique requires a mass production system for *Heliothis* before it could be regarded as a serious alternative option for *Heliothis* control. *Heliothis* production costs are commonly regarded as being so high as to limit the successful development of this line of *Heliothis* control.

5. Behaviour modifiers

There are two general areas of semiochemics which offer potential for the control of *Heliothis*. The first of these lies in the development and use of the semiochemics involved in the host or prey selection process. To date very little effort has been directed to the identification of the processes by which the pest species identify their hosts, and by which a particular parasitic species locates and identifies its prey. What data are available in this field certainly indicates the role of chemical cues in both processes, although the relative significance of such cues compared to the more physical aspects of the environment and the ways in which such cues can be modified will need to be the subject of further evaluation, before any alternative control options are developed.

The second area of interest is in the area of feeding stimulants for both the adult and larval stages of *Heliothis*. Some effort has been expended in the past to investigate the attractancy of hosts to the adult, however it is in the larval stage where considerable advances in our understanding of the processes involved would enhance the potential for the use of stomach poisons, and particularly the microbial insecticide group.

6. Biological Control

Only about 1 in 3 attempts at biological control of an insect pest species have been regarded as having some successful outcome. For the control of pest species in field crops the success rate is somewhat lower. For *Heliothis* it has been recognised for many years that the biological mortality component of the life table of the species in most crops is a critical element (although certainly not the most significant). The literature abounds with references to the impact and appropriateness of parasitic species for the control of *Heliothis* populations. Unfortunately much less is known of the impact of predators on *Heliothis* populations.

There are three approaches in the literature to the use of the biocontrol agents for *Heliothis*. The first of these is the use of inoculative releases. Unfortunately it is apparent that the activity of *Heliothis* is so variable as to make adequate control of the pest by such means difficult. Very little is understood of the factors governing the rise and fall of egg lay and in these situations, the permanency of the biocontrol system is seriously jeopardised and efforts to compensate for these fluctuations are almost impossible. In situations where early season activity of *Heliothis* pest is in any way predicable, the value of an inoculative release of parasitic species in moderating subsequent generations of the pest may prove beneficial.

Traditional biocontrol processes do not seem to be appropriate for *Heliothis*. As with the inoculative release techniques, the variability and uncertainty of the host numbers renders the potential of a permanent biocontrol system unlikely.

The major potential for the biocontrol of *Heliothis* lies in the use of the inundative release technique. In this situation, the availability of easily mass reared egg and larval parasites provides an opportunity for high levels of control of the target species. Unfortunately, as with the use of the microbial insecticides, considerable educational effort will be required for the successful implementation of any such potential control procedure. Mass rearing many of these parasitic species is difficult. The ability to provide cheap yet parasitically active release material will be critical to the further success in this area.

A number of aspects of the biological control issue are currently attracting some interest. These include the option for the development of genetically improved strains of biocontrol agent, the option for the manipulation of the pest habitat so as to enhance the activity of natural or supplemental biocontrol agents and the use of kairomones to enhance host finding by the parasites.

7. Area wide management

This is a technique which has received attention in particularly well defined areas in southern USA, where an understanding of the local ecology of the species has led to the conclusion that control or manipulation of the first spring generation of the pest will lead to a significant reduction of subsequent generations in the area. In this particular case it has been a matter of control of the target species in roadside areas. In our local situations it might involve targeting the first spring activity in cultivated areas, especially where highly attractive host crops are being grown (e.g. chickpeas).

The success of this technique relies heavily on a communal approach to pest management. As a result it will be a much more difficult option to promote and equally difficult to develop experimentally.

8. Cultural control

In the hype of finding alternative control strategies for many of our major insect pest species, this form of control is easily overlooked. In the cold examination of its benefits, cultural control represents an economically viable and ecologically sound alternative which can lessen the reliance on pesticides in any of our major crops.

GENERAL COMMENTS

Despite the number of options for alternative control techniques which can be developed, there is an obvious note of caution that, whatever option is considered, its successful development and implementation is going to be totally reliant on the fact that the ecology of the species is fully understood. To date, many of the alternative options being investigated are proceeding in the best interests of time and on the premise of the "best guess" when it comes to a number of ecological assumptions. It is critical that the major assumptions being made are openly debated and their validity pursued.

At present there are two major forces controlling the choice of control options. The first of these is the need to have control of the *Heliothis* complex now. This is currently being provided by the widespread use of insecticides, albeit in a rational way where thresholds define the urgency of any one control application. The second is the need to be more environmentally aware. At the moment much of the momentum for this force is being provided by society at large. It is probably quite valid to suggest that the future lies somewhere in between. The immediate solution to the pesticide issue is to promote the judicious use of our insecticides. Unfortunately such rules of thumb can degenerate to the situation of 10 - 20 years ago when any truly ecological consideration was given to the spray decision process. In preventing a reversion to long gone practices, it is necessary that the development and acceptance of integrated pest management based on a high degree of ecological input must prevail.