Integrated Pest Management dealing with potato tuber moth and all other pests in Australian potato crops

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Abstract

The potato tuber moth (PTM), *Phthorimaea operculella* (Zeller), is a serious pest of potatoes and other solanaceous crops in Australia. The pest status varies in different regions of Australia and related factors include insecticide resistance and the level of other pests (including other Lepidoptera) associated with potatoes. Growers in several States of Australia have implemented Integrated Pest Management (IPM) strategies with the assistance of IPM Technologies Pty Ltd and this has involved monitoring crops for all pests and making recommendations for their control. This paper reviews the approach that we have taken with regard to IPM for PTM in general and to IPM in potato crops in particular. This is not a review of potato tuber moth control in Australia but is a report on how we have implemented an IPM approach in potato crops in Australia.

Introduction

Our work on potato tuber moth (PTM), *Phthorimaea operculella* (Zeller), began in 1986 when organochlorine insecticides (including DDT and dieldrin) were still permitted for use on some potato crops in Australia, and use of organophosphates and synthetic pyrethroid insecticides were standard practice. All organochlorine insecticides except endosulfan were withdrawn from all agricultural use in Australia in 1987 and potato farmers were looking for new control measures. This change in the availability of pesticides allowed us to begin research into alternative control options, including IPM rather than simply looking for substitute chemicals.

For PTM, which is the most important pest in potato in Australia, extensive literature on its biology and biological control was available from Australia (Callan, 1974; Briese, 1981) as well as of other countries. We studied the relative importance of different species of PTM parasitoids and it could be shown that parasitism varies according to location (Horne, 1990). IPM requires an integrated set of control options for all pests, both major and minor, that are encountered in any crop. Potato crops are no different and there are beneficial species that occur in potato crops worldwide, cultural options that are available and also selective pesticide options.

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The objective of our studies was the development of an IPM system for all potato pests. We describe here how this IPM approach to potato pests was developed for Australian potato cropping systems.

Materials and Methods

Our implementation of IPM has been mainly in Victoria, in southern Australia, where we are based. We have monitored crops for farmers at weekly intervals from crop emergence to senescence or in some cases until harvest. However, we have helped potato farmers all over Australia to successfully implement an IPM strategy on their farms.

As in any IPM strategy, the primary controls are biological and cultural, supported by selective pesticides, only when necessary. Broad-spectrum insecticides such as synthetic pyrethroids, organophosphates, and others must be avoided as foliar sprays. The major pests that are encountered in Australian potato crops are PTM, the polyphagous cotton bollworm (*Helicoverpa armigera* Hubner), green peach aphid (*Myzus persicae* (Sulzer)), potato aphid (*Macrosiphum euphorbiae* (Thomas)), onion thrips (*Thrips tabaci* Lindeman), tomato thrips (*Frankliniella schultzei* (Trybom)), western flower thrips (*F. occidentalis* Pergande), whitefringed weevil (*Naupactus leucoloma* (Boheman)) (all exotic species to Australia), looper caterpillars (*Chrysodeixus argentifera* (Guenee) and *C. eriosoma* (Doubleday)) and potato wireworm (*Hapatesus hirtus* Candeze), but there are many other minor, local or infrequent pests. Potato wireworm in Australia is different from species of potato wireworm elsewhere in the world and has a very different life-history (HORNE and HORNE, 1991a). A range of native and introduced natural enemies of these pests are used in IPM strategies. The most important of these are native predators: damsel bugs (*Nabis kinbergii* Reuter), pentatomid bugs (*Oechalia schellembergii* (Guerin-Meneville), brown lacewings (*Micromus tasmaniae* Walker), ladybird beetles (*Coccinella transversalis* Fabricius, *Hippodamia variegata* (Goeze) and *Harmonia conformis* (Boisduval) and red and blue beetles (*Dicranolaius bellulus* (Guerin-Meneville)). There are many parasitoids of the pests, and these include native species that attack the native pests, and also introduced species such as *Orgilus lepidus* Muesebeck, *Apanteles subandinus* Blanchard and *Copidosoma koehleri* Annecke and Mynhardt that parasitise PTM.

Cultural controls are equally as important as the biological controls and include soil preparation and management, irrigation, location of plantings, seed source and variety selection. Weekly monitoring of potato crops by professional entomologists allows decisions to be made on the relative level of pests to beneficials and the trend in their numbers. Actions are not triggered by pre-determined thresholds. Selective bioinsecticides such as *Bacillus thuringiensis* spp. *kurstaki* (*Btk*) are sometimes used, but the main control of pests is achieved by beneficial insects and cultural means. Growers successfully applying IPM include those producing certified seed, crisping, processing, ware and organic crops. Monitoring required looking for all pests and all beneficials, and making a judgment as to the likelihood of economic loss if no further action was taken. Trends of parasitoid and predator increase rather than absolute thresholds are used. If damage was considered likely then action to be taken did not only include chemical options. Cultural controls such as rolling, watering, and harvesting early or hilling were more important options proposed than spraying insecticides. A major cultural control that we needed to implement was a good “hill” made of fine soil (not cloddy soil), which provided good soil cover over developing tubers. Soil management is a critical component of our IPM strategy.

The approach we took required monitoring for all pests that occurred during the life of the crops and recommending actions that would control that pest without interfering with control of other pests. That is, applying actions that would not kill biological control agents for other potato pests. All monitoring and advice reported here concerns commercial farms, not plot trials or small trial results within commercial crops. They include seed, crisping, processing and ware production crops.

Results and Discussion

When we commenced research on PTM in 1986 there was almost total reliance on chemical insecticides as the basis for control of all pests. This appears to be the current situation in other countries such as the USA and UK now. The potato industry had very little knowledge of biological control agents and how these could potentially be used in an IPM strategy. Although there was interest from the potato industry there was also scepticism and a need for both scientific information and on-farm demonstration of IPM. This situation is one that we have encountered in a range of horticultural and broad-acre cropping industries and our approach to dealing with it is by simultaneously gathering entomological information and providing commercial demonstrations of IPM (HORNE *et al.*, 2008).

To deal with PTM there was little information available about the level of control that parasitoids could have in PTM infestations of potato crops in Australia. We knew that three species of parasitoids had been successfully established in Australia (CALLAN, 1974; BRIESE, 1981) but we found that no potato growers knew about these species or that they could be utilized in commercial crops. BRIESE (1981) provided information about the relative abundance of parasitoids of PTM around Australia but did not take into account the fact that regular use of broad-spectrum insecticides was standard practice, the role of predators or the possibilities of an IPM approach, and really considered only a classical biological control approach.

If we were going to tell potato farmers that parasitoids were reliable control tools to help with the control of PTM then we obviously needed to know which of the three species were most important or abundant in the different regions of Australia. Firstly, it was necessary to find out how well established the parasitoids of PTM were in different locations and what level of control was being achieved. To collect such information we needed growers to collaborate and agree not to use broad-spectrum insecticides on certain paddocks. In order to give growers more confidence that their crop would not be destroyed despite the fact that they were withholding their normal applications of insecticides we provided regular information on what was happening in their crops. Essentially we provided limited information on key pests (usually that they were not present in significant numbers) but also on what we considered to be key beneficial species (parasitoids of PTM and aphids).

We found that this combination of entomological research and working with potato growers provided a very useful collaboration. We were able to show that parasitoids of PTM and aphids were present in all areas where potatoes were grown and that they exerted considerable control pressure on these two key pests. The main parasitoid recovered from samples was the larval parasitoid *O. lepidus*, followed in importance by another larval parasitoid *A. subandinus*. The egg-larval polyembryonic parasitoid *C. koehleri* was found from most locations but was far less abundant than the larval parasitoids (HORNE, 1990).

The involvement of growers in this research meant that they were suddenly aware that there were beneficial insects in their crops as well as pest species and that they needed to be aware of the impact of pesticides that they applied. This encouraged them to avoid the use of routine applications of insecticides and instead to use them strategically. Once this change in attitude happened then we had the opportunity to help growers base their use of insecticides on the results of monitoring. Importantly, the decision on insecticide use was now based on the results showing the levels of beneficial species and not just pest numbers. We do not use rigid threshold levels but rather relate pest and beneficial numbers over time and make decisions about the likelihood of economic losses. These decisions are influenced by many factors including soil management, time of harvest, variety, rainfall and age of plants.

Now that growers were aware that beneficial insects were in their crops they (and us) began asking for more information about them. Could they release them into their crops? How long did they take to breed? How did they find the caterpillars? To answer these questions, we conducted a series of laboratory and field studies.

The high number of beneficial wasps produced from a single parasitised caterpillar led us to look at the potential of inundative releases of the polyembryonic species *C. koehleri*. We undertook studies on temperature-development as there would be a need for such information if mass-rearing of wasps was required (HORNE and HORNE, 1991b). Inundative releases of *C. koehleri* were trialled but we found this approach to be both ineffective and unnecessary given the high level of naturally occurring parasitism available (HORNE, 1993a). We found that the level of parasitism of PTM was often miscalculated by entomologists and so we presented data showing how to sample and also accurately assess the level of parasitism of PTM (HORNE, 1993b). The method we propose involves taking a series of leaf-mine samples and relating percent parasitism to the time of emergence (cohort of PTM) rather than the date that the sample was taken. We suspect that the problem of incorrectly assessing parasitism still occurs in many studies.

Field studies identified *O. lepidus* as the most important parasitoid in potato crops in Australia. We therefore decided to investigate the host-finding abilities of this parasitoid to improve our ability to use them within an IPM strategy (KELLER and HORNE, 1993).

In 1996 we created IPM Technologies Pty Ltd and ceased to be government employees. One significant aspect of this change was that we began to monitor potato crops for potato growers and advise on what pesticides if any were required. The legal liability of recommending “No Insecticide Required” was a significant issue, but we knew the potential of beneficial species. The potato growers who had been collaborators in our research now largely became our clients wanting to implement IPM and reduce pesticide use on their crops. The results for the growers were often massive, with sometimes a total avoidance of insecticides over a period of 10 years, compared to 7 insecticides per crop previous to our involvement (O’SULLIVAN and HORNE, 2000). The growers’ involvement in previous commercial trials was critical in giving them the motivation and the confidence to implement an IPM approach on their whole farm. Suddenly, we needed to be aware of all pesticide inputs not only for PTM management and we realised that we had totally ignored the potential biological control provided by predators (as well as parasitoids) and that the cultural controls of hilling and irrigation were at least as important as parasitoids of PTM. We now had to deal with all pests of potatoes in a compatible way, not just promote the parasitoids of PTM. This was entirely possible, as there are IPM compatible options for all aphids, caterpillar and other pests of potatoes in Australia (HORNE, 2000). Table 1 provides an example of the integration of several options in a compatible way. To assist growers and others in recognizing the beneficial species as well as the pests, a guidebook was prepared which was distributed to all potato growers in Australia (HORNE *et al.*, 2002).

Table 1. An example of a typical IPM strategy for potatoes integrating several control options.

Pest	Beneficial	Cultural Control	Pesticide support
PTM	3 parasitoids	Soil management Irrigation	Spray after senescence
Green Peach Aphid and other aphids	Parasitoids Ladybird beetles	Weed control	Pirimicarb
Cotton bollworm	Damsel bugs Parasitoids	-	Nucleopoly hedrovirus
Loopers	Damsel bugs Parasitoids	-	*Btk*
Whitefringed weevil	Carabidae	Avoid infested areas	Insecticide before planting
Potato Wireworm	Carabidae	Avoid infested areas	Insecticide before planting

In Australia there is a problem with tomato spotted wilt virus in potatoes vectored by onion thrips, tomato thrips and western flower thrips. Control of these pests without recourse to broad-spectrum insecticides is essential to overall control of pests, including PTM (HORNE and WILSON, 2000). Obviously, broad-spectrum foliar sprays of insecticides targeting thrips will have massive detrimental effects on the biological control of PTM, aphids and aphid vectored diseases. Growers using IPM understand that they have beneficial species that help to control key pests and also avoid the development of secondary pests. Our observations showed that broad-spectrum insecticides applied to control pests such as caterpillars can cause aphid flare (Figure 1). We believe that this is a general principle that can be extrapolated to many situations.

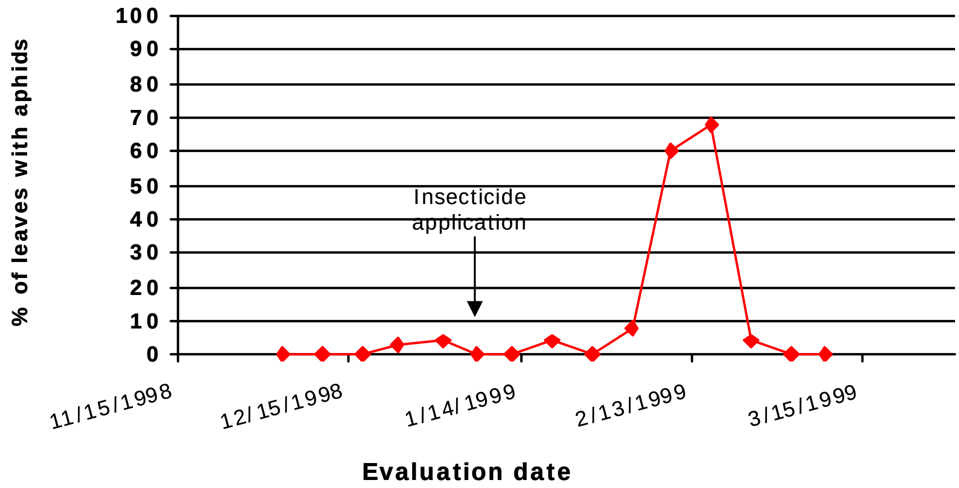

Figure 1. Aphid (*Macrosiphum euphorbiae*) development following an insecticide application (Permethrin, Amburh).

Conclusion

One of the main issues that we had to deal with in Australia was the integration of several pest issues (e.g. PTM, aphids and looper caterpillars) and the recognition that an inappropriate spray for one would disrupt control of other pests. This apparently simple issue is a stumbling block for IPM adoption in a range of horticultural and broad-acre crops in which we work.

It is apparent from other papers presented at this symposium that IPM in potato crops (e.g. for PTM) is not possible for many locations (including the USA) because of the continued use of broad-spectrum insecticides for some other pests. It simply is not possible for potato growers to expect that they can use an IPM approach and at the same time using a broad-spectrum insecticide spray for any pest. It has to be realized that the control of all pests need to be considered and that the control of some pests can disrupt the biological control of other pests.

The result of the research described here has been that Australian growers can now implement an effective IPM strategy that includes PTM as one of the key pests (HORNE *et al.*, 1999; HORNE, 2000; O'SULLIVAN and HORNE, 2000). We believe that the model of IPM in potato crops that we have developed in Australia could be applied in any country. The advantages include reduced use of insecticides and avoidance of secondary pests.

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