PT437
Development of IPM strategies for potato moth

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Know-how for Horticulture™

PT437

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Technical Summary

This project has successfully developed protocols which can now be used as the basis for an integrated pest management (IPM) strategy for the control of the major potato pests in Australia. The IPM strategy involves the use of biological and cultural control measures rather than total reliance on chemical insecticides. The project has also improved monitoring and use of thresholds for aphids, improved the use of parasitoids of the potato moth, and provided information on pesticides that are most compatible with the IPM approach.

A total of 2,364 questionnaires were mailed directly to potato growers in 6 Australian States to survey awareness and adoption of integrated pest management (IPM). Awareness of IPM ranged between 35% and 60% of growers, with large differences between States and grower groups. Adoption was highest amongst crisping potato growers. The source of information on IPM appeared to influence the level of adoption. Direct contact between growers and crop advisors resulted in the highest level of adoption.

The distribution of several species of parasitic wasps attacking the potato moth was measured in potato growing areas of Australia. The most abundant species were *Orgilus lepidus, Apanteles subandinus*, and *Copidosoma* spp. In addition, *Campoplex haywardi* was abundant in the Kooweerup district and *Temelucha* sp. was found in some Western Australian districts. *O. lepidus* was not found in any of the Western Australian samples or from the Ballarat district in Victoria. *Copidosoma* was not found in the Thorpdale district of Victoria. *O. lepidus* was released in Tasmania.

O. lepidus was found to compete more effectively for hosts than the other two common parasitoids, and mass-release work has concentrated on this species.

Monitoring aphids by leaf-count rather than pan-trapping is recommended. Very little leaf-roll virus was found in the crops monitored, even when high numbers of green peach aphid were present. The main potential source of virus in these districts is seed rather than aphid vectors. Similar studies in other districts would determine the relative risk of virus for each production area.

A representative set of insecticides and fungicides was tested in the laboratory for their relative toxicity to the potato moth and its parasitoids. Differences in relative toxicity, even to the same chemical, were found between parasitoid species. However, some insecticides including thiodicarb, were relatively safe to the major parasitoid, *Orgilus lepidus*, as they were more toxic to the pest than the beneficial.

Industry Summary

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The distribution of several species of parasitic wasps attacking the potato moth was measured in potato growing areas of Australia. There were three common species, and one of the most abundant in the eastern States, *Orgilus lepidus,* was not found in any of the Western Australian samples or from the Ballarat district in Victoria. *Copidosoma* was not found in the Thorpdale district of Victoria. *O. lepidus* was released in Tasmania.

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Introduction

The project had several main aims. These were;

- (a) to measure growers awareness and adoption of IPM
- (b) to survey potato growing districts for the presence of parasitoids of the potato moth
- (c) to improve the degree of biological control for potato moth
- (d) to measure the effectiveness of control measures for aphids transmitting leaf-roll virus
- (e) to develop sampling methods to monitor pests and beneficials in potato crops
- (f) to assess the relative toxicity of pesticides against the potato moth and its parasitoids

The survey of growers was matched by a parallel survey in NSW by Dr. Robert Spooner-Hart (University of Western Sydney). Some of the data he collected are included in summary here.

(A) Awareness and adoption of IPM by Australian potato growers

Introduction

The gross value of production of the Australian potato industry is about A$300 million. Half of the production is used for processing (crisping and French fries), the remainder sold as ware, or fresh-market, tubers. Gross tonnage produced per State in 1994 was: Victoria 322 000t, Tasmania 291 000t, South Australia 203 000t, New South Wales 139 000t, Queensland 118 000t and Western Australia 112 000t (Australian Bureau of Statistics 1994). There are between 1875 and 2,500 potato growers nationally (ABS 1994-95 and HRDC 1995), although the number can change markedly from year to year.

Differences in the species and severity of insect pest problems occur across the production districts. This is at least partly due to the distance between the districts (Western Australia to eastern Australia is approximately 3600 km), and the changes in climate (tropical Queensland to southern Tasmania). However, the main insect pests in most areas include potato moth (*Phthorimaea operculella*) and green peach aphid (*Myzus persicae*), while many districts also have one or more of the soil-dwelling pests, whitefringed weevil (*Graphognathus leucoloma*), African black beetle (*Heteronychus arator*) or potato wireworm (*Hapatesus hirtus*) (Rothschild, 1986; Horne, 1990; Matthiessen and Learmonth 1994).

Control of insect pests of potatoes in Australia relied on applications of chemical insecticides, including DDT, dieldrin and heptachlor (for some crops) until 1987, when organochlorine insecticides were withdrawn (Horne 1989; Learmonth and Sproul 1989). The regular use of organophosphate and synthetic pyrethroid insecticides remains common practice in many areas. However, Horne (1990) proposed that growers change to using an integrated pest management (IPM) approach rather than rely solely on broad-spectrum insecticides. The IPM strategy for control of potato pests involves the use of cultural techniques (soil management and hygiene), biological control (based on parasitoid wasps attacking *P. operculella*), monitoring of pest and beneficial insects, and the strategic use of 'softer' insecticides (Horne and Rae 1995).

IPM strategies have been developed for potato crops overseas, but these have to deal with different pest complexes including, in many cases, Colorado potato beetle (*Leptinotarsa decemlineata*). Strategies exist for crops grown in western USA, Wyoming, Idaho, and British Columbia in Canada, but these are necessarily different to Australian requirements, not only because of different insect species but also because of differing production methods and climates.

This study set out to measure insecticide use and awareness and adoption of IPM by potato growers in the major production districts of Australia. In addition to assessing the current status, the data produced will be useful in providing baseline information to assess future adoption rates.

Information on aspects of IPM and biological control in potato crops was also prepared as part of this project. We developed a series of colour notes, insect identification kits and a video for growers and others in the potato industry (see Appendix 1).

Materials and methods

A series of surveys were mailed to growers in major potato production areas of Australia between 1992 and 1996. The surveys commenced in Victoria (1992, 1993) and continued in New South Wales (NSW), Queensland (Qld), Western Australia (WA) and South Australia (SA) (1994), Tasmania (1995) and the Ballarat area (Victoria) (1996). The number mailed out in each State is indicated in Table 1. In an early Victorian survey, 200 questionnaires were also included in the crisping industry newsletter 'Peelings', which is distributed nationally to that section of the industry. This method of distribution meant that some growers may have received two questionnaires and therefore made it difficult to accurately determine regional response rates. A note reading "If you have previously completed a copy of this survey, please return this copy unanswered. Thank you." was included to discourage growers from returning two completed surveys.

The Ballarat district in Victoria was surveyed twice. The first survey was in 1992/93, the second survey was in 1996. The second survey was carried out to assess if awareness and adoption had changed over this 3-4 year period.

Growers were asked questions concerning the area planted to potatoes, the type of crop grown (ie. crisping, French fry, ware or seed), insecticide use, awareness of IPM and, if applicable, adoption of IPM and the main source(s) of information on IPM. Questions varied between States to accommodate local issues, but the basic topics were those listed above.

Surveys in WA, Tas, NSW, Qld and some Victorian districts also asked growers to list what they considered to be the major pests in their crops. Responses were recorded and analyses were performed using the computer database *Paradox 4.0* (Borland). The total number of survey replies received was 680, which is approximately one-quarter of all Australian potato growers (based on 2,500 growers). The response rate varied from 23% in WA to 36% in Tasmania.

Awareness

Awareness of IPM varied from 35% to 60% when considered by State. However, greater differences are evident when awareness was considered by district (eg. 0% in 'metropolitan' WA to 100% in Bundaberg, Qld.) or by crop type (Table 1).

A key element of the IPM strategy proposed by Horne (1990) is the use of beneficial insects, in particular parasitoid wasps. Therefore, responses to the question "Do you believe there are beneficial insects in your crops?" are also a good indication of awareness of IPM. Results were similar in Qld, NSW and SA, with over 40% responding "Yes" in each case, but this response was less common in WA (28%) and Tasmania (14%). This question was not included in the initial Victorian survey. However, in the subsequent survey of Ballarat growers, 63% believed they had beneficial insects in their crop. Potato moth and aphids were rated as major pests in all States where ranking of insect pests was possible.

Adoption

Adoption of IPM was assessed in two ways: (i) by asking if growers practised IPM; and (ii) by asking how much of the crop was treated with insecticide.

In response to the first question, 30% of Queensland growers stated that they used IPM; the next highest proportion was of South Australian growers (25%), then WA (18%), Victoria (16%) and NSW (15%). Answers to the question on the use of insecticides varied considerably between States. The percentage area of crop sprayed was lowest in

Victoria with 35%, then SA (54%), WA (71%) and Qld (83%). Directly comparable data are not available for NSW or Tasmania. However, in Tasmania, only 14% of growers sprayed for potato moth in 1994/95 and 11% sprayed for other pests. An increase in both awareness and adoption of IPM was measured in Victoria from 1992/3 to 1996. In the Ballarat district, awareness of IPM increased from 29% to 63% and adoption increased from 9% to 20%.

The main source of information about IPM or insect pests was quite variable (Table 1), but the main reason for not using IPM was most often a "lack of information". Adoption was highest (up to 100%) in districts where advice was given in person by crop advisors. In particular, both awareness and adoption were high in the crisping industry, where crop consultants were active in promoting IPM (Table 1).

Discussion

Adoption of IPM has been shown to give tangible benefits, both economic and environmental, in a range of horticultural and field crops (National Research Council 1989). In some cases, there are long-term benefits; for example, reducing the risks of insecticide resistance in pests. However, there are also cases where benefits are achieved almost immediately; for example, reduced costs through fewer insecticide applications.

Despite the benefits of IPM, overseas experience has shown that adoption of IPM by farming industries can be very slow, particularly in the USA (Herbert 1995). Our survey has shown remarkably rapid adoption of IPM by Australian potato growers, especially in some sectors of the industry. The crisping potato sector has the highest level of adoption, with some districts surveyed having up to 100% of respondents aware of, and using, IPM.

Overall, the level of adoption is about one-quarter of all growers surveyed. This is a high level given that until about 1990, almost all Australian growers would have relied on insecticides and may not have had the necessary local information to either develop or use IPM.

Awareness and adoption of IPM in Victoria changed between 1992 and 1996, at least as measured by the Ballarat district survey. Awareness is currently 63% and adoption is 20%. As in other districts, both awareness and adoption are higher amongst processing growers than ware growers.

The highest levels of adoption (in the crisping industry and in Bundaberg, Qld) have occurred where information on IPM has been presented to growers, in person, by someone with whom they have regular contact. Awareness may be high amongst crisping growers because contracting companies require their growers to attend meetings where IPM is discussed, however the same reasoning does not support the high rates of adoption recorded. We interpret the high adoption rates as being due to information and support received through regular contact with a person the grower trusts. Once a core group of growers in a district has adopted IPM and found it effective (the current situation), further awareness and adoption should be rapid as growers obtain information on IPM from other growers actually using the strategy.

We suggest that, to achieve high rates of both awareness and adoption, information on IPM should be presented to small, local groups of growers through a series of regular meetings with an advisor. If the information is locally validated by this core group of growers, then further adoption by a wider group of growers is more likely. The approach of using small groups was used successfully by Gunton (1993) to extend information on soil fertility management to potato growers in Queensland. Other groups of potato growers have been formed in several Australian states to promote various aspects of potato production, including IPM (Lanz 1994; Strange 1994).

All growers in Australia have been presented with written articles on IPM in industry journals, yet overall adoption rates at this stage remain relatively low. Presenting information only in written articles or at large meetings, although useful, is not sufficient if the aim is to improve the rate of adoption of IPM. The most successful approach to achieving adoption of IPM has occurred where information is presented in person.

(B) The Distribution and Relative Abundance of Parasitoids of the Potato Moth, *Phthorimaea operculella* in Australia.

Introduction

Introduced hymenopterous parasitoids are important biological control agents for the potato moth (*Phthorimaea operculella* (Zeller)), which is a serious pest of potatoes and other solanaceous crops in Australia (Horne 1990, Rothschild 1986). Callan (1974) described the distribution of parasitoids in the various potato growing districts of Australia shortly after their release by CSIRO in the 1960's, Briese (1981) provided a more recent picture of parasitoid establishment and Franzmann (1980) outlined parasitism in Queensland. This study aimed to provide more up to date information on parasitoid distribution, and to sample throughout the potato growing season wherever possible, and not rely on "spot" samples. Sampling throughout the season is important to avoid seasonal variation in the relative abundance of species due to competitive interactions.

The three most abundant parasitoids recorded by Briese (1981) were *Orgilus lepidus* Muesebeck, *Apanteles subandinus* Blanchard and *Copidosoma desantisi* Annecke and Mynhardt. Other species of parasitoids were released by CSIRO but were not recovered in his survey.

The biological control agents of potato moth are important components of integrated pest management (IPM) strategies to control potato pests in Australia. It is essential for the effective use of these IPM strategies to know which species occur in each potato growing district. Obviously growers need to know that a key biological control agent is present in their district before they rely on it to control a pest. In districts where key species are absent, then further introductions may be warranted.

Materials and methods

The larvae of *P. operculella* are leaf-miners, and these can easily be found by inspecting the foliage of potato crops. The parasitoids are either larval (*A. subandinus* and *O. lepidus*) or egg-larval (*Copidosoma* spp.) parasitoids. Leaf samples containing *P. operculella* larvae will also contain the parasitoids if they are present. Leaf samples were taken from potato crops at intervals from crop emergence to before senescence. In most cases, samples were taken at regular intervals during the normal cropping season for each district sampled. In addition, some single samples were taken from certain sites (see table 3). Samples included foliage with leaf-mines whenever they were obvious, but if leaf mines were not visible then a random sample of leaves was taken. Each sample consisted of at least 50 leaves. The leaves were placed onto punctured potato tubers in a vented, clear plastic container and left at approximately 23^{O}C for 5 weeks. All adult moths and wasps subsequently emerging were identified and counted. This method of selecting leaf samples to measure parasitism in potato crops has been described (Horne 1993).

The relative abundance of parasitoids was calculated by totalling all numbers for the season for each district. Similarly, the relative abundance of each of the parasitoids in each state was calculated by totalling all wasps from all districts. The districts surveyed, and the years the sampling took place in this study were: Victoria- Ballarat (1991), Kooweerup (1994-95), Thorpdale (1989-91), Bellarine Peninsula (1993, 1996), Swan Hill (1995). South Australia (1992, 1995)- Adelaide Hills, Adelaide Plains, Lakes District, Bordertown. Queensland (1994)- Bundaberg, Atherton, Mareeba, Gatton. Western Australia (1994-95)- Perth Metropolitan, Manjimup, Albany, Busselton, Bunbury.

This survey of parasitoids aimed to document the presence of parasitoids in potato districts, not assess the levels of parasitism in crops. Wherever possible, samples were taken from crops not sprayed with foliar applications of insecticide, but the sites included both sprayed and unsprayed crops.

Results

A total of 5,673 wasps were reared from potato moth hosts collected from leaf mines in potato growing districts. Species of introduced parasitoids were recovered from every district surveyed, except from the Bordertown area of South Australia. Low numbers were collected from Bundaberg and Atherton- Mareeba districts in Queensland, possibly because of the more frequent use of insecticides (for potato and other crops) in those districts. *Copidosoma* spp. were not collected from potato leaf samples from Bundaberg in this survey, but it was collected from tomato leaf samples collected at about the same time (Horne, unpublished data). Three species, *Orgilus lepidus, Apanteles subandinus* and *Copidosoma* spp were most commonly recorded (Table 2). However, *O. lepidus* was not recovered from any site in Western Australia or in the Ballarat district of Victoria, but *Temelucha* sp. was only recovered from Western Australia. Another species, not previously considered established, *Campoplex haywardi*, comprised a significant proportion of the parasitoids recorded from the Kooweerup and Bellarine Peninsula districts in Victoria. *C. haywardi* was introduced into Australia in the 1970's but not previously known to have established. *Copidosoma* was not recorded from the major potato growing district of Thorpdale in Victoria, a district not included in the 1981 survey (Briese 1981). The three major species were all found in the Swan Hill area, also not sampled in 1981.

Discussion

The three main wasp species found in this survey, *O. lepidus, A. subandinus and Copidosoma* spp., were the same species found by Briese (1981) to be the dominant parasitoids of potato moth in Australia. The parasitoids can have several generations during the life of a potato crop, and so parasitoid numbers and percent parasitism generally increase during the cropping season (Briese 1981, Horne 1991). However, the relative importance of the three species was not in all cases the same as found in the 1981 report. In addition to the three common species, *Campoplex haywardii*, a species thought not to have established in Australia, was found to be important in two Victorian districts (KooWeeRup and the Bellarine Peninsula).

Orgilus lepidus was relatively more important in Queensland sites than found by Briese (1981), and this species was also found from the Atherton Tableland (2 specimens only). The number of parasitoids recovered from the Atherton and Mareeba sites was low and may well be the reason that *O. lepidus* was not previously recovered. This survey confirmed that *O. lepidus* has not established in Western Australia (WA). This species is an important biological control agent in other potato growing districts of Australia and is currently not available to Western Australian growers. Only *C. koehleri* and *Bracon gelechiae* Ashmead were previously known to have established, but there is no reason to suppose that the WA environment is unsuitable for *O. lepidus.* It is possible that this species was never released in WA by CSIRO. Inoculative releases of this species are planned, to complement the parasitoids already established in WA.

The very low numbers of parasitoids found in some districts may reflect pesticide use, or even low host numbers. If the low numbers are due to poor establishment of parasitoids or a slower than usual increase in population size during the cropping season, then regular inundative releases of parasitoids could overcome this problem.

Both *A. subandinus* and *O. lepidus* attack the same stage of the host, the first instar. Competition between these two species has been suggested as a possible explanation for the changing relative abundance of these two species in Australian districts (Briese 1981). Research to measure competition between these species is currently being conducted in Adelaide, and suggests that *O. lepidus* is usually dominant (Salehi 1996).

Recent work in Tasmania by Mr Lionel Hill has confirmed that *A. subandinus* and *Copidosoma* spp. were the dominant species parasitising *P. operculella* in that state. Introductions of *O. lepidus* were made but an assessment on establishment has not yet been made. This present survey sampled in districts not sampled by Briese and so some important site information has been added. No *Copidosoma* spp. were recovered from any sites in the Thorpdale district, but they were recovered from all other districts in Victoria.

(C) IMPROVEMENT OF BIOLOGICAL CONTROL

This project has identified parasitoids of the potato moth as key biological control agents in potato crops in Australia. However, some districts lack one or more of the three common species of parasitoids. In particular, Tasmania, the Ballarat district in Victoria, and all districts in WA lack *O. lepidus.*

The lack of *O. lepidus* in the Ballarat district allowed us to test the effectiveness of mass-releases of this species. Inoculative releases of *O. lepidus* were made in Tasmania (and this work has been reported to HRDC separately by Mr. Lionel Hill, DPIF Devonport).

Sites in the Ballarat district were monitored weekly in two consecutive years during the potato growing season (December to March). Weekly releases of approximately 500 *O. lepidus* pupae were made at one site for 10 weeks following crop emergence in year one, and similar numbers of adult wasps were released at 5 sites in year two. Leaf samples to monitor parasitism were made following the method described by Horne (1993). Potato moth numbers were also monitored using pheromone traps.

As in all other monitoring of potato moth in Victoria, several generations of potato moth were recorded in the potato crops, but moth numbers were very low in the second year of the study. Only at the release sites was *O. lepidus* recorded. At the release site in year one, *O. lepidus* accounted for over 85% of all parasitism.

One section of this project, concerning the interaction of parasitoids of the potato moth, was performed as a PhD research project by Mr Latif Salehi, under the supervision of Dr

M.A. Keller (University of Adelaide). Mr. Salehi is now completing his work and has commenced writing his thesis.

(D) THE EFFECTIVENESS OF CONTROL MEASURES FOR APHIDS TRANSMITTING LEAF-ROLL VIRUS

Introduction

Aphids are a problem for potato growers, not so much because of direct feeding damage but because of the transmission of viral diseases. In particular, *Myzus persicae* (the green peach aphid) is a persistent vector of leaf-roll virus. Other aphids may also contribute to transmission of leaf-roll virus to a small degree, but *M. persicae* is the species most responsible for introducing the virus into otherwise "clean" crops.

The use of certified seed has been, and will remain, an essential component of any IPM strategy that hopes to control insect-borne (and other) viruses. In addition to using certified seed, controlling aphid vectors of virus by the use of insecticides has been a standard means, used by Australian and overseas potato growers, of limiting virus spread . However, other factors contribute significantly to virus spread and aphid control and these also need to be considered. The most important are:

(a) the seed used can be a major source of virus (if not certified seed)

(b) improper application of insecticides can result in increased aphid populations

(c) many aphid species that are not persistent vectors of leaf-roll virus are found in potato crops

(d) many insect biological control agents exist in potato crops.

Before this project commenced, the use of broad-spectrum insecticides to control both aphids and potato moth was standard practice. The successful use of biological control agents for potato moth depends on the simultaneous use of a compatible control measure for aphids. Biological control agents for potato moth will be killed by broad-spectrum insecticides targetted at aphids. That is, the wasps described in sections A and B of this report, are killed by indiscriminate use of insecticides.

Biological control agents for aphids include parasitoid wasps and predators (such as ladybird beetles, nabiid bugs and syrrphids (hoverflies). In general these act too slowly to prevent the transmission of virus to a crop if an aphid is already carrying leaf-roll. However, if the aphid is not carrying the virus, then they will achieve control.

What is required is an effective threshold for each district. That is, how many aphids can be tolerated before the use of foliar sprays is required? Obviously, if a threshold level is to be used then a monitoring method must be in place. The threshold will depend on the answers to the following questions:

(a) What was the seed source? (Certified or grower's own source)
(b) Are the aphids in that district known to carry leaf-roll?
(c) What is the end-use of the crop? (certified seed/ other).
(d) How effective are insecticides? (is insecticide resistance known?, how complete is the crop canopy and how is the insecticide to be applied - plane or boom-spray?)
(e) How are aphids to be monitored? (pan-trap or leaf count).

Monitoring is critical in the use of any threshold. In potato crops there are two quite different methods of monitoring aphid populations. The first method, commonly used in Europe, is to trap winged (alate) aphids in yellow pan-traps. This measures the number of invading aphids that may carry leaf-roll virus. The problem is that many other aphid species, that do not pose a problem to potato crops, are also captured. Similarly, many other non-aphid species are also captured. The time spent in sorting the trap captures and identifying the important aphid species is considerable and can only be done by properly trained people.

The alternative monitoring method, commonly used in the USA, is to count the number of wingless aphids (apterae) on the lower leaves of potato plants. This has the advantage that only a very few species of aphids (commonly 3-4) will actually colonise potato plants. It has the disadvantage that the measure is of aphids already established on the crop, not the invading parent generation.

This project compared both monitoring methods - pan trap and leaf count. In addition, it aimed to look at the degree of control, of aphids and leaf-roll virus, achieved by insecticides.

Materials and Methods

Crops in Victorian districts (KooWeeRup, Bellarine Peninsula and Ballarat) were monitored for aphids throughout the growing season. Sites selected included crops that were insecticide treated, untreated, and which had certified seed and 'one-off' seed. Two yellow pan traps filled with water and some detergent were placed at each site to monitor alate aphids. One hundred true leaves, from the lower part of each of 100 plants, were inspected in each crop each week. The underside of each leaf was inspected carefully, as green peach aphid normally colonise the underside of the lower leaves.

Leaf samples for ELISA assays were taken at the start and the end of each crop's life. These were taken in order to determine whether any leaf-roll detected had arrived with the seed or via aphid vectors. They were monitored using both yellow pan traps and the leaf count method. All aphids found in the pan traps were identified to species.

Insecticide treated and untreated crops were monitored so that the effect of insecticides in controlling leaf-roll virus, not just aphids, could be assessed. This aspect of the project depended upon some leaf-roll being found in the crops.

Results

The most important result was that only extremely low levels of leaf-roll virus were detected in any of the crops monitored weekly. This was in spite of numerous green peach aphids being recorded in some crops.

Many different species of aphids were found using pan traps in the crops studied (Table 3). Many of the aphids were very similar in appearance to the green peach aphids amongst them. The green peach aphids could only be distinguished by a trained person using a microscope. The process of identifying aphids was extremely time consuming. Leaf-counts also detected green peach aphids, but the process of identifying them was much faster and often completed in the field.

The lack of leaf-roll virus meant that an assessment on the effectiveness of insecticides could not be made. However, it was noted that at some sites where insecticide applications were made, an increase in aphid numbers followed.

Some additional spot samples from the Swan Hill area did contain leaf-roll virus. These were from the grower's own seed source, more than 'one-off' certified. That is, the grower had bulked up seed for more than one year and had also increased the level of leaf-roll.

Discussion

The low level of leaf-roll virus found, despite relatively high numbers of green peach aphid at certain times, suggests that, **in the districts studied**, there was a low risk of aphids introducing the virus to crops. There must have been little background, or reservoirs of leaf-roll virus for aphids to pick up before flying into crops.

This result means that a potentially greater source of risk of virus introduction, in the districts studied, was the seed source. Even the 'one-off' crops that we monitored weekly did not have problems with leaf-roll. However, we did record high levels of leaf-roll in a crop several generations from certified seed, where the grower had kept his own seed for several seasons.

In the years of this project, at least, the risk of leaf-roll was low, due to good grower practices and low background levels of virus. That is, in some districts, where there is no outside reservoir of leaf-roll virus, and where growers use certified seed, there is little risk of aphids or seed bringing in the virus. This proposal needs to be tested for several years (ie different weather conditions) before it can be relied on, and must be tested in each district.

Measuring the risk from aphid vectors also involves the monitoring of aphid numbers and the defining of thresholds. The time taken to identify green peach aphids from the many collected in pan-traps means that information from such a method is not available quickly.

However, counting apterous aphids on leaves does provide a rapid means of monitoring aphids. This method has the added advantage of observing, and taking into account, the beneficial species (wasp mummies, predatory insects) present in the crop. Instead of just assessing aphid numbers, a decision on action can be based on a knowledge of the relative abundance of pests and beneficials.

Thresholds for action (ie. how many can be tolerated before spraying, etc) will depend, amongst other things, on the district, the crop, the time of year, surrounding crops and the risk each individual grower is prepared to take. For example, working thresholds in a clean district could be 10 aphids per 100 leaves for a seed crop and 25 aphids per 100 leaves for ware crops.

Thresholds need to be studied and validated in each district. They need to be developed in conjunction with local crop advisors and growers. This process has now begun.

(E) RELATIVE TOXICITY OF PESTICIDES

Six insecticides and two fungicides were tested in the laboratory for their relative toxicity to beneficial parasitoids of the potato moth and to the pest moth. The aim of this work was to identify pesticides which were suitable for incorporation into the IPM strategy. Then, if an insecticide needed to be applied, it would cause minimal disruption to existing levels of biological control. Similarly, fungicides were tested to measure their effect on beneficial parasitoids, as some fungicides can have insecticidal properties.

The pesticides tested were chosen from different chemical groups. They were *Nitofol* (methamidophos), *Larvin* (thiodicarb), *Thiodan* (endosulfan), *Pirimor* (pirimicarb), *Ambush* (permethrin), *Confidor* (imidacloprid), *Score* (difenoconazole), and *Mancozeb* (dithane).

The insects were all reared in the laboratory and tested under controlled temperature. Log-series doses of insecticides were sprayed onto glass petri dishes using a Potter tower. (This equipment delivers a standard sprayed deposit, allowing many dishes to be sprayed separately, but each with the same spray pattern and deposit).

Dose-response curves were established by assessing the mortality of test insects after 24 hours' exposure to the dry, treated surface. Five replicates, each containing 10 insects, were used for each concentration tested. The results were compared using probit analysis.

Tests were made using both adult and larval stages of pest and parasitoid species. This was done because, for example, adult wasps are present at the same time as caterpillar stages of *P. operculella*.

Thiodicarb was the only insecticide which was relatively less toxic to one parasitoid species *Orgilus lepidus* than to the potato moth. The aphicides pirimicarb and imidacloprid were also found to be relatively less toxic to the three common parasitoids than to green peach aphid (*Myzus persicae*). However, at doses toxic to potato moth, these aphicides were relatively more toxic to the parasitoid wasps.

Methamidophos, endosulfan and permethrin were relatively more harmful to parasitoids than to potato moth. The fungicides tested showed no effects on adults of any species, but they did kill first instar potato moth caterpillars.

On the basis of these results, there is reason to expect that some insecticides (such as thiodicarb, pirimicarb and imidacloprid) could be incorporated within the IPM strategy proposed. These results also suggest that some insecticides commonly used by potato growers (such as Nitofol) are not suitable. Further testing in the field is required to confirm this result, but the laboratory results are an excellent sign that "soft" insecticides can be used by Australian potato growers in conjunction with other IPM measures.

This component of the project was performed as a PhD research project by Ms. C. Symington under the supervision of Dr T. R. New (La Trobe University) and Dr. Horne. Ms Symington is now writing her thesis.

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Finally, I would like to thank all of the potato growers around Australia who allowed us to use their crops as research sites. Their assistance and encouragement has been essential to the success of this work.

Publications arising from this project

Refereed Papers

1996: Awareness and adoption of IPM by Australian potato growers. P.A. Horne, J. Rae, A. Henderson and R. Spooner-Hart. Submitted to Crop Protection.

1993: Sampling for the potato moth (*Phthorimaea operculella*) and its parasitoids. P.A. Horne Australian Journal of Experimental Agriculture **33**: 31-96

1993: Sources of host location cues for the parasitic wasp *Orgilus lepidus* (Braconidae). M.A. Keller and P.A. Horne. Australian Journal of Zoology **41**: 335-41

Conference Papers

1996: Development and Adoption of an IPM strategy for potato crops. P.A. Horne, C.L. Edward and J. Rae Joint Conference of the Australian and New Zealand Entomological Societies. Lincoln University. New Zealand

1996: Functional response and competition between Apanteles subandinus and Orgilus lepidus, parasitoids of the potato moth. L. Salehi and M.A. Keller. Poster presented at the Joint Conference of the Australian and New Zealand Entomological Societies. Lincoln University. New Zealand

1996: Relative toxicity of pesticides to pest and beneficial insects in potato crops in Victoria, Australia. C.A. Symington and P.A. Horne. Wales

1996: IPM for potato growers: the change to precision pest control. P.A. Horne and J. Rae. VegTec 2000 Conference Brisbane 1996

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**Kits and Notes

Video

1992: Agnote: Control of Potato Moth. Paul Horne.

APPENDIX 1: NOTES PRODUCED FOR GROWERS

Countering the potato moth

Monitoring the potato moth

Insects of potato crops - southern Victoria

Insects of potato crops - southern Victoria (Agnote)

Crop Management Strategies for pest and disease control in potato crops

INSECT KIT

VIDEO Integrated pest management for potatoes. Biological control.

(Potato IPM poster produced for HRDC, in addition to the project)

APPENDIX 2: Potato Crop Monitoring: Sample Field Record Sheet

Site:

1. Pests

Date	Aphids/100	PTM	Thrips	Moth Eggs	Other	
13/11/96	0	0	0	2		

Potato Crop Monitoring

Site:
2. Beneficials

Date	Lacewings	Wasps	Hoverflies	Nabiids	Spiders	Other
13/11/96	2	5	1	0	1	

•

Table 1: Summary of Survey Data

	District/Production Type	No. of surveys sent	% Response rate (absolute no.)	% growers aware of IPM (absolute no.)	% growers adopting IPM (absolute no.)	% of crop area (ha) sprayed [of growers responding]	Source of info. on IPM*	Major reason for not using IPM#	Do you believe there are beneficials in your crop? (% who answered yes)
National	All	2291 TBC	29% (680)	43%	19%	3978ha	Crop consultant Grower meeting Magazine	info	146
Victoria .(1992/3)	All districts	569	32% (184/569)	35% (65/184)	16% (29/184)	35% (1700)	GM	info	n/a
	Leopold		13	62% (8/13)	8% (1/13)		GN	info	
	Iona		13	38% (5/13)	15% (2/13)		GM/GN/Mag		
	Warragul		15	60% (9/15)	33% (5/15)		EO/OG/GM/GN		
	Childers		21	19% (4/21)	5% (1/21)	47% (1558)	EO/GN/GM	info	
	Thorpdale		19	63% (12/19)	32% (6/19)		GM/GN	info	
	Mirboo		17	29% (5/17)	24% (4/17)				
	Ballarat		78	29% (18/78)	9% (7/78)	9% (142)			
	Seed		67	45% (30/67)	15% (10/67)	9% (468)	GM	risk/not needed	
Ballarat .(1996)		132	30% (40/132)	63% (25/132)	20% (8/132)	n/a	GM/McCains	info	63% (25/40)
	Processing		26	69% (18/26)	23% (6/26)		GM	not needed/info	50% (13/26)
	Seed		18	72% (13/18)	5% (1/18)		GM/McCains	not needed	61% (11/18)
	Ware		9	67% (6/9)	11% (1/9)		GM/McCains		67% (6/9)
Queensland .(1994)	All districts	230	27% (61/230)	57% (35/61)	30% (18/61)	83% (1181)	OG/CC/Mag	info	49% (30/61)
	Redland Bay		9	22% (2/9)	11% (1/9)		CC/GN/GM	mix	
	Kalbar		8	38% (3/8)	13% (1/8)		Mag	info	
	Gatton		16	44% (7/16)	6% (1/16)		OG	info	
	Bundaberg		4	100% (4/4)	100% (4/4)		CC		
	Atherton T'land		18	72% (13/18)	39% (7/18)		OG/CC/DPI	info/other	
	Other districts		4						
	Crisping		10	100% (10/10)	80% (8/10)	19% (274)	CC/GM/other		70% (7/10)
	Ware		53	51% (27/53)	23% (12/53)	69% (988)	OG	info	47% (25/53)

Table 1: Summary of Survey Data

	District/Production Type	No. of surveys sent	% Response rate (absolute no.)	% growers aware of IPM (absolute no.)	% growers adopting IPM (absolute no.)	% of crop area (ha) sprayed [of growers responding]	Source of info. on IPM*	Major reason for not using IPM#	Do you believe there are beneficials in your crop? (% who answered yes)
Western Australia .(1994)	All districts	350	23% (79/350)	42% (33/79)	18% (14/79)	71% (671)	Mag	info	28% (22/79)
	Metropolitan		7	0%	0%				
	Bunbury		7	57% (4/7)	29% (2/7)		OG	info	
	Manjimup/Pemberton		32	53% (17/32)	25% (8/32)		DAg/GN/Mag	info	
	Busselton		20	20% (4/20)	0%		Mag	mix	
	Albany		6	33% (2/6)	17% (1/6)		Mag	info	
	Other districts		1						
	Seed		23	30% (7/23)	9% (2/23)	29% (276)	Mag	info	30% (7/23)
South Australia .(1994)	All districts	180	28% (51/180)	47% (24/51)	25% (13/51)	54% (426)	CC/News	info/proof/other	43% (22/51)
	Mannum		25	52% (13/25)	36% (9/25)		CC	info/other	
	Penola		5	40% (2/5)	0%		Mag/News	mix	
	Mt. Gambier		6	33% (2/6)	0%		News	mix	
	Other districts		9						
	Crisping		7	100% (7/7)	86% (6/7)	13% (101)	CC	info	57% (4/7)
	Processing		6	83% (5/6)	33% (2/6)	43% (47)	News	other	50% (3/6)
	Seed		4	25% (1/4)	25% (1/4)	2% (17)			0%
	Ware		39	41% (16/39)	23% (9/39)	47% (374)	GN/CC	info/too risky	46% (18/39)
Tasmania .(1995)	All districts	550	36% (200/550)	37% (74/200)	n/a	n/a		n/a	14% (26/200)
	North Coast		119	39% (46/119)					11% (13/119)
	North East		24	29% (7/24)					21% (5/24)
	Midlands		32	44% (14/32)					22% (7/32)
	Other districts		17	41% (7/17)					6% (1/17)
New South Wales .(1994)	All districts	280 TBC	56 (20%)	57% (32/56)	29% (16/56)	n/a	CC/contractors Industry assoc. Mag	n/a	38% (21/56)

*GN - grower newsletter
GM - grower meeting
Mag - other magazine
DPI/DAg - govt. officer
EO - extension officer
OG - other grower
News - newspaper
CC - crop consultant

#Reasons:
too risky
hasn't been proven
poor results in past
not enough info
too difficult
other (specified)
not needed
mix= no one source stood out as the main reason

Table 2a: Relative abundance of parasitoids of the potato moth in potato growing districts of Western Australia and Victoria.

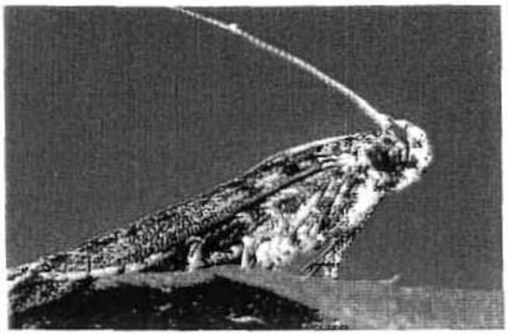
District	Year	Species				Total Wasps
		Org	Ap	Cop	Other	
WA						
Manjimup	1994, 1995	0	703 71.4%	260 26.4%	21 2.1%	984
Albany	"	0	476 93%	35 7%	0 0%	511
Busselton	"	0	160 76%	43 20%	9 4%	212
Bunbury	"	0	316 71%	125 28%	4 1%	445
Metropolitan	"	0	116 50.2%	114 49.4%	1 0.4%	231
State Total		**0 0%**	**1,771 74%**	**577 24%**	**35 2%**	**2,383**
Victoria						
Thorpdale	1988-91	343 61%	214 38%	0 0%	4 1%	561
Ballarat	1991	0 0%	234 97%	7 3%	0 0%	241
Toolangi - Kinglake	1991	233 34%	446 65%	7 1%	0 0%	686
Bellarine Peninsula	1993 1996	227 35%	256 39%	59 9%	111 17%	653
KooWeeRup	1994-94	382 65%	74 13%	22 4%	104 18%	582
State Total		**1,185 44%**	**1,224 45%**	**95 3%**	**219 8%**	**2,723**

Table 2b: Relative abundance of parasitoids of the potato moth in potato growing districts of Queensland and South Australia.

District	Year	Species				Total Wasps
		Org	Ap	Cop	Other	
Queensland						
Gatton	1994	172 78%	9 4%	36 16%	5 2%	222
Bundaberg	"	4 22%	10 56%	0 0%	4 22%	18
Atherton - Mareeba	"	2 15%	11 85%	0 0%	0 0%	13
State Total		**178** **70%**	**30** **12%**	**36** **14%**	**9** **4%**	**253**
South Australia						
Adelaide Plains	1992, 1995	110 35%	12 4%	187 60%	2 1%	311
Adelaide Hills	"	1	1	1	0	3
Bordertown	"	0	0	0	0	0
State Total		**111** **35%**	**13** **4%**	**188** **60%**	**2** **1%**	**314**

Appendix 1: Notes produced for growers

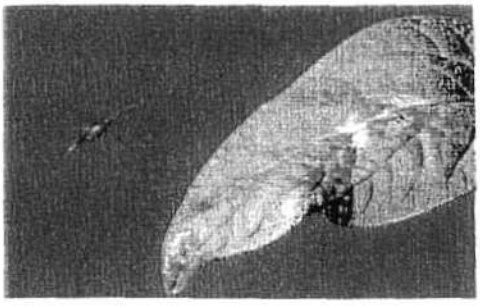
INSTITUTE FOR HORTICULTURAL DEVELOPMENT
Department of Agriculture, Victoria
HRDC



Countering the potato moth

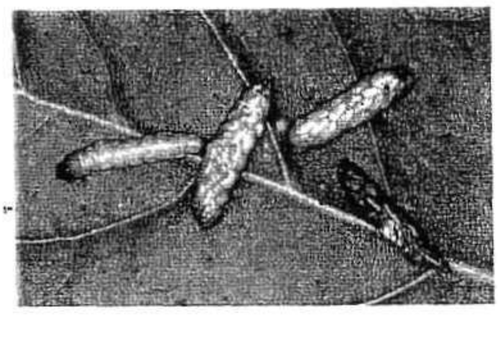
The potato moth (*Phthorimaea operculella*) attacks potatoes and other plants of the same family. The adult moth is about 8 mm long and is most active at dusk. Female moths lay up to 100 eggs each, on plant leaves or tubers or on the soil. Tiny larvae (caterpillars) hatch from the eggs and burrow either into tubers or into leaves (shown right), where they produce characteristic "mines" and often cause leaf curling. Apart from direct spoilage of tubers, burrowing by larvae can also allow pathogens to enter the tuber and spread under the soil.
Larvae feed for 2-3 weeks and grow to about 12 mm long, often turning pinkish as they mature. After pupating in the soil, they emerge as adult moths. The life cycle takes about 4 weeks at 23-25°C; however, at higher temperatures the cycle is faster and several generations may occur during a summer growing season. This leads to a build-up of moth numbers in the crop. During winter, the cycle slows down and little development occurs.

Insecticides have commonly been used to control the potato moth, but during the 1960s natural enemies of the moth were introduced to Australia. These biological control agents are small parasitic wasps, the largest species (*Orgilus lepidus*, shown left) being about 5 mm long. The wasps are present in most potato-growing areas around the country.
By themselves, wasps may not control potato moth for a whole growing season. However, early in the season they can replace insecticide sprays and keep moth numbers low enough to prevent a build-up later on. Unfortunately, most insecticides used will immediately wipe out the wasps for the rest of the season.



These parasitic wasps only attack the potato moth and cannot reproduce without it. Female wasps seek out either moth eggs or moth larvae in their leaf mines (shown left), in which to lay their own eggs. Young wasps develop inside the larvae, which usually die just before the pupation stage. Soon after, adult wasps emerge from the dead larvae. So not only do fewer moths emerge and lay eggs, but more adult wasps emerge to attack more moth eggs or larvae. If necessary, extra parasitised larvae may be placed in the crop to boost wasp numbers.

Both *Orgilus* and *Apanteles* wasp species lay eggs in the potato moth larva and one wasp emerges per larva. By contrast, the tiny *Copidosoma* wasp lays its eggs in the eggs of the moth; this results in at least 25 new wasps per larva. Shown at right is a healthy potato moth larva and larvae parasitised by *Copidosoma*. A dark colouration indicates that adult wasps are just about to emerge.
Although parasitised larvae continue to feed, this is not a threat to tubers early in the season, as long as there is a barrier of soil between larvae and tubers. This is an important cultural control method.



Cultural control of potato moth

Keeping a continuous soil cover over potato tubers not only prevents damage by larvae, but also stops adult moths from laying eggs on tubers. Even if moth numbers are high, a good soil cover will minimise tuber damage. However, low numbers of moths can be damaging if the soil is cracked or tubers are exposed. Normal irrigation and good hilling can provide a soil barrier for most of the season. As the crop matures, rolling of the soil or extra irrigation (if possible) can seal cracks and save insecticide costs.

Another cultural control method is to remove any weeds in which the potato moth can breed. These include volunteer potato plants and others of the Solanaceae family (eg. nightshades, kangaroo apples, tomato and capsicum). Early in the season, an infestation of moths from these weeds can establish a high population in the crop. This will be difficult to control later in the season.

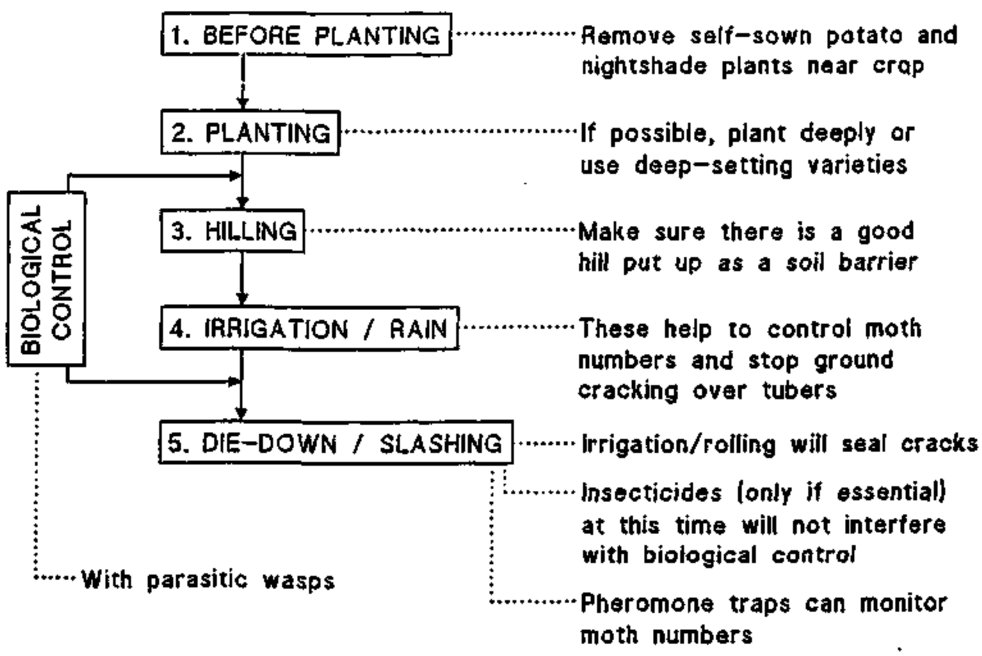
Monitoring moths in a crop will indicate when adult moths are increasing in number, which is when maximum benefit will be gained from insecticide sprays or mass releases of wasps. One way of monitoring moth numbers is to trap male moths using pheromone baits, which contain a synthetic female hormone that attracts the males. This method can easily be used by growers. Unfortunately, moth numbers cannot be directly related to tuber damage because of the variable soil cover, and so a reliable threshold number for spraying is very difficult to determine.

Putting it all together - Integrated Pest Management

Cultural, biological and chemical methods can be combined to form a flexible strategy for controlling potato moth. This type of practice is known as integrated pest management (IPM). Note that the term "IPM" does NOT mean "zero chemical use" (although this may be possible), nor does it simply mean "biological control". IPM should be seen as an approach to pest control, rather than a rigid set of rules to be followed. If the grower really wants to avoid spraying where possible, then he or she should benefit from monitoring the crop and using the best alternative methods.

Shown below is a suggested strategy for the integrated management of potato moth. It is based on preventing damage rather than totally eliminating the pest. The strategy, or parts of it, may not be feasible in all seasons or situations; the grower needs to decide how the crop is progressing during the season and to react appropriately. Sometimes, this may mean applying insecticides. However, in this particular strategy, the cultural control of providing a soil barrier is the most important single method.

Suggested IPM strategy for the potato moth in Victoria



Further information on integrated pest management of potato moth can be obtained from Paul Horne or Andrew Henderson at the Institute for Horticultural Development -
Private Bag 15, South Eastern Mail Centre, Victoria 3176. Ph.(03) 210 9222 Fax (03) 800 3521

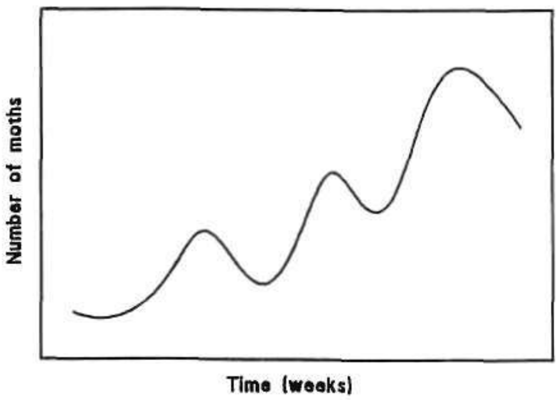
Monitoring the potato moth

AGRICULTURE VICTORIA HRDC

Deciding if or when insecticides are needed to control potato moth affects many economic and environmental issues in crop production. Unnecessary spraying may be avoided if reliable indicators about moth populations are available. Using weather patterns alone as a guide to spraying can be misleading; however, monitoring the changes in moth activity during the season can indicate when spraying will be most effective. Adult moths may be monitored by trapping them in the crop, which is a relatively easy and cheap method.

Why monitor the potato moth?

During a potato growing season in Victoria, potato moth numbers in a crop typically follow a pattern of peaks, as shown below:

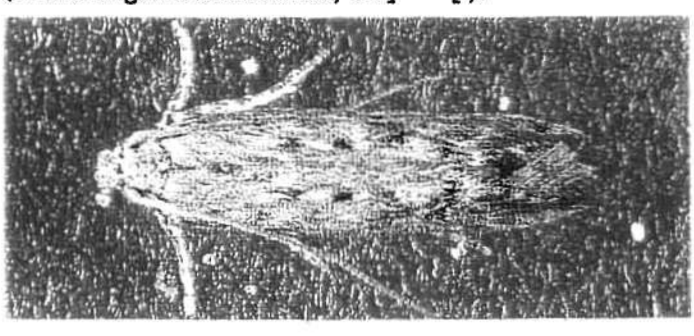


The number of peaks in a season indicates the number of moth generations and the length of time between peaks depends on the air temperature. The moth completes its life cycle in about 4 weeks at 23-25°C; in warmer weather it may only take 3 weeks and, in cooler weather, about 5 weeks. As a result, more generations occur during a very warm season and fewer during cool seasons. Over the winter period, the cycle may take 5 months.

If both moths and weather conditions are monitored from early in the season, then the approximate time of the next peak of moth numbers can be predicted from the previous peak. However, this does not necessarily mean that an insecticide will be needed. If a good soil cover can be maintained, then spraying is unlikely to be needed, especially early in the season. However, if the soil cracks or tubers are exposed, then even low numbers of moths may need to be controlled. In this case, the most effective time to spray will be just as the peak reaches its maximum height ie. just before the most eggs would be laid. Spraying at other times will certainly kill moths, but the population will build up again more quickly. Over a whole season, this could mean the need for extra sprays, so it is important to use insecticides at the most effective times.

For many insect pests in a variety of crops, the number of pests present indicates if an insecticide is needed ie. there is a **threshold** number of pests, above which significant damage to the crop may occur. However, for potato moth, crop damage depends more on the condition of the soil cover than on the number of pests. Because the soil cover is variable, a reliable threshold is very difficult to achieve. The main value of monitoring potato moth is in showing whether numbers are generally high or low and in predicting the best times to spray, if this is necessary.

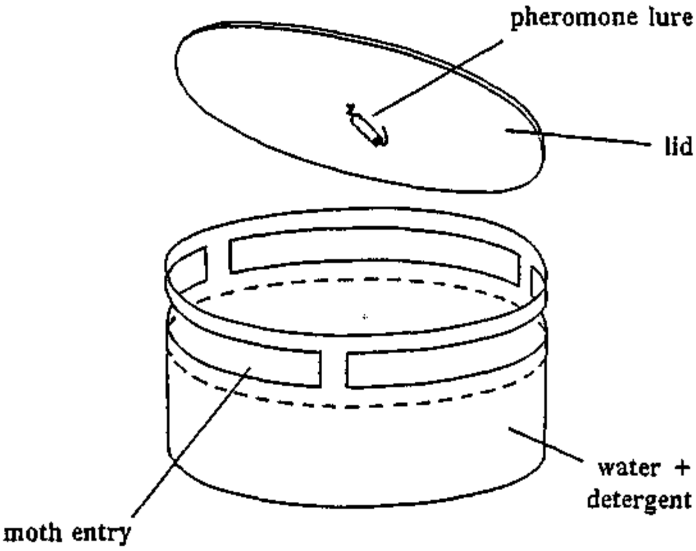
Other insects similar to the potato moth are often found in potato crops. Shown below is an adult potato moth (actual length is about 8mm, ie.]——[ ).



Monitoring with pheromone traps

Adult male moths are attracted by the sex scent (pheromone) of a female moth. Rubber tubing containing a synthetic form of the pheromone can be used to lure the males into traps. Once attracted to the lure, moths flutter around it and are trapped by falling either into a body of water or onto a sticky surface. The number of moths trapped indicates the activity in the crop.

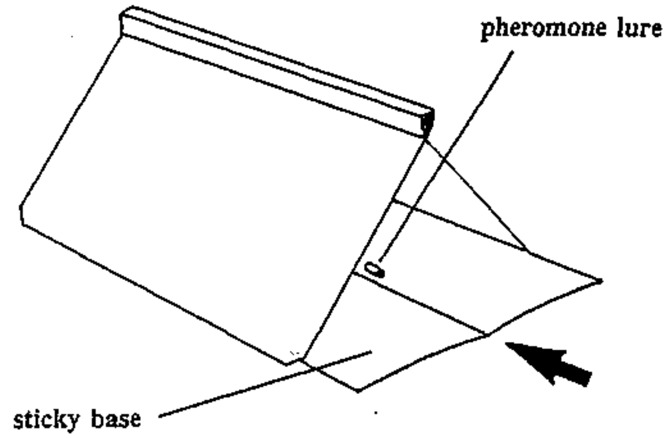
A water trap (eg. diagram below) can be made from a 2 litre sealable plastic container. The pheromone lure is held under the lid by a wire and slots (about 3 cm high) are cut in the sides of the container (just below the rim) to allow moths to enter. Detergent is added to the water to break the surface tension, so that moths will not remain on the surface and possibly escape.



WATER TRAP

Water traps need to be checked at least once a week, so that the water does not dry up and so that trapped moths do not decay, making them difficult to count. Moths can be counted while removing them from the water with a tea strainer. The traps can be used at canopy level in the crop (shown on previous page), or at ground level. The changes in moth counts are more important than the actual numbers, so either position is valid. This type of trap is very cheap, but will become brittle through exposure to the sun.

Traps which use a replaceable sticky base to capture moths ("Delta" traps) are commercially available. A pheromone lure is placed on the sticky base, which slides into an open-ended plastic "tent" (diagram below). Moths are easier to count when caught in this way, but must be removed from the sticky base before it can be re-used. Dust or mud on the sticky bases make these traps less effective, so it is best to support them above the ground (on a stake or fence post). Large numbers of moths can also clog the bases, so the traps need to be cleared quite often. This type of trap is more expensive than a water trap, but will resist the weather for longer.



"DELTA" TRAP

Setting up a monitoring system

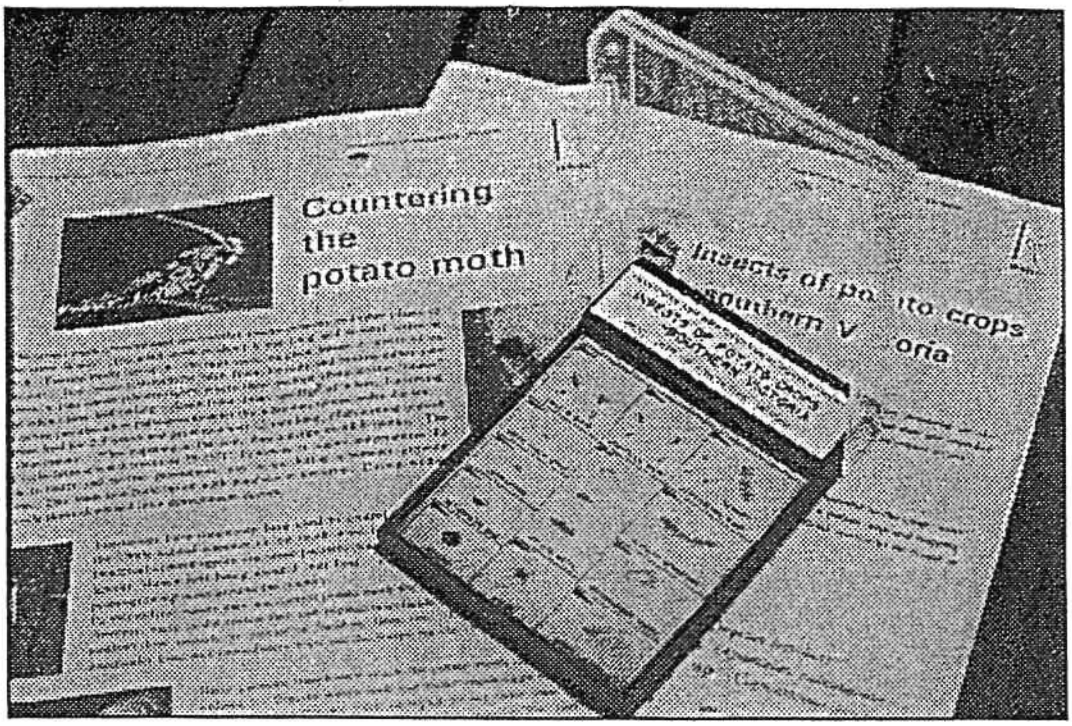
Whichever type of trap is used, 3 or 4 will be needed to properly monitor a crop paddock. However, it is not necessary to monitor each of a number of neighbouring paddocks.

Traps are normally spaced about 50m apart. They can be placed along the edge of the crop, but should not be smothered by weeds or crop foliage; this often results in few moths being caught and may underestimate the true moth activity. Rows of trees near the edge of a crop can also have this effect. The crop edge should have the highest numbers of moths, since it is the first area encountered by them as they invade. Traps along the edges are also easier to check.

Pheromone lures are supplied in aluminium foil envelopes and, if refrigerated, will last up to 4 years. Once in the field, they can be used for about 6 weeks before they must be replaced.

Monitoring should be carried out for as much of the season as possible, but especially when the crop is dying down, since this is when tubers are most likely to be exposed to moth larvae. Disturbances to the crop, such as fungicide spraying or die-down, usually cause a temporary increase in moth activity; this should be remembered when following the trends in moth numbers through the season.

Further details about trapping equipment and monitoring can be obtained from Andrew Henderson or Paul Horne at the Institute for Horticultural Development -
Private Bag 15, South Eastern Mail Centre, Vic. 3176.
Telephone: (03) 210 9222; Fax: (03) 800 3521.



The potato identification kit.

Potato-pest identification kits available

Information leaflets and an identification collection of pests and beneficial insects which affect potatoes are available from the Institute of Horticultural Development (IHD) Knoxfield, Victoria.

Prepared by Dr Paul Horne and his colleagues, the leaflets and collection will help to disseminate information from industry/HRDC-funded research on IPM in potatoes.

The full-colour information leaflets "Insects of potato crops — southern Victoria", and "Countering the potato moth" provide details about the biology and control strategies for pests.

The identification collection, in a plastic case with a clear cover, shows potato moth larvae, wireworm, whitefringed weevil larva, Rutherglen bug, leafhopper and green peach aphid as well the beneficials — *Orgilus* wasp, *Apanteles* wasp, *Copidosoma* wasp, ladybird, spider and green lacewing.

Leaflets and collections are available from Dr Horne at IHD, Knoxfield, Private bag 15, South Eastern Mail Centre, Victoria, 3176. Phone: (03) 210 9222; fax: (03) 800 3521.

The price is $10.00 including postage.

"Good Fruit & Vegetables" January 1995

Integrated Pest Management can help reduce your costs and the amount of insecticides you use.
Biological control of potato moth can now be achieved using parasitic wasps.

This video was produced by
Joanne Rae & Paul Horne, IHD, Knoxfield
with the assistance of:

McCain Foods (Aust) Pty. Ltd., Ballarat

Horticultural Research and Development Corporation

John, David & Andrew Jolliffe

Safeway Stores, Ballarat

DTC Production 1996
(03) 9827 5111

INTEGRATED PEST MANAGEMENT FOR POTATOES
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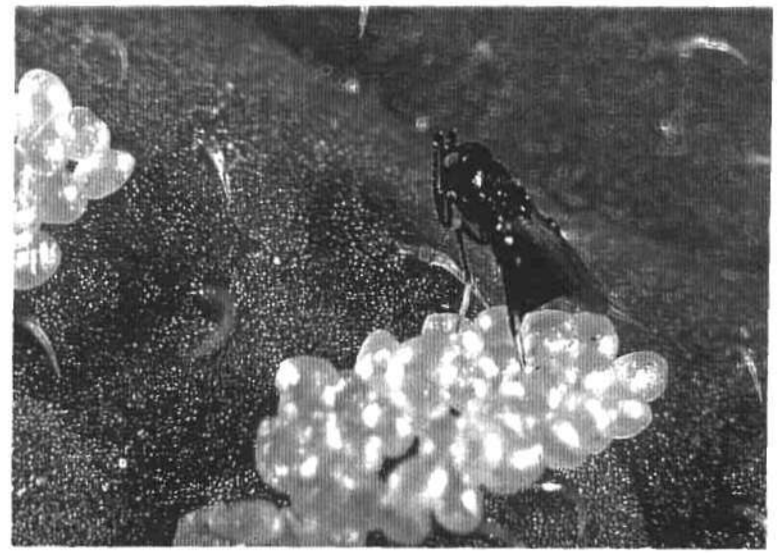
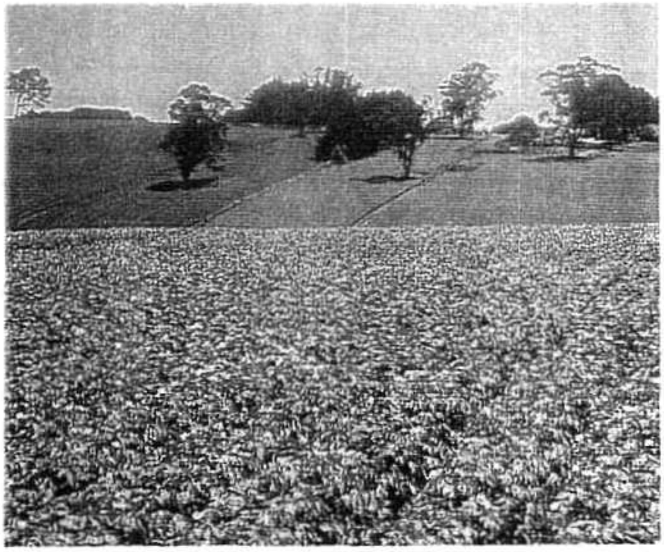
AGRICULTURE VICTORIA

INTEGRATED PEST MANAGEMENT FOR POTATOES

BIOLOGICAL CONTROL



Horticultural Research & Development Corporation



AGRICULTURE VICTORIA

HRDC

Insects of potato crops - southern Victoria

(this leaflet accompanies an insect collection prepared at the Institute for Horticultural Development; together they are intended to assist growers and others to identify insects in potato crops)

Potato crops provide food and shelter for a variety of insects and similar animals. Not all of these are harmful to the crop; many play a part in keeping pest numbers down. Small creatures such as these may not be easily visible in a potato crop and trapping may be needed to find them. The collection presents examples of the more common pest and beneficial species to be found in southern Victorian potato crops.

★ NOTE
Specimens in the collection marked with a **RED** arrowhead (➨) are potential pest species;
those marked with a **GREEN** arrowhead (➨) can help to keep pest numbers under control.

Potato moth *(Phthorimaea operculella)*

➨

Potato moth larvae ("grubs") hatch from tiny eggs laid on the soil or on crop leaves. They feed and grow by tunnelling into the leaves, but cause their worst damage by burrowing into tubers. When fully grown, the larvae pupate in the soil, before emerging as adult moths, which mate and produce more eggs. Several generations usually occur during a potato-growing season. While adult moths may shelter in other plants, they can only reproduce in plants related to the potato (including nightshades and tomato). The collection shows a larva, an empty pupal case from which an adult has emerged, and an adult potato moth.

Green peach aphid *(Myzus persicae)*

➨

The green peach aphid is the commonest aphid attacking potatoes in Victoria. Aphids feed by sucking sap from their host plant, but unless they are present in very high numbers, this is unlikely to cause major damage. The main threat from aphids is that they can introduce and spread viruses (eg. potato leaf roll virus) from plant to plant whilst feeding.
Most aphid species have both winged and wingless adult forms; only one of these is shown in the collection, but also shown is an aphid "mummy", which is an aphid attacked by a tiny parasitic wasp. The wasp egg laid in the aphid develops into an adult wasp and kills the aphid in the process. A number of wasp species attack aphids in this manner, acting as biological control agents.

Orgilus wasp *(Orgilus lepidus)*
Apanteles wasp *(Apanteles subandinus)*
Copidosoma wasp *(Copidosoma koehleri)*

➨

These wasps were brought into Australia as biological control agents for the potato moth (which was introduced accidentally). They only attack the potato moth and cannot reproduce without it. However, they are also very fragile insects and will be easily killed by insecticides currently used to control potato moth.

Female *Orgilus* and *Apanteles* wasps lay one egg in each potato moth larva, through a long egg-laying tube which can be seen in the collected specimens. The young wasp (maggot) develops inside the moth larva and finally kills it. An adult wasp then emerges, ready to attack more moth larvae.

The tiny *Copidosoma* wasp is similar, but lays its eggs in potato moth eggs. The moth larva hatches and grows, bu has an average of 25 new *Copidosoma* wasps developing inside it. When the larva dies, packed with developing wasps, it is known as a "mummy". The collection shows a "mummy" from which the adult *Copidosoma* wasps have emerged.

At least one of these wasp species is present in each of the main potato-growing areas of Victoria. Their numbers car be monitored in the field and it is also possible to releas extra wasps into the crop. In this way, the wasps can hel to reduce the need for insecticides to control potato moth.

ato wireworm *(Hapatesus hirtus)*

ι potato wireworms are a type of click-beetle. They ge in spring and summer to mate and lay eggs, then spend a winter sheltering under the bark of trees. The ralian potato wireworm (a native species), is a very -lived insect. The larva (shown in the collection) may in the soil for 5 years or more before pupating and ing into an adult beetle. This makes them difficult to :t and control. The larvae damage potatoes tubers by owing into them, and are able to move through the soil ı tuber to tuber. When potato tubers are not available, probably feed on the roots of bushes or on the taproots /eeds.

afhoppers *(eg. Zygina zealandica)*

fhoppers attack potatoes by sucking sap from the age, but rarely damage the crop directly. Like aphids, hoppers can spread diseases between plants through their ling activity. The disease most likely to be spread by hoppers in southern Victoria is purple top wilt (witch's om); however, this only occurs occasionally and, in eral, leafhoppers are a minor pest in this region.

hitefringed weevil
íraphognathus leucoloma)

ult whitefringed weevils usually appear in early summer. l adults are female ie. each is capable of laying eggs. ven a suitable food source, each adult can lay up to 1000 gs; however, weevils in cereal crops produce very few gs. Although they may feed on leaves, adults rarely use serious damage to potatoes.

ιe weevil larvae, which are maggot-like in appearance, ack several root crops and also lucerne. In potatoes, they ew directly into developing tubers, causing scarring and calloping" holes. The larval stage may take up to two ars to complete, so this insect is relatively long-lived. ecause the adults cannot fly, the weevils do not move long stances and damage is often concentrated in one area. he whitefringed weevil spreads between paddocks and rms mainly through the movement of soil containing eggs r adults (eg. on machinery).

Rutherglen bug *(Nysius vinitor)*

n southern Victoria, Rutherglen bugs are rarely common nough to cause damage in potato crops. However, where arge swarms occur, plants can be severely wilted or have heir growing tips damaged by the sap-sucking activity of he bugs. Adult Rutherglen bugs spend the winter among veeds and plant litter and breed there in early spring. As he weeds dry off in summer, the bugs seek out green plants, such as potato crops, on which to feed.

Ladybirds *(various species)*

More than one species of ladybird may be found in potato and other crops; generally, they have different markings on their backs. Ladybird eggs are usually spindle-shaped and are laid on their ends in groups among the crop foliage. Both adults and larvae of some ladybirds prey heavily on aphids. They can be useful biological control agents, especially if aphids can be tolerated in low numbers. However, if foliar sprays of insecticides are used to control aphids, then ladybirds are also likely to be killed. Ladybirds are a general type of predator and may also prey on the eggs of the potato moth and other species.

Green lacewing *(Chrysopa species)*

Like ladybirds, lacewings are major predators of aphids and more than one species may be found in a crop. However, lacewings will also attack potato moth larvae and eggs, as well as other insects. Even though they are much smaller than an adult (which is shown in the collection), it is the lacewing larvae which are the important hunters. Large, hollow jaws allow the larvae to pierce their prey and suck out the contents. The larvae are often difficult to see, because they attach the bodies of their prey to their backs as a form of camouflage. Groups of green lacewing eggs may be found attached to the undersides of leaves by long, flexible stalks.

NOTE: The normal colours of this lacewing (a bright green body and golden eyes) have been lost in the collected specimen due to the preserving process.

Spiders *(various species)*

The variety of insects found in a potato crop provides food for several types of spiders (which are **NOT** insects). These include ground-dwelling hunters such as wolf spiders, jumping spiders in the foliage and on the ground, and a range of web-spinning forms. All spiders poison their prey and then suck out the body contents without consuming the whole body. Spiders are useful general predators because they will feed on almost anything that they can catch. However, like most other predators and parasites, spiders are susceptible to insecticides used to kill pest species.

This leaflet and the insect collection it describes were prepared by entomologists at the Institute for Horticultural Development (IHD). For further information about insects in potato crops, contact Paul Horne or Andrew Henderson at:

IHD, Knoxfield
Private Bag 15
South Eastern Mail Centre
Vic. 3176.
Phone (03) 210 9222 Fax (03) 800 3521