Development of cultural control methods for pests of leafy vegetables

Dr Paul Horne
IPM Technologies Pty Ltd

Project Number: VG05008

VG05008

This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the vegetable industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of the vegetable industry.

ISBN 0 7341 1882 1

Published and distributed by:
Horticulture Australia Ltd
Level 7
179 Elizabeth Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399
E-Mail: horticulture@horticulture.com.au

Know-how for Horticulture™

Final Report

HAL Project VG05008: (August 2008)

Project Title: Development of Cultural Controls for Leafy Vegetables

Authors:
Paul Horne and Jessica Page
IPM Technologies Pty Ltd

HAL Project VG05008

Project Leader:
Dr Paul Horne
IPM Technologies Pty Ltd
PO Box 560, Hurstbridge, Victoria 3099
Ph: 03 97101554
Fax: 03 97101354
Email: ipmtechnologies@bigpond.com

Other personnel:
Jessica Page
IPM Technologies Pty Ltd

This report provides the results of research investigating the use of cultural control options that would encourage populations of key predatory insect and mite species that prey on pests of vegetable crops. It describes the results of field sampling in Victorian leafy-vegetable crops and laboratory trials with potential predators of Western flower thrips.

This study was funded by Horticulture Australia Limited and AusVeg.
June 2008

Media Summary

Cultural controls are under-utilised management options that are available for farmers to use to assist in the control of pests. They are practices that may either discourage pests or encourage beneficial species. They can be very powerful but are often overlooked even by growers using IPM. This project looked at several practical cultural controls that might encourage beneficial insects and mites and so assist with the control with a range of pests. An essential factor was that any suggested cultural control methods had to be practical and fit with existing farm practice.

An extremely simple method of increasing populations of key beneficial species was to plant strips of cereals in Spring. Planting strips of cereals ahead of the vegetable crop in spring acts as an on-farm insectary by providing cereal aphids as a food source for brown lacewings. Aphids in cereals do not affect vegetables but the predators eat all aphid species and so it is possible to favour predators of aphids generally without risking damage to vegetable crops. This has use when aphids are a serious pest, such as with lettuce aphid in lettuce crops.

Composted fowl manure can increase populations of soil dwelling predatory mites, but so also does any rotting organic matter. We suggest that the provision of any organic mulches (including crop residues) should encourage resident populations of predatory insects and mites.

Possibly the most important finding from this project is that control of Western Flower Thrips in leafy vegetables can be achieved using insect and mite predators as part of an IPM strategy. There are a range of predators of thrips that occur naturally, that can be encouraged by cultural practices, and that are effective in controlling WFT when insecticide-based approaches fail.

Technical Summary

This project aimed to evaluate several cultural controls for their potential to assist with pest management by encouraging populations of predatory species of insects and mites. In particular the project looked at whether or not certain plantings of non-crop plants could assist with pest control in leafy-vegetables. Rye-grass was selected because we knew planting it could fit in with existing farm practice and it grew well at the time of year that it was required. The project also investigated the potential of other management practices such as addition of composted fowl manure and using flowering weeds to augment populations of predatory and parasitoids insects and mites. Once again, these practices were selected because they could fit in with existing farm practices and so could be easily adopted if successful.

Such a project could only be carried out on farms where IPM is being practised, and results will only be of value to farmers using an IPM approach. [Integrated pest management involves using biological and cultural control measures, supported where necessary by pesticides]. Several farmers in Werribee South and Cranbourne, in Victoria, agreed to take part in the trial and plant non-crop strips. All of the trials were on a whole paddock basis, not small plot trials.

Farmers planted different width strips of cereals to suit their equipment. All types of plantings increased the number of brown lacewings (a major predator of aphids) in the paddocks studied. This has great potential for lettuce growers in particular who may want to stop using *Confidor*-drenched seedlings and rely on an IPM approach. In the celery crops where this approach was used there were increased numbers of lacewings but not greater control of celery mosaic virus (transmitted by aphids). No current control measures can prevent virus-infected aphids moving into a farm from surrounding areas, but control measures, including IPM, can prevent aphid populations from building up within the crop.

We have observed that predatory mites can be enhanced by the provision of composted fowl manure. We believe that this is because of the presence of sciarid flies and mites in the compost and therefore the provision of food for predatory mites. However, the same mites are present in practically any rotting organic matter including trash from previous crops. Good practice to utilise this effect would be rapid soil-incorporation of crop residues.

In commercial lettuce crops we found that suppression of Western Flower Thrips (WFT) was achieved in IPM grown lettuce crops but not in all non-IPM crops. Four potential predators of WFT were identified from the field and further studies in the laboratory confirmed that at least 3 could be important in control of WFT. Predatory thrips appear to be the most important. These predators were abundant in IPM crops but not in non-IPM crops.

This result is of great relevance to control of pests of leafy vegetables because we know that the predatory mites that we are discussing are also predators of WFT. WFT is a serious pest in lettuce crops in non-IPM lettuce and so the importance of the predators is going to be exceptionally important in the near future, and should be studied further.

Preliminary observations were also made on the potential use of flowering “weeds” to enhance populations of beneficial insects. At least some weeds (especially aniseed weed in Werribee South), have the potential to be utilised as a resource to increase populations of beneficial insects, and this needs to be studied in different locations to identify which could be used locally.

Introduction

This project aimed to evaluate whether or not certain plantings of non-crop plants can assist with pest control in leafy-vegetables such as lettuce and celery. It also assessed the potential of other management practices such as addition of composted fowl manure and using flowering weeds to augment populations of predatory and parasitoids insects and mites.

The target pests were primarily aphids and thrips. These are important groups for leafy vegetables as they include lettuce aphid (*Nasonovia ribis-nigri*) and western flower thrips (WFT) (*Frankliniella occidentalis*), both of which are resistant to a range of insecticides. WFT is also an important vector of tomato spotted wilt virus.

Strip plantings of cereals will attract certain species of aphids which may be pests in some crops (such as wheat or barley) but are not pests in leafy vegetables. However, predators of cereal aphids such as brown lacewings (*Micromus tasmaniae*) are predators of pest aphids and other insect pests in leafy vegetables. We aimed to find out whether or not strip plantings of cereals within horticultural crops can (i) increase the populations of beneficial species and (ii) increase the level of control of pests.

Mites, staphylinid beetles and predatory thrips are known to prey on thrips and this project investigated how populations of these groups could be encouraged. It has been noted recently (Beaulieu and Weeks 2007) that there are many soil-dwelling predatory mites that have potential as biological control agents in agriculture, but there has been extremely little research on this group. The use of composted fowl manure was seen as one potential means of achieving increases in resident, soil-dwelling predators. The sequence of events is hypothesised as follows:

1. The application of composted fowl manure will result in more sciarid flies.
2. Predatory mites and beetles that prey on these flies (as eggs and larvae) will be advantaged
3. The predatory mites that are encouraged feed on WFT
4. Therefore, improved control of WFT can be achieved by enhancing generalist predators including predatory mites.

There have been many studies on the provision of pollen and nectar sources to augment populations of biological control agents, particularly hoverflies. There are also some studies where “insectary plantings” have been used to provide an in-field resource to maintain populations of beneficial insects (Colley and Luna 2000). Examples of this type of approach from Australia include the use of strip plantings of lucerne in cotton (Cotton CRC 2005), grasses in citrus (Smith *et al*. 1997) and buckwheat in vineyards (Bernard *et al.* 2006, Berndt *et al*. 2002). In this project we conducted preliminary observations on the potential for existing weeds, particularly flowering aniseed weeds, to provide the same resource for beneficials.

Such a project could only be carried out on farms where IPM is being practised, and the results will only be of value to farmers using an IPM approach. [Integrated pest management involves using biological and cultural control measures, supported where necessary by pesticides]. This is because the beneficial species will only be of value where they can persist (that is, where no insecticide applications will kill them). It has been noted that farmers often do not value the role of natural enemies and were not manipulating their practices to conserve natural enemies (O'Neill *et al.* 2003). It was considered that there was great potential to improve the cultural control methods in vegetable production systems in southern Australia. It was not envisaged that this project would provide stand-alone means to control key pests, but would develop the cultural control component of IPM strategies.

A key consideration in this project was that the cultural control methods must be practical. Even if methods were developed that increased populations of beneficial species on-farm, if they were not practical then there would be no adoption.

Preliminary observations were also made on the potential use of flowering "weeds" to enhance populations of beneficial insects.

Lettuce aphid and WFT are major pests for certain vegetable crops and at present the accepted control measures are based on insecticides. At present, the most widely accepted means of controlling lettuce aphid is reliant on the use of a single chemical, imidacloprid. This is a non-sustainable situation and the APVMA permit for the use of imidacloprid as a drench on lettuce seedlings notes that the industry should develop alternative control methods such as IPM. The other major pest of lettuce is Heliothis (*Helicoverpa armigera*) which is also resistant to many insecticides. The ability of these species to develop insecticide-resistance means that providing a non-chemical alternative control strategy would have great significance for the long-term viability of several leafy-vegetable industries, particularly lettuce.

The arrival of lettuce aphid in Victoria since this project was proposed meant that most lettuce growers who had been using IPM changed to using a pesticide-based approach. This situation changed what was possible in this project from the original aims but has allowed the opportunity to observe differences in WFT populations, and predatory species, in lettuce. This project explored the possibility of biocontrol of WFT, a major pest of many crops, in leafy vegetables.

Materials and Methods

Strip plantings ("insectary plantings") of cereals

The first stage of this project found farmers who were already using IPM on their farms and who would be willing to collaborate in the project. Nine farmers in Werribee South and Cranbourne agreed to take part in the trial and plant non-crop "insectary plantings".

Insectary plantings are plants grown with the particular intention of harbouring or encouraging populations of beneficial invertebrates. All of the trials were on a whole paddock basis, not small plot trials.

A critical step in the development of any cultural control methods was that it be practical. Therefore, rather than insisting on a standard protocol all that was asked of collaborating farmers was that they plant a cereal on their farms to attract cereal aphids and their predators that would be expected to be flying in early spring. It was up to the different farmers involved in the trials as to the width of plantings, how it was managed, and the time that it remained on the farm. Most chose to plant strips of rye-grass at intervals through a paddock, but some chose to plant an entire paddock and then leave strips after ploughing. Rye-grass was chosen because it was readily available and could be planted in cool weather to be present in spring.

Key aphid predators, especially brown lacewings, were sampled from the insectary plantings using sticky traps, a vacuum sampler and direct searching.

Figure 1: Collecting insects from grassy strips using a vacuum sampler.

Composted Fowl manure

Soil samples, targeting species of predatory mites and staphylinid beetles that live in surface soil, were taken from farms using composted fowl manure and also from farms where no such manure had been applied. Samples were also taken from where it had just been applied and from sites where it had been applied 8 weeks earlier. Samples consisted of a 500 ml container filled with surface soil (to a depth of approximately 3cm). This was processed within 24 hours by direct searching in a white tray under lights. This allowed rapid processing of samples and was possible because the target species were highly active (but did not fly) and visible.

WFT control

The following sampling was undertaken to investigate WFT control in lettuce.

2006 sampling, Werribee South and Cranbourne
10 lettuces at harvest were sampled from each site and the presence or absence of WFT was determined by direct searching.

2007 sampling, Werribee South and Cranbourne
10 lettuces at harvest were sampled from each site and the presence or absence of WFT, predatory mites, staphylinid beetles and predatory thrips was determined by direct searching.

In addition, at two paired sites in Werribee South, each week for life of crop (weeks 3 to 7) 10 lettuces at harvest were sampled from each site and the number of WFT was determined by direct searching.
.

Feeding Trials (Laboratory)
Tests were conducted in the laboratory to see whether 3 species found in the sampling described above would accept WFT as prey. To do this, individuals of each species of potential predator were placed in small plastic containers with a known number of WFT and a small amount of Chinese cabbage. After 5 days the number of WFT were counted and compared to those in identical containers without the predators.

Species of potential predators were, *Dalotia sp. (*Staphlylinidae), *Parasitus sp*.(Acarina) and *Haplothrips victoriensis* (Thysanoptera).

Results

Insectary plantings and beneficial species

The first significant result was that farmers were easily able to understand the concept of insectary plantings and were able to create them using ryegrass. Examples of the different plantings that were created are shown in figures 2a-d.

Some farmers planted the entire paddock to cereals and then ploughed them in, others planted all sprinkler rows, and others planted strips throughout the crop. The decision on what sized strip to plant was made by the farmers on the basis of what was practical for them to manage. In all cases we were impressed with the fact that the growers were very happy to plant the cereals once they understood the logic behind the trials. It must be remembered that areas planted to cereals would not produce any crop for them.

One of the main aims of this project was to assess whether or not proposed methods were practical, and this project has demonstrated that planting non-crop plants is certainly possible in current practice. It especially suits farmers who grow cereals as green manure crops and may in fact encourage more farmers to do this as it has an additional benefit. It could become standard practice for some vegetable growers, but until it is, planting strips of grass is easily forgotten.

Figure 2a, b, c, d. : Different types of Strip Plantings

Vacuum sampling and direct searching were the best methods of sampling from the ryegrass strips. Sticky traps tended to become covered in dust because of the large area of bare-ground and so were of limited use in sampling for either pests or beneficials. They were useful in monitoring thrips numbers when the crop was established.

Lacewings were found in the insectary plantings in lettuce crops, but only one site continued to use IPM following the arrival of lettuce aphid. It is known that imidacloprid drenches used at the seedling stage kill brown lacewings (Cole and Horne 2006). Therefore there was only one site where lacewings encouraged by the insectary plantings could survive and so comparisons with non-IPM crops are limited.

In the celery crops where this approach was used, in the initial trial there were increased numbers of lacewings but not greater control of celery mosaic virus (transmitted by aphids).   When the crop was 6 weeks old there were as many lacewings in the crop as in the grassy strip, so the main value of the grassy strip is only in the early stages of the crop.

Flowering Weeds to Augment Beneficials

Sampling of flowering weeds adjacent to lettuce crops indicated that certain weed species could be useful in providing a pollen and nectar source to beneficial insects. It also showed that there were far more WFT in the crops than in the weeds. Direct observations showed that hoverflies and wasps were particularly attracted to the flowers.

Figure 3: Flowering Aniseed Weeds in Werribee South, a potential resource for beneficial insects

Control of Western Flower Thrips

Observations on WFT and potential biological control agents were made in commercial crops throughout the lettuce growing season in Werribee and Cranbourne. WFT were found to be present at all sites throughout the Werribee South production area. This was shown through sticky trap sampling. Counts of thrips in lettuce at harvest showed that numbers of WFT increased during the season at most sites but were well controlled in all IPM crops. ["IPM crop" is defined here to mean no seedling drench with Confidor and no broad-spectrum foliar pesticides that would detrimentally affect beneficial species as the biological control component is critical in the IPM strategy in lettuce].

Four species of potential thrips predators were identified, and laboratory studies have confirmed that at least three of these species will accept WFT as prey. Two are soil-dwelling species, a mite and a staphylinid beetle. The mite has been identified (by mite specialist Dr Jenny Beard, AQIS) as a species of *Parasitus* and the beetle is tentatively identified as *Dalotia*. The third species of importance is another thrips, *Haplothrips victoriensis.* A fourth species of predator, another thrips, was also found but laboratory studies have not been carried out to determine whether or not it will prey on WFT. The two species of predatory thrips were found only in the IPM crops.

Laboratory feeding trials confirmed that *Parasitus* and *Dalotia* accepted WFT as food. *H. victoriensis* has been kept in laboratory for 6 months on a sole diet of WFT. H. victoriensis is a known predator of mites (Bailey paper) but we believe that this is the first time that it has been recorded as a predator of WFT.

Our initial hope was that the addition of composted fowl manure would increase the resident population of predatory mites. However our sampling soon showed that any such affect was over-ridden by other factors such as soil structure and pesticide use. *Parasitus* and *Dalotia* occurred on a range of rotting organic matter, including the rotting material from the previous crop. Similar results have been found in South Australia (Dr Greg Baker, SARDI, pers. comm.).

Table 1: Presence or absence of WFT in Lettuce crops in two IPM grown crops and six insecticide treated crops in 2006. Site 1 in each area is the IPM site, all others are non-IPM sites.

Site	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
1 (IPM)	Absent	Absent	Absent	Absent	Absent	Absent
2	Present	Present	Present	Present	Present	Present
3	Present	Present	Present	Present	Present	Present
4	Present	Present	Present	Present	Present	Present
5	Present	Present	Present	Present	Present	Present
6	Present	Present	Present	Present	Present	Present
Gippsland 1	Absent	Absent	Absent	Absent	Absent	Absent
Gippsland 2	Present	Present	Present	Present	Present	Present

Figure 4: Mean number of WFT per lettuce at harvest in Werribee South lettuce crops, 2007.

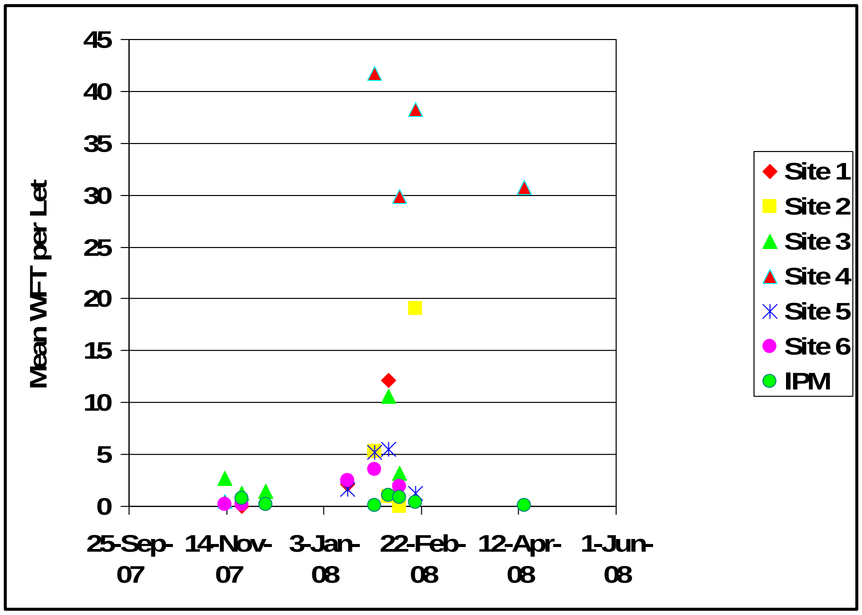
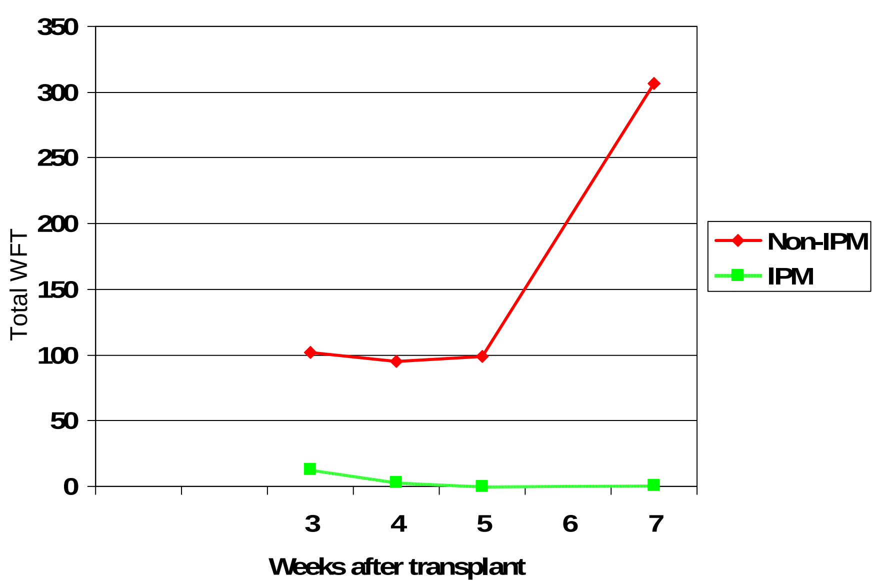


Figure 5: A comparison of WFT in two (paired) crops in Werribee South, 2007.

- Week 7 was harvest. The crops were identical in variety, climate, soil etc, and were approximately 500m apart.



Sampling of lettuce was undertaken at 4 IPM sites and 6 non-IPM sites. WFT was not abundant in IPM grown lettuce but was found at a much higher level, causing visible feeding damage, on non-IPM lettuce. Two IPM sites were in Werribee South and two were in the Cranbourne area. All of the non-IPM sites were in Werribee South.

Table 2 summarises the limited comparisons that can be made between these sites. It ranks the maximum counts of WFT in 10 harvested lettuce during the season from each site as either low (0-25 WFT total), medium (25 – 50 WFT total) or high (50 – 500 WFT). Note that only adult thrips were counted, so the actual totals would be higher where WFT was breeding successfully (ie in most of the non-IPM sites).

Table 2: Rating of WFT at all sites, using total counts of WFT in 10 lettuce: Low (L), Medium (M) or High (H). Low (0-25 WFT total), Medium (25 – 50 WFT total) or High (50 – 500 WFT).

IPM Sites				Non-IPM sites					
1	2	3	4	1	2	3	4	5	6
L	L	L	L	H	H	H	H	H	M

Discussion and Conclusions

It is clear that there are several useful cultural control measures that are practical, that vegetable growers can use to encourage beneficial insects and mites. That is, the cultural and biological components of an IPM strategy can be strengthened. This project has demonstrated that it is possible to use insectary plantings and made a part of normal vegetable production methods. The use of composted organic material was also shown to increase populations of soil-dwelling predatory insects and mites.

The beneficial insects and mites that are encouraged by these different methods fall into two categories, transient and resident. The strip plantings of cereals attract transient brown lacewings (*M. tasmaniae*) as they are dispersing through vegetable production areas in spring. They will stop in these strips but not in a bare paddock, and so it is a means to increase the population of predators on a paddock going into vegetable production. The organic composts can be used to increase the populations of resident soil dwelling predators.

The cultural control component of IPM is often given less emphasis than the biological or chemical components but this project has shown that it provides the basis for control of key pests. There are many different types of cultural controls that are available to farmers that are beyond the scope of this project but many are site or crop-specific. This work has focussed on methods to increase populations of beneficial invertebrates. Providing a suitable habitat for predatory species increases the role of both the resident and transient biological control agents. Planting insectary crops has also the added benefit of helping make growers aware of the broader approach to controlling pests by deliberately acting to encourage beneficial species. It is therefore a good starting point for those just adopting IPM, to emphasise the importance of cultural controls within an IPM strategy.

There is also potential for certain existing flowering weeds to be used to increase populations of beneficial insects by providing pollen and nectar. The situation that exists in areas such as Werribee South is that on land adjacent to crops that is usually not owned or managed by the farmer, there are often flowering weeds of different species. Management of these is restricted to limited herbicide applications which can result in bare ground or poor control of established weeds. Replanting these strips of land with native plants may be desirable (see Revegetation by Design Project) if particular species can be recommended, but no local species have been trialled in this area and it is currently not achievable by the grower, and is not a priority for them. This especially relevant for farmers leasing land on a short-term basis. We suggest here that there is scope to utilize some existing flowering weeds in preference to attempting to achieve bare earth.

The main concern is whether or not certain species of weeds will also encourage pests or be a reservoir of disease. Therefore, in brassica production areas brassica weeds would not be suitable but aniseed weed could be ideal. However, in celery production areas aniseed weed could harbour celery mosaic virus and so would not be suitable. The observations in this project have been that there are often large strips of flowering weeds on land adjacent to crops anyway, but that some of them could be considered useful rather than just weeds.

WFT Control.

The studies on WFT in lettuce crops showed that this species was surviving a range of insecticides, including drenches of imidacloprid. It was present in both IPM grown and non-IPM crops but in all sites studied the numbers of WFT never increased in IPM crops. WFT has been present in Victoria for many years but in Werribee South now has the potential to cause serious problems. The small number of IPM lettuce sites available makes firm conclusions difficult, but the results are consistent with the hypothesis that a range of predators, both resident and transient, are present in IPM crops and are preying on WFT, giving control. In the non-IPM crops the number and range of predators is much less and WFT populations have increased.

The naturally occurring predators are able to deal with WFT and we suggest that they have been doing so for many years. So there is no requirement to attempt to commercially rear and release these predators outdoors but simply not to kill them where they occur. It is much easier to avoid problems with WFT than to have to deal with this pest when it is in high numbers. Similarly, there is no need to develop specific strategies for WFT. It is dealt with through an effective IPM strategy covering all pests in leafy vegetables.

Next Steps

We suggest that the observations on control of western flower thrips without the use of chemicals needs to be explored further, in a range of crops. Given the increasing problems with WFT and its capacity to develop resistance to insecticides, we see this result as highly significant and a potential major step forward in the control of this pest in outdoor vegetable production.

It is not that any one of the predators alone is likely to succeed but when used as part of an IPM strategy they have the potential to provide significant control of WFT. This needs to be developed and tested in a range of crops and locations.

It should be emphasised that the predators involved are naturally occurring and can help avoid the problem. So for those growers that do not yet have a problem with WFT, then efforts should be made to ensure they avoid creating a problem. Managing existing populations of predators is the most important aspect, and at this stage no artificial mass-rearing of any of these predators is required.

However, an obvious next step is to assess whether an IPM approach that includes these predators can be used to solve an already bad problem with WFT (such as in lettuce and strawberries in Victoria). We suggest a HAL project to investigate the use of IPM, involving the cultural controls identified here, to deal with insecticide resistant pests such as WFT.

Communications/ Extension

An article describing this project was presented in the Ausveg publication and so distributed to all vegetable growers. The results of this project form the basis of an approach to dealing with WFT for theVictorian strawberry industry.

Acknowledgements

We thank all of the farmers that collaborated in this project, especially Tom and Theo Schreurs (J & JM Schreurs and Sons); Darren Schreurs (Peter Schreurs and Sons); Paul Gazzola (Gazzola Farms); John Fabbian; Paul Samarges; Andrew and Joseph Fragapane (Fragapane Farms); Jim Pateras; and Stan and Fred Velisha (Velisha Bros.), Con and Adam Ballan. We thank Dr. Jenny Beard (AQIS) for mite identification and Kate Lorey for conducting laboratory trials.

References

Bailey, P. and Caon, G. (1986). Predation on twospotted mite, *Tetranychus urticae* Koch (Acarina: Tetranychidae) by *Haplothrips victoriensis* Bagnall (Thysanoptera: Phlaeothripidae) and *Stethorus nigripes* Kapur (Coleoptera: Coccinellidae) on seed lucerne crops in South Australia. *Australian Journal of Zoology* **34:** 515 – 25.

Bernard, M., Semeraro, L., Carter, V. and Wratten, S.D. (2006). Beneficial insects in vineyards: Parasitoids of LBAM and grapevine moth in south-east Australia. *The Australian and New Zealand Grapegrower and Winemaker*. **513**: 21 – 28.

Berndt, L.A., Wratten, S.D. and Hassan, P.G. (2002). Effects of buckwheat flowers on leafroller (Lepidoptera: Tortricidae) parasitoids in a New Zealand vineyard. *Agricultural and Forest Entomology*. **4**: 39 – 45.

Cole, P.G. and Horne, P.A. (2006). The impact of aphicide drenches on *Micromus tasmanie* (Walker) (Neuroptera: Hemerobiidae) and the implications for control in lettuce crops. *Australian Journal of Entomology* **45**: 244 – 248.

Colley, M.R. and Luna, J.M. (2000). Relative attractiveness of potential beneficial insectary plants to Aphidophagous hoverflies. *Environmental Entomology* **29**: 1054 – 1059.

Cotton CRC (2005). Available online at http://www.cottoncrc.org.au/content/Industry/Homepage/Publications/PestsandBeneficials/IntegratedPestManagementGuidelines.aspx

Smith, D., Beattie, G.A.C., and Broadley, R. (eds) (1997). *Citrus pests and their natural enemies*. 272 pp. Queensland Department of Primary Industries and Horticulture Research and Development Corporation.

O'Neill, R.J., Yaninek, J.S., Landis, D.A. and Orr, D.B. (2003). *Biological control and Integrated Pest Management.* pp. 19 – 30. in *Integrated Pest Management in the Global*

Arena. 512pp. Maredia, K.M., Dakouo, D. and Mota-Sanchez, D. (eds). (CABI Publishing, UK.)