Integrated mite control in deciduous fruit tree orchards in Western Australia - 1993

S Learmonth
Agriculture WA
This report is published by the Horticultural Research and Development Corporation to pass on information concerning horticultural research and development undertaken for the apple and pear industry.

The research contained in this report was funded by the Horticultural Research and Development Corporation with the financial support of the apple and pear industry and the WA Fruit Industry Trust Fund.

All expressions of opinion are not to be regarded as expressing the opinion of the Horticultural Research and Development Corporation or any authority of the Australian Government.

The Corporation and the Australian Government accept no responsibility for any of the opinions or the accuracy of the information contained in this report and readers should rely upon their own enquiries in making decisions concerning their own interests.

Cover price: $20.00
HRDC ISBN 0 7341 0041 8
Published and distributed by:
Horticultural Research & Development Corporation
Level 6
7 Merriwa Street
Gordon NSW 2072
Telephone: (02) 9418 2200
Fax: (02) 9418 1352
E-Mail: hrdc@hrdc.gov.au

© Copyright 2000
HRDC Project
AP302 (30 June 1993)

Integrated mite control in deciduous fruit tree orchards in Western Australia

Stewart Learmonth
Agriculture Western Australia

FINAL REPORT
HRDC PROJECT AP 302

Stewart Learmonth, Entomologist, Agriculture Western Australia, Horticultural Research Centre, Manjimup, WA 6258.

PH: (08) 9771 2444. FAX: (08) 9771 2380. EMAIL: slearmonth@agric.wa.gov.au

This report documents the activities and results of research on the management of two-spotted mite in deciduous fruit tree orchards in Western Australia.

The financial contribution of the fruit growers of WA through the Western Australian Fruit Growing Industry Trust Fund and matched funding by the Horticultural Research and Development Corporation is gratefully acknowledged. Logistical and financial support from the research agency, Agriculture WA, is also acknowledged.

27 MARCH 2000

Any recommendations contained in this publication do not necessarily represent current HRDC policy. No person should act on the basis of the contents of this publication, whether as to matters of fact or opinion or other content, without first obtaining specific, independent professional advice in respect of the matters set out in this publication.
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEDIA SUMMARY</td>
<td>2</td>
</tr>
<tr>
<td>TECHNICAL SUMMARY</td>
<td>3</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>4</td>
</tr>
<tr>
<td>METHODOLOGY</td>
<td>5</td>
</tr>
<tr>
<td>RESULTS</td>
<td>6</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>12</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>14</td>
</tr>
<tr>
<td>TECHNOLOGY TRANSFER</td>
<td>14</td>
</tr>
<tr>
<td>RECOMMENDATIONS – SCIENTIFIC AND INDUSTRY</td>
<td>15</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>15</td>
</tr>
<tr>
<td>BIBLIOGRAPHY AND LITERATURE CITED</td>
<td>16</td>
</tr>
</tbody>
</table>
MEDIA SUMMARY

Key components of the project
This project investigated the effect of inundative releases in fruit trees of the predacious mites Metaseiulus occidentalis (MO) and Phytoseiulus persimilis (PP) in suppressing the pest mite, two-spotted mite (TSM), Tetranychus urticae. Also, MO and PP sustainability within the season of release and in following season was examined.

Industry significance
In Western Australian deciduous fruit tree orchards, control of TSM is based on monitoring populations and applying miticides when the local spray threshold is reached. Two species of predatory mite occur in WA orchards. These are MO and the Chilean predatory mite, Phytoseiulus persimilis (PP). Neither of these species is present in sufficient numbers early enough in the season to suppress TSM numbers to a level which would obviate the need for miticides. By inundative releases of MO and PP, this project aimed to develop a sustainable alternative to using chemical control for managing TSM.

Key outcomes
- The inundative release of MO in fruit trees early in the season resulted in a reversal in abundance of the two species of predatory mite, with MO becoming dominant over PP in the season of release.
- Trees receiving MO showed signs of reduced numbers of TSM, but the reduction was insufficient to obviate the need for miticide application.
- The reversal in abundance of the two species of predatory mite was partially sustained in the season following the inoculation of MO and in one of the release orchards, there were signs that TSM abundance was being reduced by MO in that season.
- In trees where PP was released the occurrence of this mite was earlier in the season, but TSM abundance was not reduced.

Recommendations for future R&D
- Further studies on variations to the method of inundative release of MO and PP in fruit trees adopted in this project may provide better suppression of TSM.
- Consideration should be given to assessing the role of the predatory mite species Typhlodromus pyri and Neoseiulus californicus, which have a reputation for success in fruit trees.
- The local threshold for spray decisions involving TSM should be examined to determine whether miticides are being used unnecessarily.

Recommendations for practical application to industry
- Early inundative release of MO could be trialed on commercial orchards with a “best bet” approach to timing and level of inoculation. Intensive monitoring would be required to avoid damage by TSM where miticides are not applied.
- Monitoring for TSM should remain the primary means for confirming the need to apply miticides for TSM control and getting the timing of applications correct. A miticide resistance management strategy should be adopted in the selection of miticides for application.
TECHNICAL SUMMARY

Nature of the problem
Deciduous fruit tree orchardists in WA rely on miticides exclusively for control of the pest mite two-spotted mite (TSM), *Tetranychus urticae*. Two species of predatory mite that attack TSM occur in WA orchards, but their abundance is low until late in the season.

Science undertaken
The two species of predatory mite that attack TSM are *Metaseiulus occidentalis* (MO) and the Chilean predatory mite, *Phytoseiulus persimilis* (PP). Both of these mites are commercially available in eastern Australia, but only MO has a reputation as a successful self-sustaining predator in tree crops. This predator was mass reared locally and released into TSM infested apple orchards. In one orchard, both MO and PP were released. Mite monitoring was undertaken to assess whether predator suppression of TSM could obviate the need for miticides.

Major research findings and industry outcomes
The inundative release of MO resulted in a reversal of the relative abundance of the two species of predatory mite, in favour of MO.

The abundance of TSM was reduced during the first season of MO release, but not below the local threshold and miticides were still required.

Only one orchard of the four monitored in this study showed indications of TSM suppression below the spray threshold in the second season after MO release.

Release of PP in one orchard resulted in the earlier occurrence of the predator, but no TSM suppression was observed.

Results of the project were sufficiently encouraging to consider further trial work and possible large scale commercial demonstrations.

In the meantime, orchardists should be encouraged to monitor for pest mites, so that miticides are used when needed, at the correct time, and the success of miticide application can be assessed.

Recommendations to industry, research peers and HRDC
Supervised release of commercially available predatory mites could be undertaken now. The suppression of TSM below threshold levels cannot be guaranteed, but close monitoring would avoid fruit damage should predatory mites fail to provide control.

Orchardists should adopt a mite monitoring approach to mite management to get best effect form miticides and use miticides according to a miticide resistance management strategy.

Contribution to new technology and future work suggested
This project sets a base line from which other studies might usefully form comparisons if the same or different species of predatory mite are used, and release methodology is altered.

Other species of predatory mite that should be considered for introduction to WA to potentially enhance predatory mite control of TSM are *Typhlodromus pyri* and *Neoseiulus californicus*.

Confirmation of the threshold for TSM in WA orchards should be undertaken.
INTRODUCTION

Deciduous fruit tree orchards in Western Australia are consistently infested with two-spotted mite (TSM), *Tetranychus urticae*. Occasionally, some orchards are infested with bryobia mite (*Bryobia rubrioculus*) and require application of pesticide, but TSM is far more common. European red mite (*Panonychus ulmi*) has not been recorded in WA.

If not managed, infestations of TSM result in leaf scorch and premature leaf drop. This can effect fruit quality in terms of colour and sunburn, as well as reduced tree health, which may effect the ability to produce and support normal fruit loads in the subsequent season.

The self-sustaining balance of predatory and pest mites in deciduous fruit tree orchards in the eastern states of Australia has lead to reduced use of miticide (Bower and Thwaite, 1995). This situation for TSM is based on the introduced predatory mite *Metaseiulus (Typhlodromus) occidentalis* (MO) (Bower and Thwaite, 1995). This predator has been introduced and released in WA orchards in the early 1970’s and is now established. MO does not, however, play a role in mite management because it is slow in building up sufficient numbers early in the season.

Another species of predatory mite introduced to Australia also occurs in apple orchards in WA. This species is the Chilean predatory mite, *Phytoseiulus persimilis* (PP). Like MO, this mite usually reaches high numbers late in the season, too late to reduce the abundance of TSM during summer when damage usually occurs. However, PP usually occurs earlier than MO and reaches greater numbers. This predatory mite is not regarded highly as a self-sustaining and reliable predator in fruit tree crops. However some New Zealand workers have reported success with inundative releases of PP. This predatory mite is commercially available from biological control companies in eastern Australia, where it is principally used in ground crops such as strawberries and in flower crops in glasshouses.

While a range of natural enemies of TSM occurs in WA (Sproul, 1981 and Learmonth, 1987), none have been shown to play a role in effectively suppressing TSM damage in commercial orchards. Therefore, management of TSM in WA relies entirely upon application of chemical miticides.

Disadvantages of this reliance on chemicals are that resistance to them has occurred in eastern Australia (Edge *et al.*, 1987) and overseas, placing further pressure on the relatively narrow range of miticides available. A survey of TSM resistance to miticides in WA found that high levels of resistance to ®Apollo and ®Torque have occurred (Herron *et al.*, 1997). More recently, the world’s first case of TSM resistance to the miticide tebufenpyrad (®Pyranica) which represents a relatively new miticide chemistry, was reported for WA (Herron and Rophail, 1998). Also, miticides are an added cost for orchardists and use of some miticides for summerfruit is not possible because of constraints regarding withholding periods.

The aim of this study was to determine whether inundative releases of the predatory mites MO and PP could play a role in management of TSM in WA deciduous fruit tree orchards.
METHODOLOGY

Mass rearing *M. occidentalis*

A strain of *M. occidentalis* held in laboratory culture at Agriculture WA in South Perth as well as a strain imported from a biocontrol facility in South Australia for a later study, were used in this project. The strain of predatory mite that was mass reared in Manjimup was originally obtained from Victoria and was supposed to have tolerance to both organophosphate insecticides and the insecticide and fruit thinning agent carbaryl.

Two-spotted mite (TSM) was used as the prey species for mass rearing the MO. A culture of TSM was maintained on potted French bean plants in a shadehouse. The shadehouse was divided into two sections – one section was clad in black shadecloth for rearing during the warmer summer months, while the other end was clad in bubble plastic to enhance plant growth and prey survival in the cooler spring months.

In a separate laboratory, MO was introduced onto the TSM infested bean plants. This laboratory was maintained at approx. 25 °C. Predators were harvested from the bean plants by removing leaves and cutting entire plants as predator numbers increased. Leaves or plants were placed in open mesh woven onion bags for distribution into orchards where their effect on TSM was measured. The bags were placed in the lower central part of the tree canopy, near the crotch of the tree.

Monitoring mites at release sites

The predatory mite MO, which was mass reared at MHRC, was released in four apple orchards – Newton Bros’, Simcock’s and Agriculture WA’s Manjimup Horticultural Research Centre in Manjimup, and Fry’s in Donnybrook. In each orchard, the predatory mite was released onto 5 trees.

To examine the effect of inundative releases of the other species of predatory mite, PP, both it and MO were obtained from commercial biocontrol factories in 1992 for releases into the apple orchard on MHRC.

Release dates for predatory mites for all studies are indicated by placing an “R” at the appropriate position in the figures below.

Pest and predatory mites were monitored fortnightly at the two orchards in two consecutive seasons. Mites were monitored in the five release trees as well as five trees in the row adjacent to the release row, where pesticide use was the same. These trees were termed RELEASE and NON-RELEASE respectively. Mites were also monitored in five trees where TSM control using miticides was carried out in accordance with the usual pest management program for the district. These trees were termed COMMERCIAL. At Newton’s orchard only, a further 5 trees in the same row and next to the five trees into which MO was released, were also monitored in the season during release and the early part of the following season. These trees were termed ADJACENT.

On each sampling occasion, 10 leaves were collected from the lower portion of canopy of each of the above category of tree. They were returned to the laboratory for examination under a dissecting microscope. The identity and number of motile mites were recorded for each leaf.

Records of pesticides used for mite, insect pests and diseases in all release orchards were kept.
RESULTS

MHRC reared MO releases
The percentage of leaves infested by pest and predatory mites where MO was released in 1990/91 for the two seasons 1990/91 and 1991/92 in the different categories of trees are shown in Figs. 1 to 4. The dates of release of predatory mites in each orchard are indicated as “R”.

The dates of miticide and relevant pesticide applications are indicated by arrows, with the miticides applied being: “A” = ®Apollo, “O” = ®Omite, “T” = ®Torque and “K+T” = ®Kelthane plus ®Tedion. Where a half strength ®Omite spray as applied, this is indicated as “½ O”. The only relevant pesticide applied was carbaryl, indicated by “C”.

At all release sites, two-spotted mite was more abundant in the season of release than the second season. The two species of predatory mite that occur naturally in the area were present at all locations.

In non-release trees, adjacent trees and commercial trees at Newton’s orchard, PP was recorded first and was more abundant than MO (Fig. 1). PP was first recorded in March, reaching a peak in abundance in April, which was well after the increasing numbers of two-spotted mites were recorded during December. In trees on Newton’s orchard where MO had been released in December, this species of predator was recorded first, earlier and displaced PP as the dominant species. Trees in the same row but adjacent to those onto which MO had been released had mite numbers and species similar to all non-release trees.

The timing, species and abundance of mites at MHRC (see Fig. 2) were similar to that at Newton’s. The most notable exception was the low number of two-spotted mites in trees in the commercial areas where a well-timed application of the ovicidal miticide ®Apollo was applied in December. An application of carbaryl insecticide for leafroller control on 13 March 1991 resulted in a drop in abundance of MO, but with continued presence of two-spotted mite, the abundance of the predator increased again.

In the Simcock orchard (see Fig. 3), the abundance of both species of predatory mites was lower in non-release and the commercial trees than at either Newtons’ or MHRC. In fact, no predatory mites at all were recorded in the commercial area where an early application of ®Apollo suppressed TSM abundance until February. In trees where MO had been released at Simcock’s, this species of predator occurred first, in greater abundance than PP and displaced this species. In release trees, the abundance of TSM fell earlier than either non-release or commercial trees.

In Fry’s orchard (see Fig. 4), the abundance of MO was highest in release trees, but was less abundant than PP, which was also more abundant in non-release trees. In all three categories, the abundance of TSM fell after an application of ®Kelthane and ®Tedion. It would seem that some drift of miticide onto the release tree rows occurred.

In three of the four orchards, the abundance of TSM fell earlier in those trees onto which MO was released compared to non-release trees. However, the abundance of TSM in these trees exceeded the local spray threshold level in the season of the release.

In the second season of monitoring, the increase in abundance of two-spotted mite was later and did not reach the same levels in abundance as in the season of release. Consequently, the abundance of predatory mites was lower.
Fig. 1. The percentage of apple leaves from Newtons' orchard in Manjimup, WA infested with two-spotted mite (TSM), and the predatory mites *Metaseiulus occidentalis* (MO) and *Phytoseiulus persimilis* (PP) where MO either had not been released (NON-RELEASE), or had been released (RELEASED), in trees adjacent to release trees and in a commercially managed section of the release block (COMMERCIAL). See text for details of miticide applications and predatory mite releases.
Fig. 2. The percentage of apple leaves from MHRC orchard in Manjimup, WA infested with two-spotted mite (TSM), and the predatory mites *Metaseiulus occidentalis* (MO) and *Phytoseiulus persimilis* (PP) where MO either had not been released (NON-RELEASE), or had been released (RELEASED), in trees adjacent to release trees and in a commercially managed section of the release block (COMMERCIAL). See text for details of miticide applications and predatory mite releases.

At Newton’s orchard, MO was the dominant species of predatory mite and was more abundant in both release and non-release trees compared to the trees treated according to usual commercial practice. Also, the abundance of TSM started to fall just prior to the application of miticide. Whether the miticide spray was required remains uncertain, but it indicates that more value may be obtained from the role of predatory mites.
Fig. 3. The percentage of apple leaves from Simcock’s orchard in Manjimup, WA infested with two-spotted mite (TSM), and the predatory mites *Metaseiulus occidentalis* (MO) and *Phytoseiulus persimilis* (PP) where MO either had not been released (NON-RELEASE), or had been released (“MO” RELEASE), and in a commercially managed (COMMERCIAL) section of the release block. See text for details of miticide applications and predatory mite releases.

At MHRC in the second season of monitoring, both species of predatory mite were found in release and non-release trees, with PP being slightly more abundant in non-release trees. In release trees, MO occurred earlier and in greater numbers, but did not displace PP for the season. An application of ®Torque in late January temporarily reduced the abundance of TSM in release trees and MO numbers subsequently declined also and were displaced by PP. Few predatory mites were recorded in commercial trees.
Fig. 4. The percentage of apple leaves from Fry's orchard in Donnybrook, WA infested with two-spotted mite (TSM), and the predatory mites *Metaseiulus occidentalis* (MO) and *Phytoseiulus persimilis* (PP) where MO either had not been released (NON-RELEASE), or had been released (*"MO" RELEASED*), and in a commercially managed (COMMERCIAL) section of the release block. See text for details of miticide applications and predatory mite releases.

In Simcock's orchard in the second season, TSM abundance was low until late January and remained below the spray threshold level (see Fig. 3). No predatory mites were recorded.
Fig. 5. The percentage of apple leaves from MHRC orchard in Manjimup, WA infested with two-spotted mite (TSM), and the predatory mites *Metaseiulus occidentalis* (MO) and *Phytoseiulus persimilis* (PP) where MO and PP had not been released (NON-RELEASE), or had been released ("MO" RELEASE and "PP" RELEASE), and in a commercially managed (COMMERCIAL) section of the release block. See text for details of miticide applications and predatory mite releases.
A similar low abundance of TSM was recorded in Fry’s orchard in the second season following the early application of Apollo (see Fig. 4). Both species of predatory mite were recorded in similar proportions in both release and non-release areas without any apparent residual effect of the release of MO in the previous season. Fewer predatory mites were recorded in the commercial area, but TSM was less abundant there also.

Commercial biocontrol laboratory reared MO and PP releases

The abundance of TSM and the two predatory mites MO and PP at MHRC where both predatory mites had been released are shown in Fig. 5. MO was released on two occasions and PP once. In both non-release and commercially managed trees, PP was the only predatory mite species recorded and it occurred late in the season in late March to early April. The release of MO produced the only trees where this species was recorded, but even in these release trees, the abundance of MO was low and it did not displace PP which was the dominant predator by the end of the season. In PP release trees, this predator was recorded earlier than in any of the other three categories of trees and in these trees there was a slight decline in abundance in the abundance of TSM compared to other trees.

Fungicides used by orchardists involved in this study were rated as having nil or minor effect on MO and PP according to the guide given by Bower and Thwaite (1995). Of the insecticides applied during this study, only butt drench applications of alphacypermethrin for weevil control could have had an effect. They were applied only at Newton’s on 6 December 1990 and 26 March 1991.

DISCUSSION

The timing of the occurrence of TSM in apple orchards in the Manjimup area is typified by the situation at MHRC in Fig. 2 for the first season. The pest mite is often difficult to detect until late December/early January, but when it is detected, air temperatures are high and the size of pest mite populations increases quickly. This has lead to the introduction of spray thresholds much lower than those adopted in eastern states’ orchards.

In WA, if miticides are not applied at around 30% leaf infestation, trees are rapidly colonised by mites to 100% infestation where mite control becomes very difficult. Such a situation requires the presence of predatory mites early in the season to prevent damage by TSM.

The mite infestation situation recorded at Newtons’ orchard where TSM was recorded on the first sampling occasion in November, is atypical for the area. This occurred to some extent in Simcock’s orchard where threshold levels of TSM occurred by the end of December. At the other extreme is the situation represented in Fry’s orchard where TSM did not reach the spray threshold until late February. This variation in the timing of occurrence of TSM emphasises the advantage of mite monitoring in order to achieve good timing of application of miticides.

For different reasons, the release dates for MO were not ideal in the sites used in this study. At Newtons’ orchard, because of an uncharacteristically early infestation of TSM, the release of MO was later than desirable. A release date in November would have been mush more appropriate. At MHRC and Simcock’s where the timing of the TSM infestation was more typical of the area, the lack of availability of MO until late January to early February meant the release dates here were later than preferred also. Timing releases of predatory mites to coincide with the first occurrence of prey is the most appropriate.
The release of the predatory mite MO into apple trees infested by TSM allowed this species to dominate PP, the other species of predatory mite that occurs in the Manjimup area. Although this study did not result in sufficient reduction in abundance of TSM to obviate the need to apply miticide, it gave encouraging signs that the abundance of predatory mites can be artificially manipulated. The earlier decline in abundance of TSM in those trees where MO did displace PP, suggests that with better timing, and the release of greater numbers of MO, natural control of TSM may be achieved.

As far as the predatory mites being self-sustaining is concerned, only in Newtons’ release trees did this appear to occur. However, MO was present as the dominant predatory mite species in both release and non-release areas which reduces the probability that the occurrence of this predator was due to the inundative release in the previous season. A detailed study on overwintering of both pest and predatory mites by Lacey (1994) showed that, while MO was capable of surviving winters in the Manjimup area, it did so in very low numbers.

In all release sites, the abundance of TSM in the second season of monitoring was very low until around mid January. This relative absence of prey would probably have been a disadvantage with respect to a build up in predatory mite numbers because the predators studied here are reliant on TSM as their major source of prey.

Similar comments can be made regarding the success of the other species of predatory mite released, PP. Because only one site was used for the release of this species, the suitability of this predator is less clear and more studies are required. Nevertheless, the present study demonstrated that releases of PP can lead to its earlier occurrence and consequently the chance for successful natural control of TSM. Given the usual situation of PP reaching large numbers in orchards without any releases, it is unlikely that the use of releases in one season would give rise to sustained biological control in the following season.

As has already been stated at the end of the Results section, foliar applications of fungicides and insecticides in release orchards were designated non-toxic to predatory mites. However, the presence of weevils in Newton’s orchards necessitated the application of a butt drenches of the synthetic pyrethroid insecticide alpha-cypermethrin.

This insecticide is very harmful to the two species of predatory mite encountered in WA orchards (Bower & Thwaite, 1995). Even though the insecticide is applied as a butt drench, that is not to say it is having no effect on the survival of the predatory mites. Synthetic pyrethroid insecticides have some residual activity. Weevil control involves the application of a butt drench against two weevil species that emerge at different times, and butt drenches could be applied from late October to mid December, and occasionally in summer as was the case at Newton’s. The effect of butt drenching with alphacypermethrin and other products toxic to predatory mites requires further investigation, especially with respect to their season to season sustainability.

Dimple bug (Campylomma liebknechti) and Mediterranean fruit fly (Ceratitis capitata) are the other major insect pests in WA apple orchards where registered pesticides may affect survival of predatory mites. Therefore, it is necessary to clarify the effect of such products. For dimple bug, insecticides are applied around blossom to early fruit set, a time most likely to be too early for much activity of both pest and prey mites. On the other hand, insecticides for medfly control may be applied from mid summer to autumn and could have a major impact on the abundance of predatory mites.
CONCLUSIONS

The inundative releases of predatory mites did not prevent TSM from reaching the local spray threshold under the strategies employed in this study.

The releases resulted in the earlier occurrence of the released species and in the case of MO, displaced the usually more dominant species PP.

Self-sustainability of the released species of predator such that they occur earlier in the season following release was either poor or did not occur.

To achieve control of the main pest mite TSM by using predatory mites, more studies are required. These could involve changes in the dynamics of the release procedure for MO and PP.

Introduction of new species of predatory mites, could enhance the possibility of sustained control of TSM using biological means. Some entomologists in Australia note a role for *Typhlodromus pyri* in suppressing TSM (for example Margaret Williams, pers. comm.) and this is supported by a study in Canada by Hardman *et al* (1997). This species is readily available from eastern Australia and should be considered for introduction. Likewise, the relatively recent and successful control of TSM in South Africa (Ken Pringle, pers. comm.) by *Neoseiulus californicus* also indicates this species of predatory mites could be considered for introduction.

In the short term, miticides will continue to be the frontline method of protection for orchards from damage by two-spotted mite. Timing of miticide applications should be based on monitoring and the selection of miticide based on a resistant management strategy (for example see Learmonth, 1999).

The use of pesticides for the control of diseases and insect pests in WA apples may have a negative impact on the success of predatory mite control of TSM. To minimise their impact, such pesticides should only be applied when necessary and only those products known to have least impact on predatory mites should be used.

TECHNOLOGY TRANSFER

Reporting to industry
The results of the investigations conducted have been presented to orchardists in WA through talks given at zone orchard improvement group meetings as well as during special industry meetings such as pesticide product releases.

Unfortunately the outcomes from the investigation perpetuate the principle of reliance on miticides for management of two-spotted mite in WA orchards.

Clarification of the role of existing predatory mites is an important step forward to pursue other objectives in relation to more effective natural control of two-spotted mite in WA. These new approaches will be pursued in partnership with industry.
Mite monitoring and mite management
While this project confirmed the need for reliance on miticides to protect crops from mites, involvement with industry has provided a two way experience that has seen the establishment of mite monitoring services in parts of the WA industry.

The reliance on miticides and the occurrence of miticide control problems through the development of resistance to miticides in WA have been important aspects in mite management to encourage orchardists to adopt new approaches to using miticides. The availability of crop scouts, all be it limited at present, and the development of a miticide resistance management strategy, are now important components of protecting orchards from mites in WA.

RECOMMENDATIONS – SCIENTIFIC AND INDUSTRY

Scientific
From experience around the world with management of two-spotted mite, the use of self-sustaining predatory mites is the most effective. For WA orchardists to be in the same position, further studies are required. To achieve self-sustaining predatory mite control of TSM, consideration should be given to importing Typhlodromus pyri. This species already occurs in Australia. Therefore it should be possible to get permission from quarantine authorities to allow its introduction and release in WA. It should be realised that this species is primarily a predator of European red mite which has not been recorded in WA. Nevertheless, for comparatively modest cost and significant potential benefits, the importation and release should proceed.

To enhance the effect of the two species of predatory mite that already occur in WA, further studies on the dynamics of inundative releases of them should be studied.

Considering the success of Neoseiulus californicus in managing two-spotted mite in the Mediterranean climate region of South Africa, consideration to start the procedure to import this predator should be given.

Industry
The results of this study offer no new approaches to predatory mite control of TSM in WA. Nevertheless, there were some encouraging signs which require clarification to further develop the role of predatory mites.

Reliance on predatory mites for managing TSM in WA is not possible in WA in the short term. In the meantime, WA orchardists should adopt a monitoring program to accurately define the need for and timing of applications of miticides. Miticides to be applied should be selected on the basis of a miticide resistance management strategy (for example see Learmonth, 2000).

ACKNOWLEDGMENTS

The technical support of the following members of Agriculture Western Australia staff and casual employees is gratefully acknowledged: Jackie Manning, Peter Needs, Eric Wootton, Sheree Mammone, Dianne Llewenden, Gaye Vardy, Sophie Spiroff.

The permission of Harvey Giblett, Glen Simcock and Graham Fry to conduct trials in their orchards is gratefully acknowledged
Supply of predatory mites by Andy Ryland and James Altmann is gratefully acknowledged.

The Western Australian Fruit Growing Industry Trust Fund, Horticultural Research and Development Corporation and Agriculture Western Australia provided financial support for this work.

BIBLIOGRAPHY AND LITERATURE CITED


