Insecticide Resistance In Mites:
Workshop Report 2012

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Prepared by:
Dr. Paul Umina and Helen Barclay (**cesar**)
Prof. Ary Hoffmann (The University of Melbourne)
Dr. Owain Edwards (CSIRO)

Workshop supported by:

cesar pty. ltd. 293 Royal Parade, Parkville VIC 3052
Phone: +613 9349 4723 Email: info@cesaraustralia.com

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Project team

Title	Name
Workshop Manager	Dr. Paul Umina
Workshop Facilitator	Helen Barclay
Workshop Consultant	Prof. Ary Hoffmann
Workshop Consultant	Dr. Owain Edwards

Abbreviations

Abbreviations	Description
RLEM	redlegged earth mite
RMS	Resistance Management Strategy
SP	synthetic pyrethroid
OP	organophosphate
GRDC	Grains Research and Development Corporation
RDC	Research and Development Corporation
MLA	Meat and Livestock Australia
AWI	Australian Wool Innovation
AHRI	Australian Herbicide Resistance Initiative

In this document, use of the term 'insecticide' refers to both acaricides and insecticides.

Contents

Executive Summary

The *Insecticide Resistance in Mites Workshop* brought together representatives from Research and Development Corporations, universities, CSIRO, state agricultural departments and agro-chemical companies in Australia. The objectives of the workshop were:

- To provide an update of the present status of insecticide resistance in mites and identify future risks.
- Develop a preliminary Resistance Management Strategy for redlegged earth mites and determine ideas for communicating this to growers and advisers.
- Identify/prioritise research gaps and extension needs.

Outcomes of the workshop are outlined in this report along with recommendations regarding resistance management strategies, communication strategies, as well as research gaps and extension needs.

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Earth mite control failures have the potential to cost the Australian grains industry >$500 million per annum, making insecticide resistance in mites an important issue. Earth mites are also significant pests of several pasture species, impacting the dairy, wool and meat industries. At present, insecticide resistance in the redlegged earth mite (RLEM - *Halotydeus destructor*) is particularly concerning. Chemicals are the most effective and widely used control method for RLEM across Australia. Resistance to synthetic pyrethroids was first detected in 2006 in Western Australia. Since 2006, resistance in RLEM has been confirmed at >15 properties in WA, with these properties ranging about 900km apart.

Very high levels of insecticide resistance in RLEM have been demonstrated in laboratory assays; this has translated to economic losses in the field due to the ineffectiveness of chemical applications and mortality of crop plants at seedling establishment caused by surviving mites. Resistance will almost certainly spread to new properties within WA, and it is likely that resistance will occur on the east coast of Australia – as long as the selection pressures are strong enough.

While there are new active ingredients currently under development among agro-chemical companies, there are very few alternative chemicals that are likely to be available for grain growers to control pest mites in the next 5-10 years. It is proposed that a Resistance Management Strategy (RMS) be developed to help growers manage resistance in RLEM and minimize future spread within Australia. In developing an effective RMS, there are many lessons to be learnt from insecticide resistance literature as well as the management of herbicide (and fungicide) resistance in Australia.

There are a number of key components requiring further consideration in developing a RMS for insecticide resistance in RLEM, including:

- Knowing the target audiences to tailor strategies and communications.
- Developing a decision tree and checklist to establish resistance risks and actions.
- Developing a genetic screening test to confirm the presence of resistance.
- Critical components of an RMS building from existing resources.
- Additional research to clarify a number of issues around resistance.

It will be challenging to ensure widespread RMS adoption for RLEM. There are still low control cost options available and resistance is not yet widespread. The 'urgency' is not there to help drive change. Such adoption challenges can be targeted with a well-considered communication campaign. A grower's decision to adopt new ideas and technologies is not only influenced by the facts, data and key arguments but also their intuitive thought processes. As an important part of understanding and engaging with the target audience, it is suggested that advisers and growers should play a key part in refining strategies, communication tools and approaches to ensure effectiveness and 'buy in'.

Beyond RLEM resistance, there is a broader issue of pesticide resistance, which poses a threat to the sustainability of Australia's agricultural industries. To help ensure resistance issues and risks are effectively managed it is suggested that a national management body be established. This would be an opportunity to consolidate expertise and efforts to build a central hub or 'alliance' with a focus beyond insecticide resistance in the grains industry.

1. Current status of insecticide resistance and future risks

RLEM biology and resistance update

The redlegged earth mite (*Halotydeus destructor*, RLEM) is an important pest of broadacre farming systems in Australia, New Zealand and South Africa, causing millions of dollars damage to crops and pastures. RLEM are extremely polyphagous, attacking a wide range of agriculturally important plant types, including most field crop and pasture species as well as many common weeds. RLEM is a seasonal winter pest, normally active between April and October. During this time, mites typically undergo three generations, with a generation time lasting approximately eight weeks. In the hotter, drier months of summer they survive as diapausing eggs in the cadavers of adult females.

Chemicals are the most effective and widely used control method, but evidence of high levels of resistance to synthetic pyrethroids (SPs) began emerging in 2006.[1] The first demonstrated case of chemical resistance in RLEM was discovered in 2006 in a canola crop north-west of Esperance, Western Australia. Researchers were alerted following multiple chemical control failures aimed at RLEM, which were attacking an emerging canola crop. Four separate chemical spray applications of SPs failed to achieve adequate control.[1]

High levels of resistance to two SPs – bifenthrin and alpha-cypermethrin – were found at this site. **cesar** found this resistance has a genetic basis, persisting after several generations of culturing in the laboratory. This means resistance can be passed from parents to offspring, and is likely to persist in RLEM populations over many years.

Between 2007 and 2010, Department of Agriculture and Food Western Australia (DAFWA) and **cesar** monitored resistance in field populations and found it had spread within the state of Western Australia. Twenty-six paddocks from 15 individual properties were identified with resistance, and these paddocks ranged over 480 km. Resistant populations were detected in three geographically separate areas: north-west of Esperance, north of Albany and near Boyup Brook. In 2011, resistance was found at another property approximately 200km north of Perth. This population is >450km from the nearest population previously detected, and almost 900km from the original Esperance site. To date, resistance has not been detected in any other Australian state. Resistance in RLEM appears to be found across the entire pyrethroid group, but not to other chemical classes such as organophosphates (OPs) and carbamates, or other chemistries with different modes of action.[2]

The high levels of resistance occurring in Western Australia have caused economic losses on affected properties due to the ineffectiveness of chemical applications and mortality of crop plants at seedling establishment. These findings highlight the need for a comprehensive resistance surveillance program to be developed for RLEM within Australia. Growers need to be aware of potential resistance developing on their properties. They should consider non-chemical approaches for pest control and should be encouraged to implement pesticide resistance management programs for RLEM.

Insecticide resistance mechanisms and non-target exposure

Insecticide resistance is predominantly achieved either by metabolic/enzymatic resistance mechanisms, or by altered target site resistance. The former usually results in a continuous distribution of resistance among field populations, whereas the distribution of the latter is more discrete, with a large gap between resistant and susceptible phenotypes. Metabolic resistance is usually partial or semi-dominant in inheritance, whereas target site resistance usually shows complete dominance or resistance.

Target site resistance to SPs is usually through modification of a sodium channel (called knockdown or '*kdr*' resistance), is usually a recessive trait, and its expected distribution is consistent with the observations of RLEM resistance in the field.

Researchers are presently investigating *kdr* as the SP resistance mechanism in RLEM by biochemical assays with synergists and/or analogy, by measuring its inheritance, and by sequencing the sodium channel gene in resistant versus susceptible mites. If *kdr* resistance is confirmed in RLEM, there may be subtle effects on fitness that should be investigated so we can predict whether resistance might disappear from affected WA properties in the absence of selection pressure. There were no fitness costs detected in mites cultured across several winter generations.[1] Furthermore, RLEM from a single paddock that were tested over four successive years were found to still exhibit high levels of resistance, even though SPs had not been applied to this paddock and neighbouring paddocks during this time.[2]

Exposure of resistant RLEM populations to targeted and non-targeted SP sprays has been reduced due to the increased popularity of imidacloprid seed dressings, and the increasing focus on cultural methods for pest control in canola. However, SP applications still remain the main control option for RLEM and other pests such as weevils, caterpillars and aphids. For RLEM, increased exposure of SPs is likely to continue for the foreseeable future even though they may not be the direct target in many cases. The repeated cumulative exposure to SPs is the main factor behind resistance developing.

RLEM genetics and future risks

Resistance was expected to evolve in RLEM because: (i) there is abundant genetic variation in this pest; (ii) it engages in sexual reproduction which makes resistance evolution more likely; (iii) resistance to pesticides has evolved in other pest mites such as the two spotted mite, reflecting the fact that genomically this group has the potential for developing resistance; (iv) selection pressures have been strong and pest population sizes are large – conditions expected to lead to resistance; and (v) researchers obtained preliminary data in 1997 for the development of tolerance to pesticides in eastern Australian field populations.[3]

Once resistance develops in RLEM in one location, it is expected to spread to others because gene flow patterns established from genetic markers indicates widespread movement in mite populations.[4] This occurs mostly at the egg diapause stage because direct measurements of movement of adults indicate that these only move tens of metres. There is also evidence that there has been gene flow between the east and west of Australia, given that populations from these regions are not differentiated from each other. The above considerations make it likely that resistance will occur at some stage on the east coast – as long as the selection pressures are strong enough.

It is unclear why resistance has so far developed for pyrethroids but not for OPs. One possibility is that there are costs to OP resistance because the initial case of tolerance detected on the east coast was lost after a season as might be expected when there are fitness costs. These might occur because of the long summer diapause phase faced by the mites, which is often the case in other invertebrates that have developed resistance and have a diapause period. Another possibility is that RLEM in southern WA were more frequently exposed to repeated pyrethroid sprays, often not as the intended target. It is also possible that RLEM may not be biochemically predisposed to develop OP resistance.

Ongoing screening of mites from the east and west is required in order to anticipate (and respond to) potential cases of resistance to the main pesticide groups. Additional research on inheritance, mechanism and local movement are also essential to understand patterns of resistance development.

Tolerance in other mite species

In addition to RLEM, there are several other mite species that are important pests of pastures and field crops in Australia. Some species have become more problematic over the last decade as farming practices have changed, and others are proving difficult to control due to tolerance and chemical resistance issues. The most economically important species are blue oat mites (*Penthaleus* spp.), Bryobia mites (*Bryobia* spp.) and the Balaustium mite (*Balaustium medicagoense)*. Unfortunately these mites are relatively similar in appearance and occur in sympatry with one another and with RLEM. Mis-identification and confusion among species leads to ineffective control of mite pests in crops and pastures. There is a significant issue among growers and advisers around mite identification.

Blue oat mites usually have three generations per season, with each generation lasting 8-10 weeks. Over-summering diapause eggs hatch in autumn, stimulated by cold temperatures and adequate moisture. There are three blue oat mite species that are pests of grain crops in Australia. Several crops and pastures are vulnerable to attack and they are most susceptible at the seedling stage. In particular, blue oat mites feed on cereals, grasses, canola, field peas, legumes and various weeds. Blue oat mites can have a higher tolerance to a range of pesticides. Spring spraying using Timerite® is largely ineffective against blue oat mites and is not recommended.[5]

Balaustium mites usually have two generations per season and do not require cold temperatures to stimulate egg hatching. Eggs will hatch as soon as there is sufficient moisture. They are easily distinguished from other mites when they are fully grown, as they are much larger in size. All crops and pastures can be attacked but canola, lupins and cereals are the most susceptible, particularly at the seedling stage. Some broadleaf weeds are alternative host plants.[6] Balaustium mites have a high natural tolerance to chemicals and will typically survive pesticide applications aimed at other mite pests.[7] There are currently no pesticides registered against Balaustium mites. In WA high rates of SPs (similar to rates used for weevils) are commonly applied. Their numbers are increasing considerably across south-eastern Australia.

Bryobia mites (also referred to as "Clover mites") are smaller than other commonly occurring pest mites. There are many species of Bryobia mites found in grain crops in Australia. They have several generations per year and are found in highest numbers during the warmer months from spring through to autumn. Bryobia mites have a preference for broadleaf plants, such as canola, lupins, vetch, lucerne and clover, but will also attack cereals. In pastures, Bryobia mites tend to have a preference for clovers and medics over grasses.[6] Bryobia mites have a natural tolerance to several chemicals.[7] There are several pesticides registered against Bryobia mites, however higher rates are required than for RLEM and blue oat mites.

Mites and resistance: RDC perspectives

The Grains Research and Development Corporation (GRDC) is the leading Research Development Corporation concerned with and active in addressing the issues of mite pests and insecticide resistance in mites. Earth mite control failures have the potential to cost the Australian grains industry >$500 million per annum,[8] with RLEM posing the most significant risk.

When it comes to protecting crops, GRDC's strategy is focused on achieving cost effective control options that prevent yield and quality losses due to pests, weeds and diseases, thus increasing overall profit. The issue of insecticide resistance among crop pests is an important component of GRDC's strategy. A key strategic aim is to have more grain growers and their advisers using practices to increase pesticide longevity and reduce the risk of resistance, which would be demonstrated by:

- Decreased rate of occurrence of new populations resistant to broadacre chemistries.
- Increased proportion of grain growers that use and rotate alternative registered chemistries.
- Increased proportion of grain growers using non-chemical control tactics.
- More advisers who provide resistance management advice to extend the longevity and efficacy of pesticides.

Another GRDC strategy that focuses on the issue of resistance is pesticide stewardship where growers and their advisers manage stewardship of pesticides and varieties to prolong pesticide effectiveness and ensure safety to health and the environment.

In addition to impacting grains crops, RLEM and other pest mites are important to several pasture species (particularly clovers, legumes and lucerne) that the meat, dairy and wool industries rely upon. While this is the case, earth mite pests are not ranked as a high priority in these industries. There are other issues beyond the scope of pest management that take priority, and in some cases, other invertebrate pests are presently more important.

For example, Meat and Livestock Australia (MLA) recently reviewed their investment priorities and invertebrate pests were placed towards the bottom of the list of fifteen topics. However, MLA recognises that invertebrate pests play an important role in ensuring stable and persistent pastures, and as such cannot be ignored. There is a need to better understand how insecticides are used and why. For Australian Wool Innovation (AWI) a large portion of their budget is spent on marketing and supporting exports. A major priority for AWI is to produce more wool to satisfy increasing demand. The concept of 'green wool' is generating more interest and as such sustainable industry practices are becoming a higher strategic priority. Reducing pesticide inputs and adopting IPM practices in pastures will therefore become more important. For Dairy Australia, new and improved feeding systems have been a priority with an increase in grain supplements compared with pastures. Invertebrate pests are important to the dairy industry, with pasture cockchafers (F: Scarabidae) regarded as one of the key pests presently troubling farmers. It is estimated that about 10% of dairy farmers spray for RLEM, and these are mostly applied as 'insurance' prophylactic sprays (R. King pers. comm.).

While RLEM and other mites are not presently perceived as major issues for industries beyond grains, there are substantial opportunities for cross industry collaboration.

Mites and resistance: agro-chemical company perspectives

The judicious use of more selective or 'soft' chemicals is common practice among other agricultural industries. However, there are very few genuine alternatives that are applicable to the grains industry. Recent research has shown that 'soft' chemicals can play a role against mite pests, but only in limited instances (P. Umina, pers. comm.).

There are new active ingredients currently under development among agro-chemical companies, however new modes of action with acaricidal properties are unlikely to be available to the grains industry in the near future, in part due to the high cost. At present, agro-chemical companies do not have a high level of commercial interest in RLEM or insecticide resistance in mites within Australia. Thus there are very few alternative chemicals that are likely to be available for grain growers to control pest mites in the next 5-10 years.

Australia is a relatively small market and pesticide priorities rank relatively low on a global scale. RLEM and mite resistance are not considered global issues, and in Australia, insecticide resistance in mites is presently impacting only a small part of the market. Growers can generally achieve adequate control of mites with current broad-spectrum insecticides. As a result there is low demand for the development of acaricide alternatives. This creates a hurdle for the timely development of chemical alternatives to support an effective Resistance Management Strategy for RLEM. Further challenging is the fact that many current broad-spectrum insecticides are very inexpensive and convenient to use. In addition, the usage of insecticide seed treatments offering a different mode of action to SP and OP chemistry (e.g. imidacloprid) is increasing in southern Australia.

There is little doubt that some insecticides that are presently registered (and largely effective) against grain and pasture invertebrate pests will be lost. There are presently several key insecticides under review by APVMA. This includes carbaryl, chlorpyrifos, dimethoate, fenithrothion, fipronil, maldison, methidathion and omethoate. Many of these insecticides have already been banned in Europe, and are presently registered to control RLEM and other mite pests.

2. Resistance Management Strategy

It is proposed that a Resistance Management Strategy (RMS) be developed to help growers manage resistance in RLEM and minimize future spread within Australia. The potential benefits of managing the risk of resistance have been highlighted in a recent review by Murray,[8] who estimated that without control measures for RLEM (e.g. if there was widespread resistance to multiple chemical classes) the potential loss to wheat, barley, oats, lupins and canola would exceed $250 million per annum. The cost to pastures and other broadacre crops would also be significant.

Lessons from insecticide resistance literature and management of herbicide resistance in Australia

The rapid evolution of herbicide-resistant weeds in Australia highlights the potential of insecticide resistance and the likely management challenges ahead. Herbicide resistance is a far greater problem for farmers in southern Australia than insecticide resistance. In part this is due to the fact that Australia has experienced one of the world's most severe herbicide resistant weed problems (S. Powles, pers. comm.). There are many lessons to be learnt from herbicide (and fungicide) resistance management in Australia.

Pesticide resistance is a fluid, evolutionary phenomena, and approaches to management must therefore continue to adapt. Although challenging and requiring significant expenditure, resistance is entirely manageable. Some key messages:

- Resistance will evolve where there is high reliance on pesticides and little diversity in pest management approaches.
- The time taken to develop resistance within a population can take a very long time due to fitness costs and the likelihood of a resistance mutation arising.
- Innovation and new management strategies are vital. An ongoing challenge is the successful adoption of recommended chemical diversification strategies.
- It is important to leverage current knowledge: general principles of resistance to chemicals can be applied across regions and different situations.
- To date, Australia has not leveraged the knowledge and capability across different disciplines of resistance (i.e. herbicide, insecticide and fungicide resistance). There is an opportunity for common lessons to be learnt.
- Growers should reap the benefits of management strategies they implement on their properties to address resistance (a situation likely with RLEM), however an Area Wide Management (AWM) approach would add further value.
- Management strategies need to be readily available and timely for growers and advisers.
- It is important to keep the end game in mind and understand the practical management of control strategies.

Some key lessons in management and minimization of resistance for RLEM:

- More persistent insecticides will result in higher selection pressure by providing selection across a longer timeframe and also by preventing immigration of susceptible individuals.
- The presence of refugia (parts of the landscape that are not exposed to insecticides) is important for pests with high movement rates as this will act to dilute resistance genes. RLEM have relatively low dispersal rates as adults, but high movement rates at the egg stage.
- The use of low versus high rates of insecticides may not be critical to resistance evolution in many cases (unless resistance is clearly recessive).
- Rotate insecticides between chemical classes (not within). Where possible, rotate and avoid mixing two or more insecticides.
- Applying mixtures of OPs and SPs to known resistant RLEM populations is not recommended. This will select for cross-resistance, particularly when the two chemicals have differing levels of persistence.
- Mosaics (alternation of insecticides across space) can be effective for species that are not highly mobile, such as RLEM. However of the three possible ways that two or more non-cross-resistant compounds can be used, mixtures, alternations, or mosaics, most situations will be best served by the alternation of pesticide groups across generations.
- Non-chemical control options (and minimizing selection pressures) will be important for the long-term management of resistance in RLEM.

Workshop outcomes

The workshop highlighted a number of key components requiring further consideration in developing a RMS for insecticide resistance in RLEM, including:

- Knowing the target audiences to tailor strategies and communications.
- Developing a decision tree and checklist to establish resistance risks and actions.
- Developing a genetic screening test to confirm the presence of resistance.
- Important components of an RMS building from existing resources.
- Additional research to clarify a number of issues/gaps around resistance.

Knowing the audience

Communication and adoption of a RMS will be challenging given insecticide resistance in RLEM is not yet widespread, and resistant populations can still be controlled by using OPs. It was determined that the target audiences should be separated into two distinct groups:

1. Localised - Growers who have insecticide resistance on their property and their immediate neighbours (one property removed).

2. National - Growers that do not presently have insecticide resistance, but want to be proactive in prevention (an approach where there is no perceived risk).

From the perspective of ensuring successful communication strategies and messages it was noted that there should be a distinction between advisers and growers as discussed in the *communicating an RMS* section (below).

Decision tree and checklist

This process would be primarily targeted at advisers (consultants and agronomists). A decision tree would help determine whether insecticide resistance is present, and if not, what the risk of it occurring is. It is envisaged that this process would also assist advisers determine the best course of action for a given situation. The basic concept is outlined below.

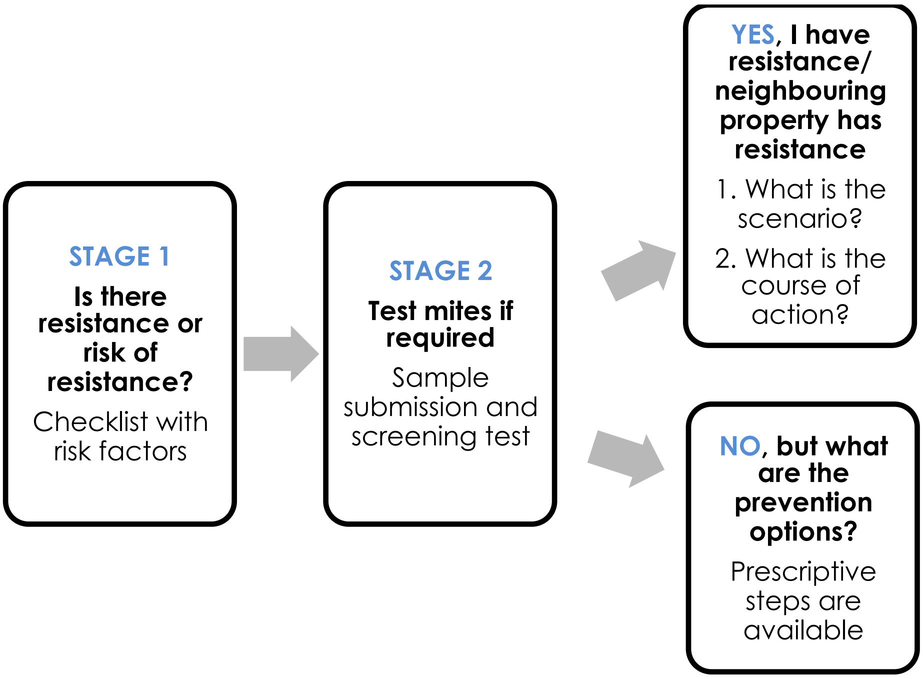

Figure 1: Proposed decision tree and checklist that could be used establish insecticide resistance risks and actions

Stage 1: A checklist to help assess the existence or risk of RLEM resistance. Such risk factors could include:

- RLEM have been identified as a problem on the property.
- Region where insecticide resistance has been identified (e.g. nearby properties).
- Intensive cropping history, with little pasture rotation or fallow.

- Signs of inconsistent crop growth (e.g. poor crop emergence, thinning of plants).
- Continual weed issues (e.g. poor autumn weed control, particularly broad-leaf weeds).
- History of repeated SP use (irrespective of target pest).
- Spray failure to control RLEM (particularly on the second attempt).

In refining this checklist, feedback from advisers is needed to ensure it will be beneficial and well received.

Stage 2: A simple robust laboratory bioassay has been developed by **cesar** following Hoffmann *et al*.[3] While extremely reliable and accurate, there is a need to develop a high-throughput molecular assay that is cheaper and requires far fewer mites and does not require samples to be alive.

Stage 3: There would be tailored action plans dependent upon a grower's scenario as established through stage 1 and 2 of the decision tree. These action plans could be focused on a management strategy or a prevention strategy.

Resistance Management Strategy components

There are two publications that can be used to form the basis of a Resistance Management Strategy for RLEM: (i) Farming Ahead (2012) - *Earth mite resistance marches on* (see Appendix 3); and (ii) DAFWA Farmnote (2011) - *Prevent redlegged earth mite resistance* (see Appendix 4). In addition, CropLife Australia has developed a simple RMS for RLEM. The key components of a RMS for RLEM are outlined below:

1. Correctly identify mites (this fits within the concept of the checklist discussed above)

- Training and development of identification guides.
- Support and rapid ID service for growers and advisers.
- Training and awareness of beneficial species (importance, ID).

2. Weed control

- Outlining weeds that are most important to RLEM breeding and survival.
- Guidelines around timing of weed control.
    - The year prior.
    - Pre-sowing.
    - Throughout the season.
- Weed control within paddock versus fence lines.

3. Cultural controls

- Plant host suitability/susceptibility for RLEM and other mites. This will allow risk factors to be determined and inform rotation best practices for paddocks that precede susceptible crops, such as canola.
- Rotations need to be practical/holistic/regional (e.g. must consider all pests in a given area, not just RLEM).
- Grazing pasture paddocks can reduce mite numbers, particularly in spring (note, this would be limited by the availability of stock and would not be possible in total cropping enterprises).
- Timing of sowing relative to risk (e.g. early sowing well in advance of RLEM hatching may eliminate the need for pre-emergent insecticides).

4. Insecticides

- Table listing chemicals currently registered against RLEM broken down into crop stage/timing of application.
- Monitor and assess mite numbers before deciding to apply chemicals (avoid insurance sprays).
- Understanding the effectiveness and role of insecticide seed dressings (and the importance of rotating seed dressings).
- Use of Timerite® in pasture paddocks in spring or an equivalent strategy (and possibly within crop if mite numbers warrant it). Rotate insecticide class used in Timerite® spray with early season applications.
- Do not mix OP/SP insecticides when targeting known resistant RLEM populations (where practical/possible).
- Growers may economically and easily establish refuges (requires further research but could be component of RMS).
- Importance of crop growth stage for susceptibility & linked to phenology of mite emergence (e.g. timing of spraying at crop emergence in autumn once mites have hatched but before they have chance to lay winter eggs).

5. Other

- A greater focus on biosecurity in situations where resistance exists.
- Area Wide Management strategies in situations where resistance exists (although acknowledging that RLEM shows limited rate of movement).

Emergency Use permits may be an option if resistance continues to spread. The potential advantages are: (i) introduction of a new chemical class, which would ensure control of resistant mites can still be achieved by growers; (ii) introduction of a new chemical class would ensure there are more options for chemical rotation which would delay resistance development; and (ii) assuming the cost of the chemical was relatively expensive (a likely scenario), demonstrate the potential cost of resistance to individual growers.

Recommended next steps

The proposed next steps for developing a Resistance Management Strategy are:

- Identify a working group to consolidate the workshop outcomes and develop a RMS for RLEM, ensuring advisers and growers are consulted and engaged in the process.
- Circulate RMS draft to workshop participants and other industry experts for comment.
- Finalise RMS content and liaise with GRDC to design and print RMS.
- Disseminate RMS through industry publications such as GroundCover in early 2013; place on appropriate websites; make available to researchers/consultants running training workshops and giving presentations.
- Seek RDC investment to bring together a team with diverse skills to:
    - develop the decision tree and resistance checklist.
    - develop a high throughput diagnostic for resistance and screen multiple samples in extensive surveys.
    - develop a national communication strategy.
    - research additional components to a RMS, including refuges.
    - oversee the implementation of a RMS.
    - monitor the success of the RMS.

3. Communicating a Resistance Management Strategy

Lessons from diamondback moth RMS communications

The diamondback moth (*Plutella xylostella*) is a damaging pest of canola and brassicaceous crops in Australia. Reliance on chemicals as a control measure for the diamondback moth has resulted in the development of resistance to many insecticides. A RMS for diamondback moth was developed by leading researchers, chemical company representatives and AvCare (now CropLife Australia) for the Brassica vegetable industry. This was launched in 1998.

The diamondback moth resistance campaign included a national resistance-screening program that spanned nine years. This allowed the industry to detect tolerance to three 'new' chemistries at the 'incipient' stage in a high-risk region (southern Queensland). With this knowledge control strategies could be modified and the industry could be cautioned accordingly.

There are some important lessons that can be learnt from the diamondback moth example. Key learning's relevant to the development of communication strategies for RLEM resistance include:

- The grower community became highly receptive to the diamondback moth RMS once crop losses and spray costs had escalated to 'breaking point'.
- The utilization of a range of communication tools (e.g. workshops and field days, print, video and web products) was very important.
- It was valuable to tailor communication tools (e.g. flyers) to specific areas and provide timely communication directly to growers, consultants and resellers.
- Outreach to other industries beyond horticulture was limited and could be improved upon. In the case of resistance in RLEM, it may be possible to have coordinated RMS messages disseminated to and jointly funded by several RDCs.
- The key elements of a communications strategy included:
    - strong collaboration within the industry.
    - significant industry investment from RDCs as well as agro-chemical companies.
    - dedicated IRM/IPM adoption coordinator(s) to produce extension products and maintain networks.
    - grower input to assist in tailoring information and identifying preferred information sources.

Communication and adoption challenges

It will be challenging to create a communication approach that successfully results in widespread RMS adoption. As highlighted by the diamondback moth example, growers only became highly receptive to an RMS once a sense of urgency was felt with crop losses and the escalation of spray costs. For RLEM, there are still low control cost options available and resistance is not yet widespread. The 'urgency' is not there to help drive change.

To ensure successful communication, it is suggested that advisers (consultants, agronomists, resellers) should be the primary target audience. It is the advisers who will have the strongest influence on grower decisions. Communicating directly to growers is important, but principally from a general awareness and support perspective.

Some other challenges that need to be considered when developing a communication strategy are:

- There is presently no committee or organisation responsible for developing and delivering a RMS.
- Seeking adoption and genuine practice change in eastern Australia when the issue is confined to Western Australia. It may be important to take a staged approach, where the west is the initial focus.
- Canola is a profitable crop and likely to be grown regularly given the right agronomic and climatic conditions, however canola is particularly susceptible to RLEM and typically requires chemical intervention to provide protection to emerging seedlings. Canola generally requires more insecticide input than most other broadacre crops, and is increasingly being grown across southern Australia.
- If messages were misinterpreted this could lead to growers and advisers becoming more risk adverse. This may result in management decisions that are contradictory to RMS recommendations (e.g. insurance sprays, mixing OP/SP chemicals, use of lower or higher spray rates).
- Growers with resistance RLEM do not necessarily have spray practices that are markedly different from their neighbours and others in the district.
- The potential conflict of interest among chemical resellers/sales agronomy and RMS recommendations.

Communication strategy

Adoption challenges can be targeted with a communication campaign. A grower's decision to adopt new ideas and technologies could be influenced not only by the facts, data and key arguments but also their intuitive thought processes (motivations and feelings). Therefore, a successful communication campaign should not only outline the present issue(s) surrounding resistance, but also focus heavily on persuading growers to change how they do things. Working with advisers will play an important part of this.

As outlined in the *How to Use Persuasion Skills to Drive Technology Adoption* training program,[7] there are some fundamental areas to consider in achieving adoption. These could be considered in the development of a communication strategy:

- Consult the client: how to build the foundation for adoption through understanding and engaging with the audience.
- Package the concept: how the RMS is presented to the audience so that it is attractive and in a form that can be implemented.
- Tune the channels: how the RMS is 'sold' to the audience ensuring that both the rational decision and intuitive decision elements are considered.
- Remove the barriers: identifying barriers that may stop adoption of the RMS and ensuring the clearest possible path for adoption is available.
- Ensure commitment: how to 'close the deal' and achieve ongoing action from the target audience.

As an important part of understanding and engaging with the audience it is suggested that advisers and growers should play a key part in refining strategies, communication tools and approaches to ensure effectiveness and 'buy in'. The fact that advisers and growers have been adhering to a RMS and IWM approaches to manage herbicide resistance in several key weeds is encouraging. It is envisaged that a RMS for RLEM resistance will not be easily ignored if/when the same level of 'crisis' or 'urgency' occurs.

The development of a decision tree and checklist discussed earlier could prove to be a core communication tool in successfully 'packaging the concept'. Other components of a communication strategy for further consideration are outlined below.

Possible channels/tools

- Effectively incorporate RMS into the content of general agronomy plans for a crop. This will help with acceptance by growers and advisers.
- Work with herbicide (and fungicide) resistance communication channels and current media strategies.
- Predict spread of resistance and highlight 'risk areas'. This will encourage monitoring and RMS uptake.
- Develop a scenario modeling technology that growers can use to assess their individual situation and potential risk factors. This could highlight short-term versus potential long-term costs. The bio-economic model *Ryegrass Integrated Management (RIM),*[10] is a good example of how models might assist users to

simulate the effect of RLEM control methods on cropping productivity and resistance risk.

- Advocate/champions (advisers or growers?).
- Promotion at existing GRDC and other industry events.
- Mentoring for growers and/or advisers.
- Workshops with ongoing support (and importantly with follow up evaluation).

Ideas for messages and delivery

- Ensure messages are simple and consistent (yet paint a holistic picture).
- Ensure communication is kept separate from advertising material(s).
- Ensure messages are appropriately 'branded' and credible (e.g. branded with GRDC logo).
- Build and promote a 'positive' picture (e.g. case studies that highlight what success looks like).
- Focus on advisers, who in turn will influence growers.
- Focus on advisers who are early innovators.
- Target growers who are neighbours of properties with insecticide resistance.
- Convincing and supporting chemical resellers/sales agronomists (often the point at where growers are making their critical decision).

Recommended next steps

The proposed next steps in successfully communicating a RMS include:

- Development of a committee responsible for RMS communication (include representatives for agro-chemical companies, researchers and growers to develop integrated efforts).
- Build a communication strategy incorporating the resistance checklist concept and ensuring both advisers and growers are targeted accordingly.
- Ensure collaboration across states, organisations and between the various agricultural industries (i.e. grains and pastures).
- Seek external advice from communication and marketing specialists.
- Ensure engagement with audiences in refining approaches (e.g. feedback from advisers and growers).
- Establish a process to measure the success of campaigns and adoption of the RMS (e.g. the GRDC IPSOS grower survey).

4. Research gaps and extension needs

Priority research and extension gaps

1. Testing Service & Surveillance of insecticide resistance

- Surveillance of resistance in WA and other states (incl. documentation of detailed paddock histories).
- Development and delivery of molecular diagnostic service for RLEM and other mites.
- Understand landscape level impacts on resistance spread.

2. Understanding insecticide resistance

- Investigate fitness costs in RLEM (this will feed into a RMS and future modelling exercises).
- Field studies on refuges for RLEM (chemical and physical).
- Investigate behavioural resistance in all mites to different chemical classes (not just SPs).
- Genetic analysis to determine multiple resistance events/gene flow versus independent event/spread in RLEM.

3. Modelling

- Spread of insecticide resistance in RLEM and link to insecticide and cropping intensity.
- Predict future outbreaks of resistance in RLEM in eastern Australia.
- Timeframe for resistance to develop to OPs and other chemical classes in RLEM.
- Sampling regime for effective resistance monitoring in all mites.

4. Extension & management strategies

- Development of a committee responsible for RMS production.
- Ensure RMS is adopted both locally and nationally.
- Include representatives from chemical industry, researchers and growers.

5. Other

- Future alternative chemistries (incl. Emergency Use permits and R&D).
- Role of beneficial invertebrates in farming systems.

National insecticide resistance management

Beyond RLEM resistance, there is an overarching issue of insecticide resistance, which poses a threat to the sustainability of Australia's agricultural industries. To help ensure issues and risks are effectively managed it is suggested that a national management body be established. This would consolidate efforts to build a national centre with a broader focus than just insecticide resistance in grains - that could attract and support sufficient capacity to allow a multidisciplinary approach. Such a nationwide group could link organisations, individuals, industries and leverage the knowledge, research, extension and funds already underway and available. Such consolidation would potentially result in greater efficiencies and outcomes, and would also become more attractive for future investment.

A national group could be a virtual centre (e.g. a place to receive funding and develop strategic investments; streamline administration). One approach could be to establish an insecticide resistance management body with a breadth of scope that includes pests not only of grains, but also of other crops, and which could be modeled upon the highly successful AHRI research centre for herbicide resistance management. Alternatively, a new centre could leverage capability at AHRI by broadening the scope of this existing initiative to include insecticide, herbicide and fungicide resistance management. There are several key research groups with expertise across these disciplines.

Some questions to consider:

- Who would be involved and who would lead the centre?
- Would a Cooperative Research Centre approach be an appropriate way forward?
- What are the cross state issues to consider?

Recommended next steps

The first step to pursuing a national resistance management 'alliance' is to hold a meeting to discuss opportunities for synergies between herbicide, insecticide and fungicide resistance management. There is a meeting tabled for 17th September 2012 at University of Western Australia. From here consequent steps of action can be established.

Acknowledgements

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Appendices

Appendix 1: Workshop attendees

Appendix 2: Workshop agenda

Appendix 3: Farming Ahead (2012) - *Earth mite resistance marches*

Appendix 4: DAFWA Farmnote (2011) - *Prevent redlegged earth mite resistance*

Appendix 5: Workshop Presentations

- RLEM biology and resistance update (Dr. Paul Umina)
- Insecticide resistance mechanisms (Dr. Owain Edwards)
- RLEM genetics & future risks (Prof. Ary Hoffmann)
- Crop mites – other species and tolerance issues (Dr. Paul Umina)
- Herbicide resistance and it's management (Prof. Stephen Powles)
- Resistance Management – how to choose (Prof. Rick Roush)
- Protecting your crop – future options mite control (Dr. Rohan Rainbow)
- Effectively Communicating a RMP – lessons learned from DBM vegetable industry experience (Dr. Greg Baker)

Appendix 1: Workshop attendees

Allen	Cameron	Meat & Livestock Australia
Baker	Greg	South Australian Research and Development Institute
Barclay	Helen	**cesar** pty. ltd.
Burnett	Ralph	Grains Research & Development Corporation
Downard	Paul	Dow AgroSciences
Edwards	Owain	CSIRO
Hoffmann	Ary	University of Melbourne
King	Ray	Dairy Australia
McDonald	Garry	The University of Melbourne
McKee	Ken	Syngenta Crop Protection
Manatsa	Gus	Australian Wool Innovation
Micic	Svetlana	Department of Agriculture and Food Western Australia
Nansen	Christian	University of Western Australia
Powles	Stephen	University of Western Australia & AHRI
Rainbow	Rohan	Grains Research & Development Corporation
Robertson	Geoff	Bayer CropScience
Roush	Richard	University of Melbourne
Shannon	David	Grains Research & Development Corporation
Umina	Paul	**cesar** pty. ltd. & The University of Melbourne
Wells	Andrew	NuFarm

Workshop - Final agenda

Insecticide resistance in mites

20th - 21st June 2012

Bio21 Institute (The University of Melbourne), 30 Flemington Road, Parkville

Day 1

Time	Topic	Speakers
8.50 - 9.00	Arrive at Bio 21 reception to be signed in	
9.00 - 9.20	Introduction	Helen Barclay (cesar)
9.20 - 9.50	RLEM biology & insecticide resistance update	Paul Umina (cesar)
9.50 - 10.20	Insecticide resistance mechanisms & non-target exposure	Owain Edwards (CSIRO)
10.20 - 10.50	RLEM genetics & future risks	Ary Hoffmann (UniMelb)
	BREAK	
11.10 -11.30	Tolerance in other mite species	Paul Umina (cesar)
11.30 - 12.20	Overview of Australian herbicide resistance & lessons to be learnt	Stephen Powles (UWA)
12.20 -13.00	From an RDC perspective	GRDC, MLA, AWI and Dairy Aus
	LUNCH	
13.30 -14.10	From an insecticide product perspective	Dow, Bayer, NuFarm and Syngenta
14.10 -16.00	Developing a Resistance Management Strategy (RMS)	Discussion (led by Rick Roush)
	BREAK	
16.20-17.00	Developing a RMS - continued	Discussion (led by Paul Umina)
17.00 -17.30	Medium and long term planning	Rohan Rainbow (GRDC)
	Dinner, 7.30pm, The Leveson, Level 1, 46 Leveson Street, North Melbourme	

Day 2

Time	Topic	Speakers
8.50 - 9.00	Arrive at Bio 21 reception to be signed in	
9.00 - 9.45	Components of a RMS	Group discussions
9.45-10.30	Research gaps	Group discussions
	BREAK	
11.00-11.45	Communication of RMS & extension gaps	Discussion (led by Greg Baker and Helen Barclay)
11.45 -12.30	National Insecticide Resistance Management Centre	Owain Edwards (CSIRO)

Control: *There is concern over growing resistance to synthetic pyrethroids in redlegged earth mites.*

Source: A.Weeks (cesar)

Earth mite resistance marches on

Pesticide-resistant redlegged earth mites are on the rise, reports Dr Paul Umina, requiring growers to rethink control strategies

At a glance...

- RLEM have been identified with high levels of resistance to synthetic pyrethroid pesticides
- Resistant populations have been identified at more locations across the southern, high rainfall, grain belt of Western Australia
- To date only synthetic pyrethroids are affected and growers should use other chemicals for control

The analysis of redlegged earth mite (RLEM) specimens collected from more than 200 paddocks across Western Australia has confirmed the spread of high levels of resistance to synthetic pyrethroid pesticides.

RLEM is a serious broadacre pest in Australia, New Zealand and South Africa, causing millions of dollars damage to crops and pastures.

Chemicals are the most effective and widely used control method, but evidence of high levels of resistance to synthetic pyrethroids began emerging in 2006.

The first demonstrated case of chemical resistance in RLEM was discovered in a canola crop north-west of Esperance, Western Australia.

Researchers were alerted following multiple chemical control failures aimed at RLEM, which were attacking an emerging canola crop.

Four separate applications failed to achieve adequate control.

Warning signs

High levels of resistance to two synthetic pyrethroids — bifenthrin and alpha-cypermethrin — were found at this site.

This resistance has been found to have a genetic basis, persisting after several generations of culturing in the laboratory.

Which means resistance can be passed from parents to offspring, and is likely to persist in RLEM populations over many years.

Mapping efforts

Since the initial detection near Esperance, the distribution and spread of resistance has been closely monitored by the Department of Agriculture and Food WA (DAFWA) and Cesar.

Between the 2007 and 2011 winter growing seasons, RLEM samples were collected from more than 220 paddocks across 140 different properties in WA. This included:

- Random samples collected from paddocks with various crop and pasture types
- Targeted samples from paddocks with a relatively high pesticide load and intensive cropping history
- Samples collected from paddocks with reported chemical control failures involving RLEM

Mites were collected from each of these paddocks, transported to the laboratory and screened for pesticide resistance.

Seventeen samples were screened in 2007, 14 in 2008, 39 in 2009, 43 in 2010 and 113 last year.

Spread

Thirty-six paddocks were found to contain resistant mites.

These paddocks ranged over 480km across 15 properties and the distribution of paddocks sampled between 2007 and 2011 were predominantly from the high-rainfall areas of WA's great southern and south coastal grain belt regions.

The extent of resistance is concerning given the high levels found and the increasing number of chemical control failures involving RLEM experienced by growers.

Resistant mites at the majority of these locations have caused significant economic losses due to ineffective chemical applications, mortality of crop seedlings and the cost of re-sowing.

Resistant populations were detected in three geographically-separate areas.

Fourteen paddocks across nine properties had confirmed resistance in an area north-west of Esperance.

The majority of resistant populations were located in an area north of Albany, Western Australia, here there were 20 paddocks across 12 properties with resistance.

The most westerly known area of resistance is north of Boyup Brook, Western Australia, where a single paddock was found to contain resistant RLEM.

Resistant mites at the majority of these locations have caused significant economic losses due to ineffective chemical applications, mortality of crop seedlings and the cost of re-sowing.

Dispersal

RLEM dispersal predominantly occurs during summer via the movement of diapausing eggs.

Eggs may be dispersed long distances by wind, on soil adhering to livestock and farm machinery and through the transportation of plant material such as hay.

Given this movement, it is almost certain pesticide resistance in RLEM will spread to other parts of WA and probably to other Australian states in the future.

To date, extensive screening efforts have not detected resistance outside WA, although populations from South Australia, Victoria and NSW will continue to be monitored. The situation in WA will also be closely monitored.

Other resistance

In addition to screening synthetic pyrethroids, a range of chemicals has been tested using laboratory bioassays.

This includes several organophosphates (Group 1B), fipronil (Group 2C), carbosulfan (Group 1A), abamectin (Group 6A) and diafenthiuron (Group 12B).

The good news for growers is resistance in RLEM appears confined to the synthetic pyrethroid class of pesticides.

Thus, resistant mites can still be adequately controlled using some registered chemicals such as omethoate, dimethoate and chlorpyrifos.

In addition, numerous synthetic pyrethroids have been tested.

It is clear RLEM resistance is found across the entire pyrethroid group, which has implications for the management of resistant populations in the field.

Growers should not continue to use pyrethroids on resistant RLEM populations as it is likely to waste time and money.

Management approaches

There are several management tactics available to growers to combat RLEM and minimise resistance issues.

1. Identify your mites

RLEM often occurs in situations with other mites, such as blue oat mites, bryobia mites and balaustium mites.

It is important to correctly identify the pest present because these mite species respond differently to registered pesticides, and therefore insecticide products and rates need to be chosen accordingly.

The wrong chemical treatment will cost money and only act to increase the selection pressure for further resistance development.

2. Control weeds

Clean fallowing and controlling weeds around crop and pasture perimeters will act to reduce mite numbers.

Control of weeds, especially thistles and capeweed, is important, as they provide important breeding sites for RLEM.

Where paddocks have a history of damaging, high-density RLEM populations, it is recommended farmers avoid sowing canola and pastures with a high clover content.

3. Controlled grazing of pastures

Appropriate grazing management in the year before sowing a susceptible crop can also reduce RLEM populations to below damaging thresholds, possibly because shorter pasture results in lower relative humidity, which increases mite mortality and limits food resources.

Sustained grazing of pastures throughout spring to maintain feed on offer (FOO) levels below two tonnes per hectare (dry weight) will further restrict mite numbers to low levels.

4. Cultural controls

Rotating crops or pastures with non-host crops can reduce RLEM colonisation, reproduction and survival.

For example, prior to planting a susceptible crop such as canola, a paddock may be sown to cereals, lentils or chickpeas to help reduce the risk of RLEM population build up.

Cultivation can also help reduce RLEM populations by decreasing the number of over-summering eggs. Hot stubble burns can provide a similar effect.

5. Use pesticides only when necessary

Avoid insurance sprays and only use pesticides after careful monitoring and correct identification of pest species.

If RLEMs are at damaging levels, carefully-timed spring spraying can be an effective control method.

Further information can be found on the Timerite website www.timerite.com.au.

Only specific paddocks should be selected based on FOO levels, future grazing management requirements and intended paddock use next season.

It is important for WA growers to implement a resistance management program immediately and rotate chemical classes with different modes of action to minimise resistance problems.

Do you suspect resistance?

If you have RLEM which survive registered rates of pesticide treatments or suspect you have resistant RLEM, contact Svetlana Micic (DAFWA) on (08) 9892 8591 or Dr Owain Edwards (CSIRO) on (08) 9333 6401.

Alternatively, contact Dr Paul Umina directly (03) 9349 4723, or pumina@unimelb.edu.au, who can arrange a free resistance test.

Any information obtained from growers or advisers will be kept confidential and assistance with recommendations for control can be provided if resistance is found.

Acknowledgements

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GRDC RESEARCH

GRDC Grains Research & Development Corporation

Dr Paul Umina
(03) 9349 4723
pumina@unimelb.edu.au

Timerite
www.timerite.com.au
www.grdc.com.au/UM00033
www.grdc.com.au/UM00043

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

Note: 457
February 2011

Farmnote

Prevent redlegged earth mite resistance

Svetlana Micic, Peter Mangano, Alan Lord, Tony Dore

Current state of resistance in WA

To date (September 2010), 19 properties in southern Western Australia have redlegged earthmites (RLEM) that are resistant to the synthetic pyrethroids (SPs) bifenthrin and alpha-cypermethrin. Resistant RLEM populations are likely to be present in more localities in Western Australia and elsewhere in southern Australia, especially in paddocks that have a history of repeated SP applications.

How does resistance occur?

Repeated use of SP insecticides, within seasons and between seasons, suggests there is strong selection pressure for RLEM to develop resistance to this chemical group. Even if a SP insecticide is used against pests such as weevils or aphids, RLEM also receive a dose of the chemical, even though they are not the direct target. It is likely that the repeated cumulative exposure of RLEM to SPs is the main factor behind resistance developing.

Farmers with resistant RLEM have been able to control these mites by using insecticides from the organophosphate (OP) group (Group 1B), e.g. dimethoate or omethoate. However, residual populations of SP resistant RLEM were found on weeds along fencelines and re-infested paddocks.

Resistance in RLEM is heritable and mechanisms to switch it off have not been found. RLEM from one site have been tested each year for 4 years and are still resistant to SPs, even without further SP application. This indicates that resistance, once established, is likely to persist in RLEM populations over many years. We need to prevent further development of resistance by decreasing overall use of SPs.

Spread of resistance?

Locations of resistance within southern WA are geographically quite distinct, suggesting that the resistance develops in isolated RLEM populations within each property. Resistant RLEM have been found on properties near Esperance, Cranbrook, South Stirlings, Tenterden and Boyup Brook, making it unlikely that resistant RLEM have spread between locations. However, resistant RLEM can move into adjacent paddocks from weeds on fencelines.

Managing resistance

Identify your mites

RLEM are often found with other mites, such as blue oat mite (BOM), Bryobia (clover) mite or Balaustium mite, but resistance has only been found in RLEM. In situations where spray failures have occurred, it is important to correctly identify the mite. Blue oat mites (BOM) are controlled by all chemicals registered for RLEM control, whereas chemical controls for Bryobia mite and Balaustium mites differ. Refer to *Farmnote 165: Pest mites of broadacre crops* for further information.

Plan ahead to reduce mite numbers

If you prepare paddocks in the preceding season, there will be lower numbers of pests on your crops. Consider the following to reduce pest numbers:

- **Control weeds in the crop and along fencelines.** Weeds provide habitat for mites. Controlling weeds with herbicides, cultivation or heavy grazing will decrease mite numbers. A weed free crop will have few mites and over-summering eggs to carry through to the following season.
- **Controlled grazing of pasture paddocks** in the year prior to a cropping year will reduce RLEM and BOM numbers to levels similar to chemical sprays. Sustained grazing of pastures throughout spring to maintain Feed On Offer (FOO) levels below 2 t/ha (dry weight) will restrict mite numbers to low levels.
- **Control RLEM in spring.** Applying insecticides to some paddocks during spring to prevent RLEM populations producing over-summering

eggs will minimise the pest population in the following autumn. Only specific paddocks should be selected for spring spraying based on FOO levels, future grazing management options, seed production requirements and intended paddock use next season. The routine spraying of all pasture paddocks in spring using "Timerite®" dates to prevent a build-up of mites is unlikely to be sustainable. TIMERITE® is a free package that provides a date in spring for a spraying to stop RLEM from producing over-summering eggs. For your TIMERITE® date see www.timerite.com.au.

- **Cropping rotations to decrease reliance on pesticides.** Some paddocks will have a higher or lower risk of RLEM damage depending on previous crop rotations. The risk is generally highest if paddocks have been in long term pasture (with high levels of broad-leafed plants) where mite populations have been uncontrolled. Lower risk paddocks that generally do not require mite control are often those which follow a cereal or canola weed free crop where conditions are less favourable for mite increase.

What you can do this season

Spray only if you need to

Farmers, that currently have populations of resistant RLEM, have mostly used repeated applications of SP chemicals as "insurance" sprays to minimise anticipated pest risks. To decrease the likelihood of resistance developing on your property apply insecticides only on paddocks have damaging numbers of pests.

Where spraying is needed, rotate chemical groups, for example between SPs and OPs, in and between seasons, as this will help to reduce resistance build-up. If spraying other pests, such as aphids, try not to use SP's. Consider other chemical options such as pirimicarb.

Predict hatchings of RLEM on your property to target your control strategy

Knowing approximately when the first autumn hatchings of RLEM is occurring on your property will help to determine if they will coincide with seedling crops. RLEM hatch in autumn from their over-summering egg stage, after adequate rainfall and at least 7 days of average temperatures below 20°C. Crops sown in seasons with "early breaks" with maximum temperatures well above 20°C (e.g. canola sown in April) will not be damaged by RLEM.

As the season progresses, it will be harder to assess if weather conditions have been suitable for RLEM to hatch. It is best to look for early hatchings of the mites in paddocks that get coldest first as winter approaches. Typically this will be the south side of slopes, in low valleys and where tree shelter belts provide shady areas in paddocks. To find RLEM, look on any green plant material in mid-morning. It is important to be aware that Bryobia and Balaustium mites may also be present.

Critical populations of mites

The number of mites present and the crop growth stage are two critical factors that determine if RLEM require control. During seedling emergence and early plant establishment, moderate to low numbers of mites may cause some plant mortality and visual silvering and leaf distortion which is concerning to farmers but may not be of economic importance. Trial results show that moderate RLEM numbers cause no measurable yield loss in canola, lupins or cereals. The degree of any yield loss depends on the plant density remaining after mite feeding, the compensating ability of the remaining plants and length of season. The impact of mite populations is further compounded when additional crop stresses (e.g. drought, disease etc.) limit the plants' ability to out grow mite feeding damage.

Control weeds before seeding

In paddocks that are sown late in autumn, weather conditions often prevail that allow the RLEM to hatch before seeding. In these situations if at least one week of complete bare fallow (no green material) can be achieved by herbicide or cultivation then the majority of the mite population and other pests will be "starved out" before crops are sown.

Use insecticide seed treatments

Use insecticide seed treatments for crops and sown pastures with moderate pest pressure rather than spraying whole paddocks. Seed treatments allow smaller quantities of pesticide to be used that directly target plant feeding pests, allowing any predatory insects to continue their important beneficial role.

Do you suspect you have resistant RLEM?

If you have RLEM that survive registered rates of insecticide treatments or suspect that you have mites resistant to chemicals , please contact the Department of Agriculture and Food's broad-acre Entomologists. Arrangements can be made to have mites sampled and tested for their level of resistance.

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3 Baron-Hay Court South Perth WA 6151
Tel: (08) 9368 3333 Email: enquiries@agric.wa.gov.au Website: www.agric.wa.gov.au