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The 3rd Australian Agrichemical Resistance Meeting

12th November 2015
MELBOURNE, VICTORIA

THE UNIVERSITY OF MELBOURNE

Curtin University

AHRI
AUSTRALIAN HERBICIDE RESISTANCE INITIATIVE

Providing the opportunity to discuss one of the biggest issues facing Australia's agricultural industry: the sustainable use and resistance management of pesticides.

#AARM2015

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Australian Agrichemical Resistance Meeting

The 3rd Australian Agrichemical Resistance meeting (AARM) will provide the opportunity for researchers, extension professionals, industry representatives and R&D corporations to discuss one of the biggest issues facing Australia's farmers and agricultural industries: the sustainable use and resistance management of pesticides. AARM is invitation only and free to attend, thanks to the generous support from our sponsors.

Crop protection products help Australian agricultural industries produce high quality food that is competitive in global markets. Each year pesticides help increase Australian crop yields by approximately 40 per cent and the value of food production by A$13 billion (CropLife Australia). However pesticide resistance poses a persistent and expanding threat to growers, the agrichemical industry and the nation's ability to remain productive and competitive.

The meeting will explore new and innovative research and extension being applied to agrichemical resistance in Australian agricultural industries. It will provide insight into mechanisms and processes behind the continuing evolution of resistance to fungicides, herbicides and insecticides. The meeting combines expert discussions on all areas of pesticide resistance with the aim of preserving the longevity of Australian agrichemicals in the face of the resistance threat.

Friday November 13th

Specialist workshops will be held on insecticide resistance, fungicide resistance and weed research and development.

Sponsors

This meeting is sponsored by

The University of Melbourne
Curtin University
Grains Research and Development Corporation

2015 Events

Thursday November 12th

Australian Agrichemical Resistance Meeting

Informal networking dinner

An informal networking dinner will be held at Naughtons Parkville hotel. Costs are $40 per head for a two course meal. This is a pre-paid event.

Friday November 13th

Specialist workshops

The Grains Pest Advisory Committee (GPAC) workshop on The Status of Insecticide Resistance in Australia'

The Fungicide Resistance Industry and Research Meeting, sponsored by GRDC, Curtin University, and Melbourne University

Grain Weeds Advisory Committee (GWAC) Weeds Research and Development Forum

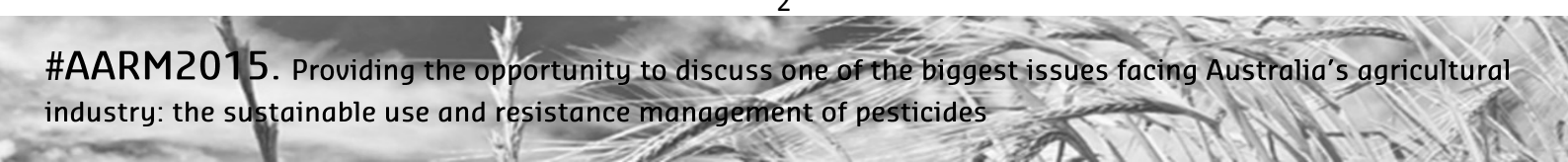
Morning tea, lunch and afternoon tea will be provided on both days.

Post event networking drinks

Post event drinks will be available at Naughtons Parkville hotel.

Venue

The meeting and workshops will be held in the Alan Gilbert building at the University of Melbourne in Parkville, north of Melbourne's CBD. The University was founded in 1853 and is Australia's second oldest university with an eclectic mix of old and new architecture.



Committee Members

This event is organized by members of the University of Melbourne, GRDC supported Centre for Crop and Disease Management (CCDM) at Curtin University, and GRDC supported Australian Herbicide Resistance Initiative (AHRI) at the University of Western Australia.

We would like to acknowledge

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Miss Emily Thomson (UoM)

Dr. Fran Lopez-Ruiz (CCDM)

Miss Alexandra Kay (CCDM)

Prof. Steve Powles (AHRI)

Dr. Paul Umina (**cesar**, NIRM)

Acronyms used in this Booklet

AARM	Australian Agrichemical Resistance Meeting
AHRI	Australian Herbicide Resistance Initiative
CCDM	Centre for Crop and Disease Management, Curtin University
CRDC	Cotton Research and Development Corporation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSU	Charles Sturt University
DAFWA	Department of Agriculture and Food, Western Australia
DPI NSW	Department of Primary Industies, New South Wales
FAR	Foundation for Arable Research
FIRM	Fungicide Resistance Industry and Research Meeting
GPAC	Grains Pests Advisory Committee
GRDC	Grains Research and Development Corporation
GWAC	Grain Weeds Advisory Committee
HAL	Horticulture Australia Limited
NIRM	National Insecticide Resistance Management
QDAF	Queenslands Department of Agriculture and Fisheries
SARDI	South Australian Research and Development Institute
UoA	University of Adelaide
UoM	University of Melbourne
UoQ	University of Queensland
UoS	University of Sydney
UWA	University of Western Australia

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Agenda Overview

3rd Australian Agrichemical Resistance Meeting

Thursday 12th November 2015

University of Melbourne, Parkville
Alan Gilbert Building, Mezzanine Level (Theatre 2)

9:00am Welcome and Introduction by Prof. Ary Hoffmann (UoM)

9:05am **Session 1: Recent Field Developments**

Session chair: Prof. Barbara Howlett (UoM)

Speakers

- Fran Lopez Ruiz (CCDM): Fungicide resistance in Australia: from traditional monitoring to rapid identification of resistance in the field
- Andrew Milgate, Merrin Spackman and Melanie Renkin (DPI NSW): Characterising levels of fungicide resistance in the wheat pathogen *Zymoseptoria tritici* in Australia
- Paul Umina (UoM): The contrasting stories of resistance evolution and spread in green peach aphids and redlegged earth mites.
- Grant Herron (DPI NSW): Resistance detection and management of secondary sucking pests of Australian cotton.
- Mahima Krishnan (UoA): New developments in herbicide resistance in Australia

10:20am Open Discussion

10:40am Morning Tea

11:00am **Session 2: Molecular Mechanisms**

Session chair: Prof. Steve Powles (AHRI)

Speakers

- Tom Walsh and Owain Edwards (CSIRO) :The evolution and distribution of insecticide resistance in pests of Australian grains and cotton
- Charles Robin and Derek Russell (UoM): Using population genomic approaches to identify and monitor insecticide resistance mechanisms
- Qin Yu (AHRI): Herbicide resistance mechanisms: a highlight
- Mahima Krishnan (UoA): Gene amplification of EPSPS in glyphosate resistance
- James Hane (CCDM): Genome mutation and the risk of pathogen adaptation

12:15pm Open Discussion

12:35pm *Lunch*

Agenda Overview

3rd Australian Agrichemical Resistance Meeting

Thursday 12th November 2015

University of Melbourne, Parkville
Alan Gilbert Building, Mezzanine Level (Theatre 2)

1:25pm **Session 3: Resistance Modelling and Management**

Session chair: Prof. Ary Hoffmann (UoM)

Speakers

- Joe Helps (Rothamsted): Insecticide resistance management: the dose rate debate continued
- Michael Renton (UWA): Recent developments in modelling evolutionary dynamics of resistance in weeds, invertebrates and pathogens
- Paul Ebert (UoQ)/ David Schlipalius (QDAF): Genetically informed strategies for managing fumigant resistant insect pests
- Bhagirath Chauhan (UoQ): Integrated weed management options in Australian agriculture
- Michael Walsh (AHRI): The need for zero weed tolerance in cropping systems

2:40pm Open Discussion

3:00pm Afternoon Tea

3:20pm **Session 4: Education / Extension / Communication**

Session chair: Dr Ken Young (GRDC)

Speakers

- Peter Newman (AHRI): ARHI communication: telling the story, not just the science
- Sally Ceeney (CottonInfo): Insecticide resistance management in the Australian cotton industry
- Nick Poole (FAR): Foliar fungicide management and resistance: defining the messages and terminology for extension

4:05pm Open Discussion

4:30pm **Session 5: Wrap up Panel Discussion**

5:30pm Close

7:00pm Networking Dinner at Naughtons Parkville hotel

Speaker Abstracts #AARM2015

Session 1 Recent Field Developments

Dr. Fran Lopez Ruiz
Acknowledgement to Prof. Richard Oliver, Madeline Tucker, Weiwei Deng, Wesley Mair, Steven Chang, Lincoln Harper, Kejal Dodhia, Belinda Cox.
Centre for Crop and Disease Management, Curtin University
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Fungicide resistance in Australia: from traditional monitoring to rapid identification of resistance in the field

Fungicides are a critical component of food security worldwide contributing about $8 extra productivity for every $1 spent in Australia. However this fungicidal crop protection is threatened by ever-increasing regulatory stringency and the development of resistance. Along with cultural practices, the main control measures for most fungal diseases are the application of effective fungicides and the use of cultivars with genetic resistance. Unfortunately for Australian growers, the majority of cultivars commercially available for each major crop are either susceptible or moderately susceptible to fungal infection. Therefore growers have largely relied on the application of fungicides for disease control. However, disease management has been compromised by the emergence of fungicide resistance in the last few years in different fungal species. In fungi, resistance often emerges as a result of single or multiple mechanisms. Five general mechanisms have been described to confer resistance to fungicides been target site modifications the most important and widespread. Poor anti-resistance strategies (i.e. continuous use successful fungicides and lack of mixtures) and disease management will lead to the development of resistance and failures in disease control.
Here we summarise the current status of fungicide resistance in major Australian crops to some of the most important groups of fungicides worldwide, and evaluate the best approaches to unravel the molecular mechanisms involved in the resistance found. The implications of these findings for the development and deployment of fungicide resistance monitoring strategies in Australia are discussed.

Speaker Abstracts #AARM2015

Session 1 Recent Field Developments

Dr. Andrew Milgate
Acknowledgement to Dante Adorada, Merrin Spackman, Beverley Orchard and Melanie Renkin.
Wagga Wagga Agricultural Institute, Department Of Primary Industries NSW
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Characterising levels of fungicide resistance in the wheat pathogen *Zymoseptoria tritici* in Australia

Zymoseptoria tritici is an important pathogen of wheat globally and is capable of causing 50% yield loss in susceptible varieties. Control of the disease relies on the use of host resistance, cultural practices and fungicides. However the pathogen is capable of rapidly overcoming host resistance in cultivars and modern farming systems favour stubble retention creating ideal conditions for its survival. Thus, in many countries there has been an over reliance on fungicides to control the disease. This has led to the evolution of resistance to several classes of fungicides including the demethylation inhibitors (DMI) and quinine outside inhibitor (QOI). In Australia *Z. tritici* is a production constraint in the high rainfall zones of south eastern Australia. The use of DMI fungicides, in Australia, to control foliar diseases in wheat production has increased rapidly over the past decade. We have examined a historical set of isolates spanning from 1979 – 2013 and can confirm the evolution of mutations in the Cyp51 gene known to reduce DMI sensitivity occurring in Australia for the first time. Isolates carrying the L50S, Y137F and L50S-Y461S have been phenotyped and their resistance factors estimated to a number of DMI fungicides. The impact of the emergence of these mutations will be presented and discussed.

Dr. Paul Umina
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The contrasting stories of resistance evolution and spread in green peach aphids and red-legged earth mites

Drawing on recent research undertaken by cesar in conjunction with The University of Melbourne, CSIRO and multiple state agricultural departments, this presentation will contrast the resistance stories of two important grains pests, the green peach aphid (*Myzus persicae* - GPA) and the red-legged earth mite (*Halotydeus destructor* - RLEM). RLEM and GPA attack a wide variety of grain crops across Australia and are frequently targeted with insecticide sprays; often these are applied prophylactically at crop emergence. Due to differences in life history characteristics, dispersal capabilities and selection pressures in the field, the evolutionary history and spread of insecticide resistance in these two species differ markedly. Resistance management strategies must account for these contrasting situations in order to appreciably minimise selection pressure and prolong the life of current chemistries.

Speaker Abstracts #AARM2015

Session 1 Recent Field Developments

Dr. Grant Herron
Elizabeth Macarthur Agricultural institute, Department of Primary Industries, New South Wales
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Resistance detection and management of secondary sucking pests of Australian cotton

With the introduction of transgenic Bt cotton secondary sucking pests have emerged as a major threat in Australia. Bugs including *Creontiades dilutes, Tetranychus urticae* and *Aphis gossypii* receive targeted control with the latter associated with pirimicarb and neonicotinoid failures. It is worrying then that *A. gossypii* against Sulfoxaflor has pushed to its limits of tolerance within a season. *Tetranychus urticae* remains resistant to many chemicals used for its control but anecdotally its abundance has reduced suggesting the overall reduction of sprays in Bt cotton is changing the pest complex. *C. dilutus* has potential to develop resistance but monitoring remains problematic due to: 1. difficulty in getting fragile mirids from the field to the laboratory; 2. once in the laboratory culturing C. dilutus prior to bioassay is almost impossible. Clearly a DNA based method(s) is desirable but methods are lacking so possibly a field based bioassay is the solution. I consider immediate and long term future challenges to resistance management will revolve around such issues of detection and the premise; you can't effectively manage what you can't measure. New chemistries such as spirotetramat, pymetrozine and flonicamid add significantly to the challenge of timely and accurate resistance detection as they have unique modes of action making their bioassay extremely difficult. DNA based monitoring is an alternative but it can't replace bioassay for early resistance detection because the mechanism is initially unknown. Even when the causal mechanism is known DNA test methods are heavily based around target site SNPs with little information on detoxification mediated resistance available.

Dr. Chris Preston
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New developments in herbicide resistance in Australia

The intensive use of herbicides has meant continued evolution of herbicide resistance. There are a number of key herbicides where the evolution of resistance causes major practical problems. Glyphosate is a key herbicide for fallow management, non-crop areas and prior to crop sowing. In the past 2 years resistance has occurred to glyphosate in *Brachiaria eruciformis*, *Sonchus oleraceus* and *Lactuca serriola* all in fallow situations, making a total of 11 weed species in Australia with glyphosate resistance. The phenoxy herbicides are important for broadleaf weed control in cereals and as an addition to or alternative to glyphosate in fallows. In the past year resistance to 2,4-D has occurred in *Sonchus oleraceus* and *Actotheca calendula*. Paraquat is the main alternative to glyphosate for grass weed control, but is also used in numerous other situations. In the past year resistance to paraquat has occurred in *Eleusine indica*, *Solanum nigrum* and *Gamochaeta pensylvannica* in sugar cane production systems. Pre-emergent residual herbicides have become essential tools for the control of grass weeds in cereal production systems. In the past year resistance to one of these pre-emergent herbicides, triallate, has been reported in *Lolium rigidum*.

Speaker Abstracts #AARM2015

Session 2 Molecular Mechanisms

Dr. Tom Walsh and Dr. Owain Edwards
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The evolution and distribution of insecticide resistance in pests of Australian grains and cotton

Resistance to pesticides in insect pests of agriculture can impose major costs on growers though yield loss or increased inputs for control. The Heliothine moth *Helicoverpa armigera* is a major pest of cotton in Australia and H. armigera has a long history of developing resistance to conventional pesticides. More recently, insecticide resistance to chemicals relied upon by growers to achieve effective control has been detected in two pests of Australian grains: the green peach aphid, GPA (*Myzus persicae*) and the red-legged earth mite, RLEM (*Halotydeus destructor*). The resistance mechanisms to the various pesticides are known and this allows us to use molecular methods to detect and monitor for resistance. Combined with knowledge of the ecology (migration ability, host range) of these species we can make inferences about movement within Australia and internationally and also understand the selection histories that affect the risk of resistance developing in Australia or being introduced from overseas.

Dr. Charles Robin and Dr. Derek Russell
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Using population genomic approaches to identify and monitor insecticide resistance mechanisms

The field frequency of specific resistance mechanisms is often assessed by laborious F2 crosses or by genotyping a subset of candidate loci. This talk will discuss two new population genomic approaches that can be used to monitor, and indeed identify, resistance mechanisms. The first searches for patterns of genetic variation known as 'selective sweeps'. The second looks at correlations between genetic variation and survivorship upon exposure to insecticide. The vision is that field samples will be genotyped in such a timely manner that wide-ranging outbreaks of resistance would be averted. We will discuss what is required to realize this vision by drawing on our population genomic analyses of *Drosophila melanogaster* and *Helicoverpa armigera* (cotton bollworm). Then we will discuss how such approaches could be applied to grain pests.

Session 2 Molecular Mechanisms

Dr. Qin Yu
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Herbicide resistance mechanisms: a highlight

Field evolved herbicide resistance in weedy plants can be target-site based (e.g. target-site mutation, gene amplification) or non-target-site based (e.g. due to reduced herbicide uptake, translocation or enhanced herbicide metabolism). Target-site mutations are commonly reported in resistant plants as they are relatively easier to identify. Resistance mutations are not always strong, and weak mutations can be also selected as long as they enable plant survival and reproduction but often overlooked by researchers. High herbicide rates may favour selection of strong mutations whereas low rates favour both strong and weak mutations. Target-site resistance in polyploid weedy species (e.g. wild oat, barnyard grass) is more complex than diploid species (e.g. Lolium spp) due to multiple copies of target genes. At least 3 resistant alleles may be required to provide a level of resistance in polyploids achieved by one resistance allele in diploids (especially for semi dominant resistant alleles). This in part explains why hexaploids are slower in target-site resistance evolution. Fitness penalty of target-site mutations ranges from undetectable to severe, and, if any, often only associated with homozygous resistant plants. Non -target-site resistance is also common but much less studied. Resistance mechanisms of reduced herbicide translocation (primarily as enhanced vacuole sequestration) can be temperature-dependent, thus may be manipulated to mitigate resistance. Non-target-site metabolic resistance is widespread and often confers resistance to herbicides of different chemical groups and sites-of-action, and can even extend to new herbicide(s). However, precise biochemical and molecular genetic elucidation of metabolic resistance has been stalled until recently. Complex metabolic enzyme superfamilies, high genetic diversity in weedy plants (especially cross-pollinated species) and the complexity of genetic control of metabolic resistance have all been barriers to advances in understanding metabolic resistance. However, next-generation transcriptome-wide gene expression profiling is now revealing the genes endowing metabolic herbicide resistance in plants, and much will be revealed in the near future.

Dr. Mahima Krishnan
Acknowledgement to Jenna Malone, Sarah Morran, Peter Boutsalis, Christopher Preston
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Gene amplification of EPSPS in glyphosate resistance

Two populations of *Bromus diandrus* (brome grass) from Victoria and South Australia were identified as resistant to glyphosate. In both cases qPCR identified duplications of the EPSPS gene in resistant populations that were not present in the susceptible population. The resistant populations had 10-30 fold EPSPS gene copies which gave rise to 2-12 fold higher gene expression than the susceptible population. Further studies with an F2 population from a cross between resistant and susceptible individuals segregated in a non-Mendelian fashion with all individuals resistant to glyphosate. This suggests that the EPSPS gene copies are dispersed throughout the genome. In addition, expression data indicates that 3 out of 4 EPSPS genes in *B. diandrus* are expressed, only one of which is the duplicated allele.

Session 2 Molecular Mechanisms

Dr. James Hane
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Genome mutation and the risk of pathogen adaptation

Fungi are responsible for the majority of major crop diseases, however there are far higher numbers of serious crop pathogen species clustered within certain phylogenetic taxa, such as the *Pezizomycotina*. Through the study of the genome sequences of pathogenic fungal species, we have been able to identify several genome-based factors contributing to their success as pathogens. This includes genome mutation processes that rapidly alter the sequence and structural organisation of genes in fungi. Consequently, species utilising these methods of genome mutation may be capable of rapidly adapting to both host and chemical resistances. This presentation summarises the molecular and comparative genomics analyses that have defined mutation processes contributing to pathogen adaptability, and speculates on potential means of disrupting them.

Session 3 Resistance Modelling and Management

Dr. Joe Helps
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Insecticide resistance management: the dose rate debate continued

The use of full label dose for sustainable pest management has been heatedly discussed in both the insecticide, fungicide and herbicide areas. While a low dose of a pesticide will provide less effective pest control, whether it reduces or increases the selection for resistance may depend on several biological or pesticidal traits. Therefore when choosing between a high or low dose of pesticide for long-term effective pest management, both the efficacy of the applied dose and the rate at which resistance builds up must be considered. While in the management of fungal diseases low doses of fungicide are now accepted by many as resistance management tactic (conditional on effective control) in the UK, in insecticides reducing the dose of pesticide applied is discouraged. While there may be excellent reasons for this, particularly with respect to metabolic resistance mechanisms, we demonstrate that the use of a high dose to control insects with target-site resistance to an insecticide may be counter-productive in several cases. In many cases it appears to be a good idea to reduce the dose of the insecticide applied as much as is feasible from a control aspect.

Dr. Michael Renton
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Recent developments in modelling evolutionary dynamics of resistance in weeds, invertebrates and pathogens

Simulation modelling can help understand and predict how different factors are likely to influence evolutionary dynamics in crop pests, weeds and diseases, through integrating current knowledge and hypotheses, and thus help identify optimal management strategies. This talk will present some recent work where simulation modelling has been used to investigate evolutionary dynamics in crop pests, weeds and diseases, including the evolution of resistance to pesticides in red-legged earth mite; tillage and rotation as strategies for delaying evolution of resistance to herbicides; and spatial and temporal deployment of resistant crop varieties to delay evolution of virulence (counter-resistance) in fungal pathogens. Considering the similarities and differences involved in modelling the different types of organisms (invertebrates, weeds, pathogens) helps lead to some general insights and future perspectives.

Session 3 Resistance Modelling and Management

Dr. Paul Ebert and Mr David Schlipalius
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Genetically informed strategies for managing fumigant resistant insect pests

Phosphine is the only generally useful fumigant for the protection of stored grain against insect pests, but now resistance to phosphine threatens its continued use. We have identified two genes (rph1 & rph2) that act synergistically to cause >600x resistance to phosphine. The same two genes are responsible for the strong resistance phenotype in the four pest species that have been studied. A marker for the rph2 gene has been used to map the distribution and spread of strong resistance in the eastern states of Australia and is currently being used to monitor early outbreaks of strong resistance in Western Australia. We have developed a marker detection system that can be used to monitor the patchwork of resistance variants that are seen in eastern Australia as well as the emergence of potentially novel resistance variants in Western Australia.

The parameters for managing resistance in stored grain pests are completely different than those encountered in the management of pests of field crops. The resistance factors often have no obvious fitness cost, pest management occurs in the closed system of a grain storage bin and inputs (and insect access) to the system are well defined. Furthermore, the market dictates 'nil tolerance' as the economic threshold for pest infestation.

Dr. Bhagirath Chauhan
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Integrated weed management options in Australian agriculture

The adoption of no-till systems in Australia has increased reliance on herbicides for weed management. With conservation tillage, small-seeded weeds with abundant seed production have evolved as dominant weeds in different cropping systems. Annual ryegrass, wild radish, wild oats, feathertop Rhodes grass, windmill grass, fleabane, barnyard grass, and sowthistle are some of the major weeds that dominate the crop growing regions in Australia. The introduction of herbicide-tolerant crops have further reduced herbicide options, leading to the evolution of many herbicide-resistant weeds. Therefore, a strategy following the principles of integrated weed management would help to preserve the available herbicide options.

Session 3 Resistance Modelling and Management

Dr. Michael Walsh
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Michael.walsh@uwa.edu.au

The need for zero weed tolerance in cropping systems

In cropping systems, very low weed densities allow flexibility in production practices and opportunities. Crop choice, seeding time, and reduced herbicide use all become realistic choices allowing producers to readily adjust production practices in tune with seasonal and market considerations. Low weed densities in crop fields also play a critical role in sustaining herbicide resources for the ongoing control of crop-weeds, despite their demonstrated potential for herbicide resistance evolution. Resistance evolution is related to population size and initially rare resistance endowing traits will evolve rapidly in large populations exposed persistently to herbicide selection. In fact the repeated use of any weed control technology on large genetically diverse weed populations will inevitably lead to resistance evolution to that technology. Thus the preservation of any weed control strategy for long term use is reliant on restricting weed population densities to very low levels. The substantial benefits are the reduced potential for resistance evolution to highly valued herbicide resources and other control techniques but also, significantly, a more productive cropping system.

Session 4 Education / Extension / Communication

Mr. Peter Newman
Australian Herbicide Resistance Initiative, The University of Western Australia
petern@planfarm.com.au

ARHI communication: telling the story, not just the science

What is the lead of this story? (From the book 'Made to Stick by Chip Heath & Dan Heath)
You are a journalist and have been given this information. Please write the lead.
"*Kenneth L. Peters, the principal of Beverly Hills High School, announced today that the entire high school faculty will travel to Sacramento next Thursday for a colloquium in new teaching methods. Among the speakers will be anthropologist Margaret Mead, college president Dr. Robert Maynard Hutchins, and California governor Edmund 'Pat' Brown*."

Now, you may be tempted to regurgitate the paragraph above in a different order to make it a newsworthy story, which is how most journalism and science communication works. But that would be wrong. You are trying to find the core of the story. Read it again, step back from the story, and see if you can find the lead.

Have you go it yet?
The lead to this story is, "There will be no school next Thursday".
The art of science communication is to step back from the information and ask yourself, 'what is the story that this piece of science is trying to tell me?' We at AHRI believe that the secret to our success of science communication is that we tell the story, rather than just the science. We give our audience what they need, not just what we have.

Ms. Sally Ceeney
CottonInfo Technical Specialist
sally@ceenag.com.au

Insecticide Resistance Management in the Australian Cotton Industry

Successful insecticide resistance management aims to protect the efficacy and longevity of insecticides used to control insect pests. Insecticide resistance can destroy an industry and the collapse in 1975 of the cotton industry in the Ord River Irrigation Area in Western Australia is testament to this. History has shown repeatedly that reliance on a single tactic approach will result in resistance problems, and the cotton industry in Eastern Australia has been seriously challenged by insecticide resistance in its 60-year history.

In response to this challenge, the Australian cotton industry implemented an Insecticide Resistance Management Strategy (IRMS) that aims to manage resistance in all key pests in cotton to all commercially available registered insecticide products. The success of the IRMS has been that its is supported by:

- High industry commitment to implementing sound Integrated Pest Management Principles
- Industry funded resistance monitoring in key cotton pests
- Annual review system that requires input from growers, consultants and research
- Industry extension and communication program

Session 4 Education / Extension / Communication

Mr. Nick Poole
Foundation for Arable Research
Acknowledgement to Tracey Wiley
poolen@far.org.nz

Foliar Fungicide Management & Resistance – defining the messages and terminology for extension

Unfortunately Australian growers and advisers have become all too familiar with the terminology surrounding herbicide resistance, words such as target site, enhanced metabolism and windrow burning are all well-established words in the vocabulary. In contrast, knowledge of fungicide resistance is in its "infancy" with the vast majority of growers and advisers in the eastern states having little knowledge and awareness of how this issue could impact them. With the likelihood that fungicide resistance issues will increase in "at risk pathogens" there is an opportunity for the research community to both clarify anti resistance approaches and tighten up the terminology based on experience in WA and elsewhere in the world.

The communication of fungicide resistance is complicated by a number of factors and the complexity of the subject itself. The cross resistance characteristics between the DMI triazoles are just one example that is making it difficult to predict the value of alternating triazoles as an anti-resistance strategy in the paddock. The word resistance itself is not without its issues when it comes to describing how pathogen mutations will affect the activity of a triazole fungicide, for many it might signify that the fungicide is ineffective when actually the reality in the field is that the pathogen is a little more insensitive to the fungicide than it was the year before, but it will still give 90% control of the disease. So is it fungicide resistance or insensitivity? In comparison with herbicide resistance the greatest hurdle to overcome in the field will be the social nature of pathogen resistance, growers and advisers are quickly realising that if all growers don't adopt the anti-resistance measures then pathogen spores have no respect for farm boundaries. Since fungicide resistance is still a relatively new phenomenon in broadacre cereal cropping in Australia we have the benefit of being able to look around the world to see how best to communicate the issues.

Session Review

Session 1: Recent field developments	No	Neutral	Yes
1. Was the session topic interesting and topical to agrichemical resistance?			
2. Were the speakers relevant for the session topic?			
3. Was the session discussion engaging?			
4. Was the session facilitated appropriately?			
5. Did the session run to schedule?			

6. Overall, how satisfied were you with the session? (Please circle) Very dissatisfied Dissatisfied Neutral satisfied Very Satisfied

7. How could this session be improved?

Other comments

For further feedback and comments, please remember there is a feedback box available on the event website "aarm2015.weebly.com/feedback.html"

Session Review

Session 2: Molecular mechanisms	No	Neutral	Yes
1. Was the session topic interesting and topical to agrichemical resistance?			
2. Were the speakers relevant for the session topic?			
3. Was the session discussion engaging?			
4. Was the session facilitated appropriately?			
5. Did the session run to schedule?			

6. Overall, how satisfied were you with the session? (Please circle) Very dissatisfied Dissatisfied Neutral satisfied Very Satisfied

7. How could this session be improved?

Other comments

For further feedback and comments, please remember there is a feedback box available on the event website "aarm2015.weebly.com/feedback.html"

Session Review

Session 3: Resistance modelling and management	No	Neutral	Yes
1. Was the session topic interesting and topical to agrichemical resistance?			
2. Were the speakers relevant for the session topic?			
3. Was the session discussion engaging?			
4. Was the session facilitated appropriately?			
5. Did the session run to schedule?			

6. Overall, how satisfied were you with the session? (Please circle) Very dissatisfied Dissatisfied Neutral satisfied Very Satisfied

7. How could this session be improved?

Other comments

For further feedback and comments, please remember there is a feedback box available on the event website "aarm2015.weebly.com/feedback.html"

Session Review

Session 4: Education / extension / communication	No	Neutral	Yes
1. Was the session topic interesting and topical to agrichemical resistance?			
2. Were the speakers relevant for the session topic?			
3. Was the session discussion engaging?			
4. Was the session facilitated appropriately?			
5. Did the session run to schedule?			

6. Overall, how satisfied were you with the session? (Please circle) Very dissatisfied Dissatisfied Neutral satisfied Very Satisfied

7. How could this session be improved?

Other comments

For further feedback and comments, please remember there is a feedback box available on the event website "aarm2015.weebly.com/feedback.html"

AARM Review

We thank you for your feedback.

1. What were your primary objectives for attending AARM? (mark with a **X** the answers that apply)

- ☐ Present or hear the latest research findings
- ☐ Learn about cross-disciplinary implications involving resistance
- ☐ Network with research and/or industry peers
- ☐ Other (please specify) _____

For question 2 -7. Please mark with an **X** one answer once per question. If your answer is 'No' , feedback provided is appreciated

	Yes	Neutral	No	
2. Were your objectives for the meeting met?				If no, please explain:
3. Did the meeting allow sufficient time for you to network?				If no, please explain:
4. Did the meeting provide enough information prior to the event?				If no, please explain:
5. Did the information received prior to the event, reach you in a timely manner?				If no, please explain:
6. Was the event website useful to you?				If no, please explain:
7. Was the event registration page easy to use?				If no, please explain:

8. Overall, how satisfied were you with the meeting? (Please circle your answer) Very dissatisfied Dissatisfied Neutral satisfied Very Satisfied

9. If AARM was held next year, how could this meeting be improved?

Other comments

Agenda Overview

Specialist Workshops
Friday 13th November 2015

University of Melbourne, Parkville
Alan Gilbert Building

Workshop Times and Location

1. Grains Pest Advisory Committee (GPAC) workshop on 'The Status of Insecticide Resistance in Australia'

Alan Gilbert building, Room 103

8:50 am – 4 pm

Contact: Dr. Garry McDonald

gmcd@unimelb.edu.au

2. Fungicide Resistance Industry and Research Meeting (FIRM) sponsored by GRDC, Curtin, UoM, and GeneWorks

Alan Gilbert building, Room 101

9.00 am – 4 pm

Contact: Dr. Fran Lopez Ruiz

fran.lopezruiz@curtin.edu.au

3. Grain Weeds Advisory Committee's (GWAC) 'Weeds Research and Development Forum'

Alan Gilbert building, Lecture Theatre 3

9.00 am – 4 pm

Contact: Claire Gutsche

cgutsche@ruraldirections.com

****

Workshop Break Times

10.30 am - Morning tea
12.30 pm - Lunch
3.00 pm - Afternoon tea
4.00 pm - Latest time to close sessions

Agenda Overview

Specialist Workshops

Grains Pest Advisory Committee (GPAC)

The Status of Insecticide Resistance in Australia

Friday 13th November 2015

University of Melbourne, Parkville
Alan Gilbert building, Room 103

Contact: Dr Garry Mcdonald
gmcd@unimeld.edu.au

8:30am	**Registration tea and coffee served**
8:50am	Prof Ary Hoffmann: Welcome and introductions

1. Where are we now? What have we learnt? The State of Play in 2015

9:00am	Prof Ary Hoffmann: A broad view of current resistance issues
9:10am	Owain Edwards / Nancy Schellhorn: Global perspectives
9:20am	Open Discussion
9:30am	Lewis Wilson: Bollworm: Lessons from a (cotton) cropping system perspective
9:40am	Greg Baker: Diamondback moth (DBM): working across cropping systems
9:50am	Svetlana Micic: Red-legged Earth Mite (RLEM): Emerging issues
10:00am	Table discussion (Lessons and Opportunities)
11:00am	**Tea and Coffee**

2. Predicting insecticide resistance

11:15am	James Maino: Predicting the spread of resistance of RLEM
11:23am	Paul Umina / Owain Edwards: Predicting new resistance and species at risk; and future projections of current resistances
11:35am	Discussion

3. Preparing for the future: assessing risk and identifying opportunities

11:45am	Geoff Cornwell: Industry perspective: CropLife Australia
11:55am	Ian MacPherson: Industry perspective: Agronomic consulting
12:05am	Discussion

Agenda Overview

Specialist Workshops

Grains Pest Advisory Committee (GPAC)

The Status of Insecticide Resistance in Australia

Friday 13th November 2015

University of Melbourne, Parkville
Alan Gilbert building, Room 103

Contact: Dr Garry Mcdonald
gmcd@unimeld.edu.au

12:30pm	**Lunch**
1:00pm	Table discussion lead by Paul Umina
	Industry practices
	Policy / institutional issues
	Leadership and stewardship
	Education
3:00pm	**Afternoon tea**
3:15pm	Garry McDonald: Group discussion on recommendations
3:55pm	Wrap Up
4:00pm	**Close**

Agenda Overview

Specialist Workshops

Fungicide Resistance Industry and Research Meeting

Friday 13th November 2015

University of Melbourne, Parkville
Alan Gilbert building, Room 101

Contact: Dr Fran Lopez Ruiz
fran.lopezruiz@curtin.edu.au

8:30am	**Registration tea and coffee served**

Topic1: New technologies, methodologies and products developing in the field of fungicide resistance management (session 1 –3)

9:00am	Dr. Fran Lopez Ruiz (CCDM): Workshop introduction
9:10am	Dr. Joe Helps (Rothamsted): Sustainably integrating multiple modes of pest control; resistant cultivars and fungicides
9:40am	Miss Madeline Tucker (CCDM): fungicide resistance in *Blumeria graninis hordei*: is it a harbinger for triazole failure in wheat powdery mildew?
10:00am	Ms. Belinda Cox (CCDM): Mutations by numbers: quantifying fungicide resistance by Digital PCR
10:20am	Session 1 discussion
10:40am	**Morning break**
11:00am	Miss. Kejal Dodhia (CCDM): Killing two birds with one stone: Duplex in-field diagnostics. LAMP demonstration part 1.
11:20am	Dr. Roger Mandel (BASF): Systiva: control from the ground up, benefits and challenges
11:40am	Mr. Tom Loveless (DuPont): A global approach to resistance management : DuPont guidelines and product development priorities to reduce resistance risk
12:00pm	Miss Kejal Dodhia (CCDM): Results. Killing two birds with one stone: Duplex in-field diagnostics. LAMP demonstration part 2.
12:10pm	Session 2 discussion
12:30pm	**Lunch**

Agenda Overview

Specialist Workshops

Fungicide Resistance Industry and Research Meeting

Friday 13th November 2015

University of Melbourne, Parkville
Alan Gilbert building, Room 101

Contact: Dr Fran Lopez Ruiz
fran.lopezruiz@curtin.edu.au

12:30pm	**Lunch**
1:00pm	Ms. Barbara Hall (SARDI): Fungicides resistance in Australian viticulture
1:20pm	Dr. Andrew Milgate (DPI): Developing in vivo methods for assessing STB fungicide sensitivity
1:40pm	Ms. Sue Cross (BAYER): SDHI resistance patterns
2:00pm	Session 3 discussion
	Topic 2: Future opportunities and threats to the industry (session 4)
2:20pm	Prof. Richard Oliver (CCDM): Reducing the governing principles of fungicide resistance management to practice
2:40pm	Mr. Nick Poole (FAR): Field performance of new fungicide active ingredients to combat pathogen resistance
3:00pm	**Afternoon tea**
3:20pm	Dr. Angela Van de Wouw (UoM): Tolerance to fluquinconazole identified in *Leptosphaeria maculans* populations surveyed across Australia
3:40pm	Session 4 discussion and general closing discussion
4:00pm	**Close**

Agenda Overview

Specialist Workshops

Grain Weeds Advisory Committee (GWAC)

Weeds Research and Development Forum

Friday 13th November 2015

University of Melbourne, Parkville

Alan Gilbert building, Lecture Theatre 3

Contact: Clair Gutsche
cgutsche@ruraldirections.com

8:30am	**Registration tea and coffee served**
9:00am	GWAC—introduction and outcomes by David Heinjus (GWAC)
9:10am	Rick Llewellyn (CSIRO): Cost of weeds
9:40am	Katherine Hollaway (DEPI VIC): eXtension Aus
10:05am	John Cameron (ICAN): Advisor training needs and adoption
10:40am	**Morning break**
10:50am	Rob Wheeler (SARDI): Herbicide tolerance
11:15am	IWM Project: Summary from each region
	Michael Widderick (QDAF): Northern
	Leslie Weston (CSU): Southern
	Michael Walsh (AHRI): Western
12:15pm	Ken Young (GRDC): investment in weed RD&E
12:30pm	**Lunch**
1:20pm	Q&A panel session with farmers and advisers: moderated by John Cameron
3:00pm	**Afternoon tea**
3:20pm	Q&A panel session with farmers and advisers: moderated by John Cameron (GWAC)
3:44pm	David Heinjus (GWAC): wrap up
4:00pm	**Close**

Notes

If you wish to forget anything on the spot, make a note that this thing is to be remembered

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