

FEATURED IRAC MEMBER:

Steve Skillman (Syngenta) leads the IRAC Sucking Pest WG. One of the team's main projects has been the Myzus persicae resistance monitoring in Southern Europe.



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About This Issue

Welcome to another IRAC eConnection newsletter. As always, we try to bring you interesting and informative articles about the work of IRAC and keep you updated on developing insecticide resistance problems around the world.

In this issue we focus on the ongoing neonicotinoid resistance monitoring of *Myzus persicae* in peach orchards in Southern Europe, with results from samples taken during 2012, along with the latest corresponding IRAC resistance management guidelines. We also report on the IRAC US Symposium at the recent ESA, listing presentations given by speakers. In addition we have a short article describing MoA subgroups with details of how and when they should be used in IRM programs and also some other IRAC news such as further posters published and the new IRAC Philippines group described below.

Remember, if you have any news or resistance topics of interest, please let us know so that we can inform others in the IRAC Network. We hope you enjoy the issue.

New IRAC Philippines Group

IRAC are pleased to announce the formation of a new Country Group, IRAC Philippines which is working in close collaboration with CropLife Philippines.

The IRAC team is being led by Florence Vasquez of Bayer CropScience. The team was originally formed to implement insecticide resistance management strategies with the new Diamide chemistry, but it quickly became apparent that to be successful, all companies and all chemistries need to be included when discussing IRM programs. It is hoped that in time other Diamide Country Teams will follow the lead of the Philippines Team.

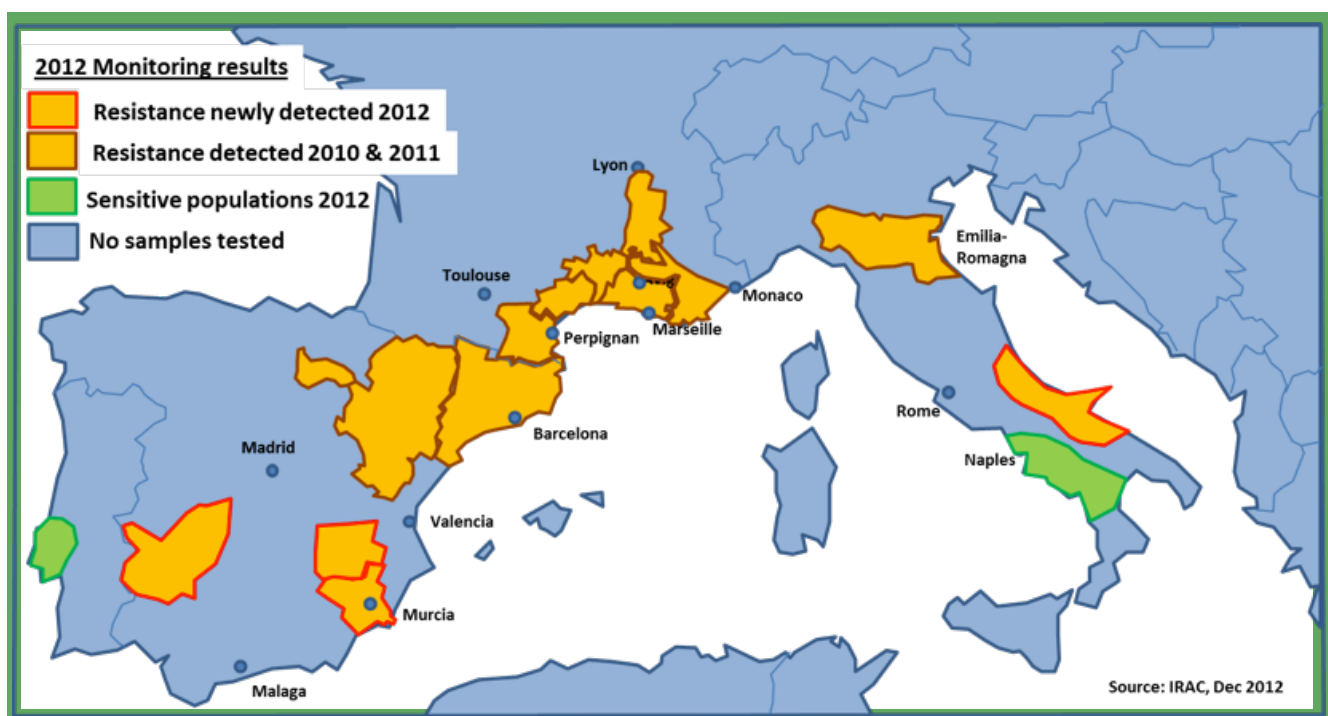


***Myzus persicae* neonicotinoid resistance: IRAC Management Guidelines 2013**

In March 2012, IRAC issued a 'resistance alert update' to inform of the status of neonicotinoid resistant green peach aphid (*Myzus persicae*) in the peach orchards of southern France and north-eastern Spain and northern Italy. During 2012, further samples of aphids have been collected from these countries in peaches and other *Myzus* host crops to determine their resistance status. The resistance is based on a target-site mutation which strongly affects neonicotinoid efficacy. Individuals of all samples collected were analyzed for the mutation by molecular diagnostics.

The results of the survey confirm the presence of neonicotinoid-resistant aphids in many of the stone fruit orchards of southern France and north east Spain as well in the Emilia-Romagna region of Italy. The samples also revealed resistant populations in southern and western Spain and central and southern Italy for the first time.

Map of the region showing areas where target site resistance to neonicotinoids was detected in *Myzus persicae* collected from stone fruit orchards from 2010 to 2012.



IRAC have worked with local agricultural ministry officials, and entomological experts from Spain, France, Italy and the UK, to provide the following advice for the 2013 season in stone fruits, notably peaches:

Where no loss of performance to neonicotinoids has been experienced, it is recommended to use a maximum of one neonicotinoid application per crop cycle against *Myzus persicae* to minimise the further spread and intensification of the resistance and maintain effectiveness of the neonicotinoids. Depending on crop and country and local guidelines, this single spray may be pre-flowering or post-flowering, but not during flowering, to fit with local IPM recommendations.

It is recommended that growers that have experienced a decline in activity to neonicotinoids in past seasons do not continue to use this group of insecticides as a preventative measure to halt the spread of resistance, and use insecticides with other modes of action to control *Myzus persicae**. It is recommended that control of pre-flowering pests in these regions is managed with mineral oils combined with or without insecticides of a different mode of action (note that pyrethroids in some areas are also affected by resistance).

Myzus persicae neonicotinoid resistance: IRAC Management Guidelines 2013 (Contd.)

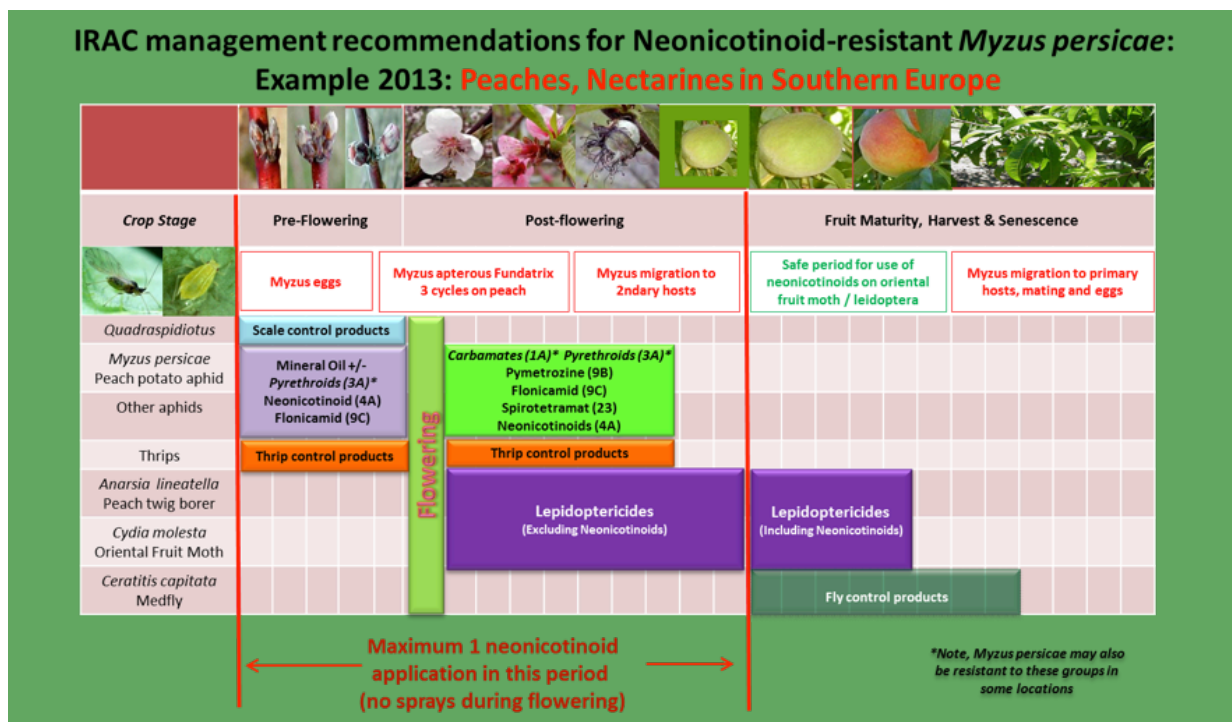
As an alternative it is recommended to use other aphicides, according to local registrations, with a different mode of action not affected by resistance**; such as IRAC MoA groups 1A, 3A, 9B, 9C, 23 as well as mineral oil. IRAC also recommends the use of any other IPM measures locally recommended.

*Consult local advisors for advice on which aphicides are affected by resistance in your locality.

** See [IRAC guidelines on Myzus persicae resistance management](#) on the IRAC website

Acknowledgements: Many thanks to representatives of Rothamsted Research International, Università Cattolica del Sacro Cuore - Piacenza Campus, Italy, University of Cartagena, Spain, Chamber of Agriculture in Catalunya and Aragon in Spain) and the IRAC Spain Sucking Pest Working Group for inputs into these IRM recommendations.

Example of IRM-based programs to limit spread of target site Neonicotinoid resistance in *Myzus persicae*:



New French version of the IRAC Mini-Vector Manual

French is spoken by an estimated 115 million people across 31 African countries. Many of these countries have endemic malaria and undertake mosquito vector control as part of their malaria control programmes. Like the rest of the world, these countries also face the challenge of insecticide resistant mosquitoes.

To support vector control programme managers and practitioners, the IRAC Public Health team updated their publication [“Prevention and Management of Insecticide Resistance in Vectors of Public Health Importance”](#) in 2011. This manual aims to provide the Vector Control programme manager with the background information and recommendations they will need to design and undertake best practice Insecticide Resistance Management (IRM) programmes. In the same year the IRAC Public Health team also published a [“pocket” version of the manual](#), focusing more on vector control practitioners and students, with the aim of providing them with the knowledge and tools required to implement IRM in vector management programmes. With nearly 4000 copies of each version distributed, these booklets have proven to be popular and valuable tools.

Originally these publications were only available in English, however, to support mosquito vector control practitioners in francophone countries, the [“pocket” edition has now been translated into French](#), and is available from the [Public Health Team Page](#) of the IRAC website. Printed copies will be available upon request in the future.




2012 IRAC-US Symposium - Do Crises Drive Innovation? Insect Resistance Management: Proactive or Reactive?

This symposium, the 8th in a series, was held at the 60th Entomological Society of America (ESA) meeting in Knoxville, TN, on Tuesday, 13 November 2012. The session was very well attended by industry and academia. Ten speakers from academia, government and industry presented many excellent examples of old and new challenges in insect control as it relates to insect resistance management programs. The speakers and their talks are shown in the following list. An article regarding the information given in this symposium is being prepared by IRAC-US for publication.

1. Russell L. Groves, University of Wisconsin-Madison. *Interaction of insecticide resistance and delayed emergence in the Colorado potato beetle – new challenges for an old pest.*
2. Aaron J. Gassmann, Iowa State University. *Western corn rootworm and Bt maize: A case study illustrating the need for IPM and IRM.*
3. Randall G. Luttrell, USDA-ARS, Stoneville, MS. *Deployment of Bt cotton and Bt corn in the agricultural landscape of the southern U.S., opportunities and challenges for strategic resistance management.*
4. Lukasz L. Stelinski, University of Florida – Lake Alfred. *Inevitable emergence of insecticide resistance in populations of Asian citrus psyllid, vector of the greening disease pathogen: Current status, mechanisms, and efforts for proactive management.*
5. John C. Wise, Michigan State University. *Managing resistance in the complex world of tree fruit IPM.*
6. Anthony M. Shelton, Cornell University. *Long-term insecticide resistance management for the diamondback moth: Dreaming the impossible dream?*
7. Brian A. Nault, Cornell University. *Proactive IRM for thrips – a case study of onion thrips in onion.*
8. Ralf Nauen, Bayer Crop Science. *A reactive approach to manage pollen beetle in European winter oilseed rape: Good news, bad news and challenges ahead.*
9. Lance S. Osborne, University of Florida – Apopka. *Are resistant pests more of a threat than new invasive species in ornamentals?*
10. Caydee Savinelli, Syngenta Crop Protection. *Results of a proactive global IRM strategy for diamides.*

New Posters from the [IRAC Sucking Pest Working Group](#) - Rice Hoppers



Rice Hoppers

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Introduction

There are five species of plant and leaf hoppers which are known to be important pests of rice in Asia and Australia. They belong to two families, the Delphacidae and Cixiidae. Delphacidae includes the brown planthopper (*Nilaparvata lugens*), small brown planthopper (*Sogatella orizivora*) and whitebacked planthopper (*Sogatella orizivora*) which tend to inhabit the base of the plant, whilst the green grassy leafhopper (*Nezara viridula*) and rice green leafhopper (*Neohumana procopis*) from the Cixiidae family tend to inhabit the upper parts of the plant. Both families are economically important pests of rice, when favourable conditions allow them to reach high infestation levels. All the species feed by the insertion of their mouth parts into the plant phloem tissue and damage is caused by either direct sap loss or through the injection of toxic saliva. The distinctive bowing and wilting of rice plants, which is caused by hopper infestation is commonly known as 'hopper burn'. Plant and leafhoppers are also known to transmit various plant viruses such as grass stunt and rice stripe cereal mosaic. Treatment with insecticides has been the primary control option for growers, with systemic insecticides more favoured in recent years. However the selection of resistant plant varieties and use of biological control agents are also important control methods for these pests.

Insecticide Resistance

Insecticide resistance has been recorded in rice hopper species since the early 1960's, when organophosphates, carbamate and cyfluthrin organochlorine insecticides were the main methods of chemical control. Although further insecticide chemistry has been introduced to control hoppers, the importance of rice as a staple food crop and the reliance on insecticides for the control of insect pests has seen the continued evolution of insecticide resistance. The most recent developments have seen populations of *Nilaparvata lugens*, *Cixiidae orizivora* and *Sogatella orizivora* independently develop resistance to neonicotinoid and phenylpyrazole insecticides. At the time of writing there is no evidence of a common cross-resistance between chemical classes of insecticide across these species, however there is evidence that individual hoppers may exhibit multiple mechanisms of resistance to one or more insecticide modes of action.

Insecticide Chemistry	Mode of action	Delphacidae species	Cixiidae species	Resistance mechanism	Neurotoxic resistance	Metabolic resistance
Carbamate	1A	X	X	X	X	X
Organophosphates	1B	X	X	X	X	X
Cyfluthrin organochlorine	3A	X	X	X	X	X
Phenylpyrazoles (Fluralaner)	2B	X	X	X	X	X
Pyrethroids	3B	X	X	X	X	X
Neonicotinoids	4A	X	X	X	X	X
Selective Feeding Blockers (SFA)	10 & 11					
Chitin Biosynthesis Inhibitor	19	X	X	X	X	X

Table 1: Insecticide modes of action to which field collected rice hoppers have been reported in literature as being resistant (IRAC 2012).

*Neurotoxicity recorded in the field is based on peer-reviewed published reports of field collected populations of rice hoppers. Field and screen data being tested for resistance susceptibility. Resistance evidence is a degree of resistance, not absolute. The information provided does not reflect the current status of resistance in all hopper or hoppers.

Distribution & Migration

The regional range of each of the five rice species of rice hoppers varies and in many cases over-lap. Many of the species are migratory in nature and therefore each species may not reach pest status in all of its range areas. The brown planthopper (*Nilaparvata lugens*) for example is recorded as being an immigrant pest in China, Japan and Korea after migrations from tropical and sub-tropical regions of S.E. Asia. Infestation levels in these countries are often dependent on environmental conditions throughout the year.

Species	China	India	Japan	Korea	Thailand	Vietnam
<i>Nilaparvata lugens</i>	X	X	X	X	X	X
<i>Sogatella orizivora</i>	X	X	X	X	X	X
<i>Nezara viridula</i>	X	X	X	X	X	X
<i>Neohumana procopis</i>	X	X	X	X	X	X

Resistance Management

As there is no evidence of cross-resistance amongst the groups of insecticides used for rice hopper control, it is recommended that the rotation of effective insecticides with different modes of action are used to provide insect control, whilst at the same time reducing the risk of insecticide resistance from developing. The following should be considered when designing an insect control program for rice hoppers:

- Plan ahead. Determine when in a typical season insecticide applications are likely to be needed and plan for the rotation of insecticides with different modes of action, avoiding the consecutive use of products belonging to the same mode of action group. Plan for contingencies in case extra applications are needed due to unusual pest infestations. Consider the presence of other insect pests of rice (e.g. stem borers or leaf folders) and required treatments.
- Determine which insecticides are most effective for controlling each rice pest during each application timing. If the presence of other rice pests over-lap with rice hoppers, consider using pest specific insecticides rather than broad spectrum insecticides, which may increase unnecessary resistance selection pressure for either or both pests.
- Evaluate the current insecticide resistance situation in the area (consult local crop advisors and experts). Rotate using insecticides already affected by resistance where possible.
- Consider the impact of the insecticides on non-target insects and natural predators, especially during early season applications, where maintaining natural predators can reduce the need for later sprays.
- Consider the use of insect resistant rice varieties and the use of biological control agents.
- Always follow insecticide label instructions for application timings, volumes and concentrations.


Susceptibility Monitoring

The topical application of insecticides using a syringe, as described in the IRAC approved method No. 320, provides a method of assessing the activity of all insecticides which are utilized for the control of planthoppers, including pyrethroids, which primarily acts by reducing feeding and egg lay. A video of this method is available via the IRAC web-site.

Alternatively leaf dip assays, as described in the IRAC approved method No. 320, provides a method of assessing the activity of all insecticides which are utilized for the control of planthoppers, including pyrethroids, which primarily acts by reducing feeding and egg lay. A video of this method is available via the IRAC web-site.

This poster is for educational purposes only. Details are accurate to the best of our knowledge but IRAC and its member companies cannot accept responsibility for how this information is used or interpreted. Advice should always be sought from local experts or advisors and health and safety recommendations followed. Designed and produced by IRAC Sucking Pest Working Group, December 2012. Photograph courtesy of Syngenta Crop Protection & Bayer Crop Science.

New Posters from the [IRAC Sucking Pest Working Group](#) - Asian Citrus Psyllid



IRAC
Insecticide Resistance Action Committee

The Asian citrus psyllid, *Diaphorina citri*:
'Insect Resistance Management' the Base for a Successful IPM Program

www.irc-online.org

Introduction and Biology

The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama (Fig. 1a.), is the insect vector associated with the bacteria *Candidatus Liberobacter asiaticus* and *C. L. americanus*. These bacteria are suspected to be the causal agents of Huanglongbing (HLB) in Asia and America. Trees infected with the bacterial pathogen begin to show symptoms such as early fruit drop and mottled leaves anywhere from 5 months to 3 years after infection. Even during this asymptomatic period, plants can also be source of inoculum, hence the need to manage the vector even if the trees are not showing symptoms (Fig. 1b). Once the trees are infected, the production rapidly declines rendering the infected trees unproductive in a few years.




Fig. 1 (a) Adult of ACP feeding on a young orange leaf. (b) HLB infected trees with symptoms (left) and asymptomatic (right). Nectar traps on the ground, leaf collection, and dissects are more prominent on the symptomatic plant.

Citrus psyllids lay their eggs on the inner-side of unfolding leaves which protect the eggs and early nymphs from adequate insecticide contact, rendering applications of non-systemic insecticides inefficient to manage nymphs. The psyllid nymphal stage has 5 instars taking between 15 and 47 days to become adults depending on environmental conditions. Nymphs acquire the bacteria and the adults vector the disease to uninfected plants and to plants that are already infected, increasing the bacterial titer in already diseased plants. Adults are considered to be the preferred target for foliar insecticide applications since they vector the bacteria. Systemic soil insecticide target nymphs and adults for the first 2 years after planting, after that period, trees are too big for the current chemistries to be effective.

Resistance to Insecticides

Various levels of insecticide susceptibility have been reported in Florida, USA (Table 1). Although the resistance ratios are not high in comparison to those of other pests, it is important to be vigilant to prevent the onset of resistance for this pest. The results in table 1 are correlated with elevated levels of detoxifying enzymes in both adults and nymphs collected in the field. However, ACP carrying HLB were shown to be more sensitive to insecticides than non-infected psyllids.

Table 1: Highest resistance factor (RF) values observed on various wild populations of ACP in Florida in 2010. (Thwait et al. 2012)

Population	Imidacloprid	Thiamethoxam	Acetamiprid	Permethrin	Spinosad	Spinetoram
WFLA-101	200	120	100	50	50	20
WFLA-102	40	50	No tested	No tested	50	50

Management Plan Example

Figure 2: Management plan and opportunities for host-rotation used for citrus psyllid based on plant phenology. The rotation uses various MoA which are registered and labeled for control of citrus psyllid. The rotation and number of MoA might vary according to the number of products registered in each rotation.




Figure 2: Management plan and opportunities for host-rotation used for citrus psyllid based on plant phenology. The rotation uses various MoA which are registered and labeled for control of citrus psyllid. The rotation and number of MoA might vary according to the number of products registered in each rotation.

Table 2: Modes of action registered for ACP management. Pest and Resistance management should be based on an appropriate rotation of these MoA.

Modes of action registered for ACP management			
1. ACP-101	2. ACP-102	3. ACP-103	4. ACP-104
5. ACP-105	6. ACP-106	7. ACP-107	8. ACP-108
9. ACP-109	10. ACP-110	11. ACP-111	12. ACP-112
13. ACP-113	14. ACP-114	15. ACP-115	16. ACP-116
17. ACP-117	18. ACP-118	19. ACP-119	20. ACP-120

Integrated ACP Management Guidelines

- Protect nursery plants under netting and use only HLB free certified stock.
- Transport infected nursery stock according to government regulations.
- Protect young and non-bearing trees with soil applied systemic insecticides. In older trees, soil applied systemic insecticides may not satisfactorily work on the pest.
- Rotate soil-applied insecticides with foliar sprays of other modes of action. Rotation of different modes of action is key to resistance management.
- Management of adults during dormant season is key to maintain low populations for the rest of the year.
- Use locally defined monitoring methods and intervention thresholds to make spray decisions. Notify to manufacturers any product performance failures immediately.
- Use and protection of bio-control agents is encouraged as part of the IPM programs and to reduce the risk of insecticide resistance development.

Relevant Literature

Arévalo, H.A., R.S. Frazier, G. Smedley, and R.A. Stansly. 2011. Citrus Greening Etiological Database. University of Florida. <http://www.irc-online.org/etiological-database/>

Rogers, W.L., P.A. Stansly, L.L. Seebold. 2012. 2012 Florida Citrus Pest Management Guide. Asian Citrus Psyllid and Citrus Leaf Miner. IFAS, University of Florida. 234-236. <http://www.irc-online.org/>

Thwait, S., R.S. Warren, M.S. Rogers, L.L. Seebold. 2011. Insecticide Resistance in Field Populations of Asian Citrus Psyllid in Florida. Pest Management Science 67: 1239-1258

** Professional method used by IRAC to evaluate insecticide susceptibility for Asian citrus psyllid

This poster is for educational purposes only. Details are accurate to the best of our knowledge but IRAC and its member companies cannot accept responsibility for how this information is used or interpreted. Advice should always be sought from local experts or advisors and health and safety recommendations followed.

Designed & produced by the IRAC Sucking Pest Team, Jan. 2013. Poster No. L10. Photographs courtesy of: M.S. Rogers (University of Florida), H.A. Arévalo (University of Florida) and W.L. Rogers (University of Florida).

What are Mode of Action (MoA) Subgroups?

The IRAC MoA Classification ensures that insecticide and acaricide users are aware of MoA groups and that they are a sound basis on which to implement season-long sustainable resistance management strategies. But what are subgroups?

There are multiple instances of subgroups within MoA groups in the IRAC MoA Classification Scheme. Subgroups represent distinct chemical classes which share a common insecticidal target site and are sufficiently unique so as to have a reduced risk of cross-resistance when resistance is mediated by metabolic rather than target site based mechanisms. As insecticides from different subgroups may be metabolized by distinct enzymes, they have reduced risk for cross-resistance over insecticides within a subgroup.

Is it appropriate to rotate between subgroups?

The cross-resistance potential between subgroups is higher than between different MoA groups, therefore it is not advisable to rotate between subgroups unless there are no alternatives among other MoA groups. In the absence of a suitable rotation group option, it may be possible to rotate insecticides between subgroups if it is clear that cross-resistance mechanisms do not exist in the target insect populations. Knowledge and experience of cross-resistance patterns, resistance mechanisms, and furthermore pest, crop and region should be considered. Consequently, consultation with local experts for advice and information as to existing resistance mechanisms in the pest population being treated, is strongly recommended.

Where can I find more information on subgroups and their use?

For details on specific subgroups and their use, please consult the MoA Classification scheme: (<http://irc-online.org/teams/mode-of-action/>).

Additionally, a recent publication provides an excellent overview of the objective of the MoA working group and the use of the MoA Classification Scheme:

R. Nauen, A. Elbert, A. Mccaffery, R. Slater, T.C. Sparks, IRAC: Insecticide resistance, and mode of action classification of insecticides, In W. Kramer, U. Schirmer, P. Jeschke, M. Witschel (Eds.), Modern Crop Protection Compounds: Vol. 3 Insecticides, 2nd ed., Wiley-VCH, Weinheim, GR, (2012), pp.935-955.

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IRAC News Snippets

- ★ The third video from the IRAC Test Methods Group, this time on plant hoppers, has now been finalised and can be viewed on the [IRAC Methods Team](#) page of the website or directly on [YouTube](#).
- ★ [Pest Pages have now been added to the IRAC website](#). This is still under development as new pests are added and information is updated but so far 15 of the most common insect pests have been included with some brief background on biology and pest distribution, status of resistance and links to any IRAC test methods, or other resources available. It is planned to add further pests including those important to vector and hygiene pest control in the future.

Conferences & Symposia

- ★ 79th AMCA Annual Meeting, Atlantic City, February 24-28, 2013
- ★ 48th IRAC International Meeting, Bracknell, UK, March 18-22, 2013
- ★ 1st Intl. Whitefly Symposium, Kolymbari, Crete, May 20-24, 2013
- ★ 246th American Chemical Society (ACS), Indianapolis, Sept., 8-12, 2013
- ★ MIM Pan African Malaria, Durban, S. Africa, Oct 2013
- ★ NPMA PestWorld, Phoenix, Arizona, Oct. 2013
- ★ Entomological Society of America meeting, Austin, TX, Nov. 10-13, 2013
- ★ ASTMH Annual Meeting, Washington, DC, Nov. 2013

Feedback

The eConnection is prepared by the IRAC International Communication & Education Working Group and supported by the 15 member companies of the IRAC Executive. If you have information for inclusion in the next issue of eConnection or feedback on this issue please email aporter@intraspin.com

Disclaimer

The Insecticide Resistance Action Committee (IRAC) is a specialist technical group of CropLife. Information presented in this newsletter is accurate to the best of our knowledge but IRAC and its member companies cannot accept responsibility for how this information is used or interpreted. Advice should always be sought from local experts or advisors and health and safety recommendations followed.

FURTHER INFORMATION

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