

FEATURED IRAC MEMBER:

Lixin Mao works for BASF, based in RTP North Carolina. She is a member of several IRAC Working Groups and has taken over the role of IRAC Treasurer.



IN THIS ISSUE:

MOA CLASSIFICATION

Latest updates to the IRAC MoA Classification and associated publications.

MIXTURES

IRAC Position Statement on the use of mixtures and IRM considerations.

NEW POSTERS

- *Pollen Beetle Monitoring Results from 2011*
- *Strategies for Sustainable Control of *Spodoptera exigua**

RECENT RESISTANCE PUBLICATIONS

Spotlight on recent research articles appearing in journals.

NEWS SNIPPETS & CONFERENCES

Ongoing IRAC activities, conferences and symposia.

www.irac-online.org

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 report on the latest update to the IRAC MoA Classification, highlighting new actives added and the revision of Group 11, the *Bacillus thuringiensis* products. In addition we publish for the first time the IRAC Position Statement on the use of mixtures and caveats when considering resistance management and two new IRAC posters, one reporting the results of the pollen beetle monitoring in Europe during 2011 and the other covering strategies for sustainable control of *Spodoptera exigua*. The final article is our regular spotlight feature, picking out some of the key insecticide resistance articles that have appeared in journals over the past few months and we conclude with some IRAC News Snippets and details of upcoming meetings and conferences.

47th Meeting of IRAC International

Dow AgroSciences kindly hosted the 47th IRAC International meeting at their research facility in Indianapolis last week in March, 2012. The meeting was held in conjunction with the IRAC US group and there was a useful exchange of information with around 40 participants representing 10 of the IRAC member companies along with some invited guests. The meeting consisted of a mixture of concurrent IRAC working group sessions, a meeting of the Executive Committee, the IRAC US group and an International resistance review day.



IRAC Mode of Action (MoA) Classification Update

A number of changes have recently been made to the MoA Classification scheme resulting in publication of Version 7.2. The main updates are listed below, but the full MoA Classification Scheme can be downloaded from the IRAC website.

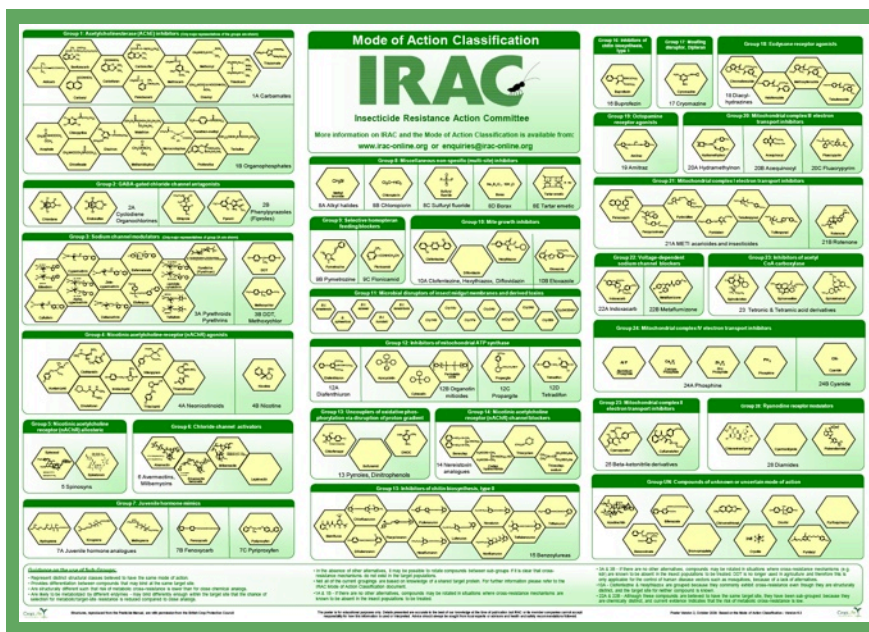
Some background information for the active ingredients included in the scheme:

- Cyantriliprole – Soon to be registered insecticide that is effective on a broad spectrum of sucking and chewing insect pests. Group 28
- Cyflumetofen – Registered in Japan as an acaricide for use on tree fruit, vegetables and ornamentals, and under development with BASF for use outside of Japan. Group 25
- Pyrifluquinazon – Registered in Japan and in development for the US for use on a wide variety of sucking insect pests and thrips. Group UN
- Sulfoxaflor – Registered in Korea and anticipating a registration in the US this year. It is effective on a wide spectrum of sap-feeding insect pests. Group 4C
- Group 11 revised – Following much discussion, the Biotech Team has revised the classification for Group 11 to provide more meaningful information.

Other MoA updates:

e-Classification: The e-Classification on the IRAC website, used to search for MoA by Group or active ingredient, has been updated to reflect all the accumulated changes and is now in line with Version 7.2 of the Classification Scheme.

MoA Posters: The MoA pest specific posters (sucking insects, mites, Lepidoptera and mosquito) have all been updated to reflect the most recent changes in the MoA Classification Scheme. Likewise, the MoA Structures poster has been updated and many of the structures have been redrawn / reformatted to make them easier to read. This has been issued and printed as a third edition of the poster with a different colour scheme to differentiate it from the earlier versions. In addition a Japanese version of the MoA Structure poster has been developed and the Spanish version updated. The MoA Working Group is currently updating the Chinese and Portuguese versions of the poster. All the MoA posters are available on the IRAC website.



MoA Booklet: The IRAC MoA booklet has been updated and is now in its third edition. Four thousand copies were printed this spring and are currently being distributed. Copies have already been provided for several meetings and conferences. Notably, the third edition of the MoA booklet along with English and Japanese versions of the MoA Structures poster were distributed at the Meeting of the Japanese Society of Applied Entomology and Zoology in March of 2012.

Book Chapter on IRAC MoA Classification: Earlier this year, an updated book chapter was published as part of the second edition of the Modern Crop Protection Compound book set; Nauen et al., 2012, IRAC, insecticide resistance and mode of action classification of insecticides. In Modern Crop Protection Compounds. Vol. 3, 2nd ed. (W. Kramer, U. Schirmer, P. Jeschke, M. Witschel, eds.), Wiley-VCH, New York, pp. 935-955.

IRAC Position on the use of Mixtures and their Role in Insect Resistance Management

Globally, there is an increased tendency and interest in developing insecticide mixtures. Whereas mixtures are common place for both herbicides and fungicides, insecticide mixtures are often a matter of debate, which mainly reflect differences in requirements for control, with insecticides usually controlling one target as opposed to a complex of targets, with the notable exception of insecticide seed (and soil) treatments. The considerations for any proposed mixture will vary depending on the actives and intended uses involved.

In order to provide some guidance when considering the use of insecticide mixtures a few basic principles have been drawn together from a series of considerations over the benefits and disadvantages of mixtures, and basically applying for crop, public health and biotech applications. These considerations regarding the potential justification for using insecticide mixtures, and their resistance management implications, are part of a fairly general insecticide mixture statement recently developed by the IRAC Executive member companies.


IRAC International Insecticide Mixture Statement

As with applying single active ingredient products, insecticide mixture products should be used with careful consideration of the characteristics of the individual active substances, use pattern and pest complex targeted. The primary intention for the use of an insecticide mixture (tank-mix or pre-formulated mixture) is, in most cases, not resistance management, but pest¹ management. The following should be considered before using insecticide mixtures for insect pest control:

- 1) Mixtures of insecticides provide technical advantages for controlling pests in a broad range of settings, typically by increasing the level of target pest control and/or broadening the range of pests controlled.
- 2) Most mixtures are not primarily used for purposes of insect resistance management (IRM).
- 3) In the majority of settings, the rotation of insecticide modes of action is considered the most effective IRM approach. Insecticide mixtures may offer benefits for IRM when appropriately incorporated into rotation strategies with additional mode(s) of action, but generally a single mixture should not be relied upon alone.
- 4) All of the following should be considered when using mixtures for IRM:
 - a) Individual insecticides selected for use in mixtures should be highly effective and be applied at the rates at which they are individually registered for use against the target species.
 - b) Mixtures with components having the same IRAC mode of action classification are not recommended for IRM.
 - c) When using mixtures, consider any known cross-resistance issues between the individual components for the targeted pest/s.
 - d) Mixtures become less effective if resistance is already developing to one or both active ingredients, but they may still provide pest management benefits.
 - e) The IRM benefits of an insecticide mixture are greatest if the two components have similar periods of residual insecticidal activity. Mixtures of insecticides with unequal periods of residual insecticide activity may offer an IRM benefit for the period where both insecticides are active.

¹ Pests include species relevant to both crop protection and public health

New Posters from the IRAC Coleoptera and IRAC Lepidoptera Working Groups




IRAC
Insecticide Resistance Action Committee

IRAC Coleopteran Working Group

Pollen Beetle Resistance Monitoring 2011

www.irc-online.org

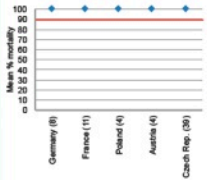


Introduction and Background

Pyrethroid resistance has been recorded in European populations of the pollen beetle (*Meligethes aeneus*) since 1999, when it was first reported in Eastern France. The IRAC Coleopteran Working Group brings together expertise from agrochemical companies and independent researchers in order to monitor the development and spread of resistance in pollen beetles and other coleopteran pests of oilseed rape.

Pyrethroid, neonicotinoid and organophosphate susceptibility is measured by the use of insecticide coated glass vial assays. Results of the 2011 susceptibility monitoring program are presented in this poster. More details of the methods used in this survey can be found on the IRAC website (www.irc-online.org).

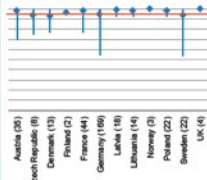
1B Organophosphate susceptibility



IRAC method # 25
• 0.3ug/cm² chlorpyrifos-ethyl dose
• > 90% mortality indicates susceptibility.

All European populations of pollen beetle tested were susceptible to organophosphates based on the IRAC recommended discriminating dose.

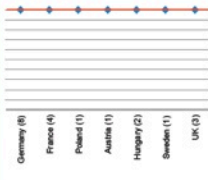
4A Neonicotinoid susceptibility



IRAC method # 21
• 1.44ug/cm² thiacloprid dose
• > 95% mortality indicates susceptibility.

Most populations were susceptible to neonicotinoids, but there is some variation in response which needs to be observed in future monitoring programs.

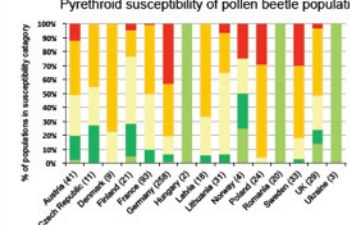
22A Indoxacarb susceptibility



IRAC method # 27
• 1.00ug/cm² indoxacarb dose
• 100% mortality indicates susceptibility.

All European populations of pollen beetle tested were susceptible to indoxacarb based on the IRAC recommended discriminating dose.

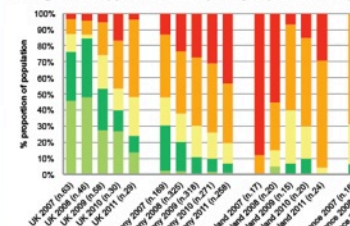
3A Pyrethroid susceptibility of pollen beetle populations 2011



IRAC method #11
• 0.075 & 0.015 ug/cm² lambda-cyhalothrin doses
• Scoring system based on mortality at both doses indicates susceptibility status.

Pyrethroid resistant populations of pollen beetle dominate in western mainland European countries.

3A Changes in the pyrethroid susceptibility of pollen beetle populations 2007 - 2011



Susceptibility surveys conducted between 2007 & 2011 suggest that in general pyrethroid resistant populations are continuing to increase in Europe.

Summary & Recommendations

- Pyrethroid resistant populations of pollen beetle were the dominant population type in all the countries surveyed, except Romania, Ukraine and Hungary.
- The survey indicates that pyrethroid resistant populations are increasing in frequency across Europe. With largest increases (2010 to 2011), observed in the UK, Poland, Latvia and Finland*. There are some indications of a decline in resistant populations in the Czech Republic compared to surveys in previous years.
- Most populations were susceptible to neonicotinoids, but there is some variation in response which needs to be observed in future monitoring programs.
- All populations of pollen beetle tested were susceptible to organophosphates and indoxacarb based on the IRAC recommended discriminating dose.
- In order to prevent further insecticide resistance development, it is recommended that insecticides with different modes of action are utilised in an effective resistance management program, dependant on local insecticide availability and national use guidelines. IRAC guidelines for resistance management in oilseed rape can be found on the IRAC website (www.irc-online.org).
- IRAC would like to thank all of those who contributed to the survey. Participants are too numerous to name, but their contributions are very much appreciated.

*Data not presented on poster.

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.

Version 1.0, Designed and produced by IRAC Coleopteran Working Group, May 2012, Photographs courtesy of Syngenta Crop Protection

Visit to IRAC web-site for further details at www.irc-online.org



IRAC
Insecticide Resistance Action Committee

Strategies for Sustainable Control of Beet Armyworm, *Spodoptera exigua*

www.irc-online.org



Introduction and Biological Background

Beet armyworm *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae) is a highly dispersive, polyphagous species that can be a serious pest of vegetable, field and flower crops. Susceptible crops include asparagus, cabbage, pepper, tomato, lettuce, celery, strawberry, eggplant, sugar beet, alfalfa, cotton.

Life cycle:



Beet armyworm is native to southeast Asia but is now found in Africa, southern Europe, Japan, Australia and north America. It lacks a diapause mechanism and can only overwinter successfully in warm regions or in greenhouses. Nevertheless, because of its dispersal abilities, beet armyworm will regularly invade temperate areas and cause damage during the growing season. The larvae are gregarious and may feed in large swarms, causing devastating crop losses. Larvae feed on both foliage and fruit. As they mature, the larvae become solitary. Damage includes consumption of fruit and leaf tissue and contamination of the crop. One generation can be produced in as little as 21-24 days.



S. exigua damage to cabbage and tomato

Resistance Mechanisms

Several biochemical mechanisms may contribute to the evolution of insecticide resistance in beet armyworm. These mechanisms may act separately or in concert.

- Enhanced metabolic detoxification, including increased activity of esterases, mixed-function oxidases, and microsomal-O-demethylase.
- Target site insensitivity.
- Sequestration by proteases or esterases, efficient cellular repair or an increase in the immune response.

Benefits of Maintaining Insect Susceptibility:

- For growers:**
 - More choice of control options.
 - Consistent pest control allows higher and more predictable crop yields.
 - Stable crop protection costs.
 - No need to increase the number of applications or amount of control product used.
- To the environment:**
 - Lower risks to the ecosystem because less pest control product is applied to crops.
- To the industry:**
 - Increased product longevity with better return on investments.
 - Correct use of insecticides is a critical product stewardship goal.

Integrated Resistance Management

Resistance occurs because of repeated exposure of multiple pest generations to insecticide(s) with the same mode of action. Integrated resistance management strategies take advantage of all available pest management options to decrease insecticide selection pressure on insect populations. A combination of all available tools for *S. exigua* management should be used to prevent the development of insecticide resistance:

- Chemical control**
 - Always follow the directions for use on the label of each product.
 - Consult product label or IRAC's website (www.irc-online.org) to determine the mode of action of each product.
- Integrated Pest Management**
 - Apply insecticides only when needed by following insect pest pressure and using thresholds.
 - Choose crop varieties less susceptible to beet armyworm and consider crop rotation.
 - Safeguard predators and parasitoids and/or release natural enemies.
- Integrated Resistance Management**
 - Don't treat successive generations with products of the same mode of action.
 - Use an approximately 30 day window to control sprays of insecticides of the same mode of action.
 - Only reuse a mode of action if 30 days have passed since the previous treatment window.
 - Do not apply products of the same mode of action over more than 50% of the crop cycle.
 - To avoid treating subsequent plantings of short cycle crops (<50 days) with products of the same mode of action, consider using the duration of the crop cycle as the treatment window.

IRAC MoA Class	Primary Site of Action
1	Acetylcholinesterase inhibitors
2	GABA-gated Cl channel antagonists
3	Sodium channel modulators
4	Nicotinic acetylcholine receptor agonists
5	Nicotinic acetylcholine receptor allosteric activators
6	Chloride channel activators
11	Microbial disruptors of insect midgut membranes
13	Uncouplers of oxidative phosphorylation
15	Inhibitors of chitin biosynthesis, type 0
18	Ecdysone receptor agonists
22	Voltage-dependent Na channel blockers
28	Ryanodine receptor modulators
UN	Compounds of unknown/uncertain MoA

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 by IRAC Lepidoptera WG, January 2012, Poster Ver. 1.0 - For further information visit the IRAC website: www.irc-online.org
Photographs courtesy: Dufport Crop Protection

Spotlight on recent Insecticide Resistance Articles in Publications

The first half of 2012 has provided some excellent publications from insecticide resistance scientists, with reports of new cases of field derived resistance, characterization of new resistance mechanisms and several reviews which collate key learning.

Will it make the top 20 resistant pests?

Many of the reported cases of resistance are often attributed to the 'prime suspects' so when cases of resistance occur in new species it often peaks the interest of researchers. Early in the year it was reported that UK populations of the cabbage whitefly (*Aleyrodes proletella*) had evolved resistance to pyrethroid insecticides¹. Although resistance to pyrethroids is far from a new discovery, this is the first case of resistance to insecticides recorded for this species. As reported in the last review, the Asian citrus psyllid (*Diaphorina citri*) is a hot topic for researchers, after the first reports of resistance were recorded in the USA last year. Neonicotinoid resistant strains are now also reported in China², where cross-resistance was observed amongst all the neonicotinoids tested.

How do insects do that?

Molecular and biochemical techniques continue to advance our knowledge in the ways insects are responding to the chemical and biological techniques that we apply to control them. An interesting report on the gene up-regulation response of the diamondback moth (*Plutella xylostella*) to selection pressure with diamide insecticides was published in April³. Ryanodine receptor mRNA expression was increased in individuals exposed to diamide insecticides, but not other classes of insecticide chemistry. The over-expression of the receptor mRNA is linked to a reduced susceptibility to diamide insecticides and it is speculated that the upregulation is reason for the difference in susceptibility. A new mechanism of resistance was also reported for the tetrone acid class of insecticides, which target the acetyl-coenzyme A carboxylase enzyme (ACCase). A single point mutation (E645K) in the ACCase gene of the glasshouse whitefly (*Trialeurodes vaporariorum*) was associated with a reduction in the activity of at least one tetrone acid derivative⁴. This is the first recorded case of a target site resistance associated with this class of insecticide chemistry. Discovering mechanisms of resistance is not only restricted to new insecticide chemistry. A stimulating review of ligand gated ion channels in the two-spotted spider mite (*Tetranychus urticae*)⁵ reveals novel mutations associated with abamectin resistance in glutamate-gated chloride channels.

Transgenic turnover

The first two quarters of 2012 have seen a number of publications related to field evolved resistance to transgenic *Bacillus thuringiensis* (Bt) crops. Programs established to monitor fall armyworm (*Spodoptera frugiperda*) susceptibility to the Cry1F toxin in Puerto Rico, continue to show widespread resistance in the country, however resistant populations have not spread to surrounding countries⁶. Summaries of resistance situations in Chinese pink bollworm (*Pectinophora gossypiella*) and cotton bollworm (*Helicoverpa armigera*) were also provided in early 2012^{7,8}, as well as an evaluation of the resistance risk associated with Cry3Bb1 resistant western corn rootworm (*Diabrotica virgifera*)⁹.

And finally.....

Two additional papers of note: An excellent review of spinosyn resistance is provided in Pesticide Biochemistry & Physiology¹⁰ and details of all too rare field scale studies investigating the practicalities of non-treated host plant refuges and insecticide resistance management were provided in the Proceedings of the National Academy of Sciences of the United States of America¹¹.

References:

1. Springate S., Colvin J. Pyrethroid insecticide resistance in British populations of the cabbage whitefly, *Aleyrodes proletella*, Pest Management Science. (2012) 68(2), 260-267.
2. Deng M., Pan Z., Tan Y., Tang J., Qin X., Chen G., Tang M. Cross-resistance of Asian citrus psylla to 4 neonicotinoid insecticides, Nongyao (2012), 51(2), 153-155.
3. Sun L., Yang D., Ru C., Cui L., Yuan H. Effects of chlorantraniliprole on expression abundance of ryanodine receptor gene mRNA from *Plutella xylostella*. Nongyaoxue Xuebao, (2012) 14(2), 136-142.
4. Karatolos N, Williamson MS, Denholm I, Gorman K, Ffrench-Constant R, Nauen R, Resistance to spiromesifen in *Trialeurodes vaporariorum* is associated with a single amino acid replacement in its target enzyme acetyl-coenzyme A carboxylase, Insect Molecular Biology 21 (3) 327-334, 2012
5. Dermauw W., Ilias A., Riga M., Tsagkarakou A., Grbic M., Tirry L., Van Leeuwen T., Vontas J. The cys-loop ligand-gated ion channel gene family of *Tetranychus urticae*: Implications for acaricide toxicology and a novel mutation associated with abamectin resistance. Insect Biochemistry and Molecular Biology (2012).
6. Storer, N. P. Kubiszak, M. E. King, J. E. Thompson, G. D. Santos, A. C. Status of resistance to Bt maize in *Spodoptera frugiperda*: lessons from Puerto Rico. Journal of Invertebrate Pathology; (2012). 110(3), 294-300.
7. Tabashnik BE., Wu KM, Wu Y. Early detection of field-evolved resistance to Bt cotton in China: cotton bollworm and pink bollworm. Journal of Invertebrate Pathology. (2012), 110(3), 301-306.
8. Wan P., Huang Y., Wu H., Huang M., Cong S., Tabashnik B.E., Wu K. Increased frequency of pink bollworm resistance to Bt toxin Cry1Ac in China. PLoS one. 7 (1) (pp e29975), 2012.
9. Gassmann, A J. Field-evolved resistance to Bt maize by western corn rootworm: predictions from the laboratory and effects in the field. Journal of Invertebrate Pathology. (2012), 110 (3), 287-293.
10. Sparks, TC., Dripps, JE., Watson, GB., Paroanagian, D. Resistance and cross-resistance to the spinosyns - A review and analysis Pesticide Biochemistry & Physiology. (2012), 1, 1-10.
11. Carriere, Y., Eilers-Kirk, C, Hartfield, K., Larocque, G., Degain, B., Dutilleul, P., Dennehy, TJ, Marsh, SE., Crowder, DW., Li, X., Ellsworth PC., Naranjo, SE., Palumbo, JC., Fournier, A., Antilla, L., Tabashnik, BE. Large-scale, spatially-explicit test of the refuge strategy for delaying insecticide resistance. Proceedings of the National Academy of Sciences of the United States of America. (2012) 109(3) 775-780.



IRAC News Snippets

- ★ Following agreement at the IRAC International Meeting, Ralf Nauen (Bayer CropScience) will continue as IRAC Chairman for a further year, Russell Slater (Syngenta) continues as Vice-Chair now joined by Tatjana Sikuljak (BASF) who takes over from Jonathan Henen (Makhteshim Agan) and Lixin Mao (BASF) takes over from Nigel Armes (BASF) as IRAC Treasurer.
- ★ As reported previously the IRAC Test Methods WG have developed two methods videos (*Tuta absoluta* & *Myzus persicae*) which are available on YouTube via links on the IRAC website. A third video describing the test method for brown planthoppers is under development. Details will be available in future eConnection issues.
- ★ The IRAC Diamide WG continues to develop a network of country groups around the globe who are working on implementing IRM strategies for the Diamide group of compounds. There are currently over 20 active groups established and a number of other countries are in the process of establishing teams.

Conferences & Symposia

- ★ National Pest Management Assoc., Pestworld, Boston, October 17-20, 2012
- ★ 60th ESA Meeting, Knoxville, Tennessee, November 11-14, 2012
- ★ 61st ASTMH Meeting, Atlanta, Georgia, November 11-15, 2012
- ★ Beltwide Cotton Conferences, San Antonio, Texas, January 7-10, 2013
- ★ NAICC Meeting, Hyatt, Jacksonville, Florida, January 23-26, 2013
- ★ 79th AMCA Annual Meeting, Atlantic City, February 24-28, 2013
- ★ 1st Intl. Whitefly Symposium, Kolymbari, Crete, May 20-24, 2013

Feedback

The eConnection is prepared by the IRAC International Communication & Education Working Group and supported by the 14 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

SOURCE:

The eConnection is the newsletter of IRAC International

SUBSCRIPTION:

Free via the IRAC website

EDITOR:

Alan Porter, IRAC Coordinator

WEBSITE:

www.irac-online.org

IRAC Executive

Member Companies

FMC **syngenta**



BASF
The Chemical Company

Bayer **CropScience**

BC **BELCHIM**
—Crop Protection—

Dow **AgroSciences**

NIHON NOHYAKU CO.,LTD.

CHEMINOVA

SUMITOMO CHEMICAL

Nufarm **MONSANTO** **imagine**

VESTERGAARD **FRANDSEN**
DISEASE CONTROL TEXTILES