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The evolution of IRAC

IRAC is almost 40 years old. It was formed by the crop protection industry in 1984 to address globally increasing insecticide resistance problems. Over the years, the focus of IRAC has evolved from defining and documenting cases of insecticide resistance to proactively developing and promoting insecticide resistance management (IRM) strategies and providing information on insect pests and bioassay methods. A key tool developed by IRAC is the Insecticide Mode of Action (MoA) Classification Scheme, which is widely accepted in the industry and academic community. With the support of CropLife International, Mode of Action labelling, including basic resistance management guidance, is now widely adopted by IRAC members globally

An article describing the history and evolution of IRAC, authored by IRAC members, was published in Pest Management Science early this year Sparks, et al. (2021) Insecticide resistance management and industry: the origins and evolution of the Insecticide Resistance Action Committee (IRAC) and the mode of action classification scheme. Pest Management Science, Science 77, 2609, published online open access https://doi.org/10.1002/ps.6254.

Featured Member

Dr. John Andaloro (FMC) , one of the veteran scientists and dedicated member of IRAC for many years, is retiring August 2021. John played a pivotal role in the Lepidoptera Working Group, the Outreach Team and the Executive Committee. We wish John a happy and well-deserved retirement.

In this issue

IRAC International Meeting, April 2021

At the virtual meeting, new educational and outreach materials were presented that provide guidance to growers and crop advisors on strategies intended to delay the onset of resistance in important pests and pest groups. The website has been modified to accommodate external groups and associations. Together with CropLife International, IRAC is focusing on resistance management of fall armyworm (Spodoptera frugiperda), an invasive species originating from the Americas but now one of the major pests in corn in Africa and Asia. Last year IRAC was very successful in integrating and supporting several resistance management country groups. The annual meeting provided an opportunity to review reports from many of the country teams, identify common technical, logistical, and communication needs. A major success was the definition of common IRM guidance language to appear on crop protection product labels, which will be implemented by IRAC member companies as labels are updated.

While during early annual meetings, IRAC members could fit around one table, over 70 members participated in our latest annual meeting in early April this year. Like last year, this meeting was held online, but we hope to be able to meet face to face again in 2022. IRAC is currently expanding from a network for specialists into a network for information. At the meeting, member companies together affirmed their commitment to the goals and practices of resistance management, collaboration, and engagement with influential organizations, and contributing to sustainable management of crop and public health pests.

Finally, the Annual Meeting saw Juergen Langewald (BASF) approved as Chair of IRAC International, taking over from Nick Storer (Corteva). Billy Annan (FMC) took over the Co-Chair position from Juergen Langewald and leadership of the Outreach Team.

Changes to IRAC MoA Classification Scheme

A key purpose of the IRAC Mode of Action (MoA) classification is to provide growers, advisors, extension staff, consultants and crop protection professionals with a guide to the selection of insecticides or acaricides for use in an effective and sustainable resistance management (IRM) strategy. In response to a growing interest, IRAC has recently added biologics to the MoA classification scheme organized into Groups UNB, UNE, UNF, UNM and UNP under unknown or undefined MoA. In addition, a separate nematicide classification has been proactively put in place although the risk of resistance development to commercial nematicides used in agriculture is considered low.

Summarized below are the newest changes to the MoA classification.

New groups added

Two new groups have been added to the MoA Classification.

Group 33 falls under the class of active ingredients acting on nerve and muscle targets and is named 'Calcium-activated potassium channel (KCa2) modulators'. It contains the acaricide Acynonapyr that modulates the activity of this new target. KCa2 channels are activated by increase of the intracellular calcium concentration and are involved in the regulation of action potentials. Negative modulation of KCa2 causes hyperexcitation and convulsions.

Group 34 targets the respiratory chain and is named 'Mitochondrial complex III electron transfer inhibitors – Qi site'. Inhibition of electron transport complex III prevents the utilization of energy by cells. In contrast to active ingredients belonging to Group 20, the Group 34 insecticide Flometoquin does not bind to the Qo site and has been renamed ‘Mitochondrial Complex III electron transport inhibitors - Qo site’.

New sub-groups added

A new sub-group has been added to Group 4 ‘Nicotinic acetylcholine receptor (nAChR) competitive modulators’. Group 4F falls under the chemical class Pyridylidenes and contains the insecticide Flupyrimin.

Other changes

Group UNM has been renamed from ‘non-specific mechanical disruptors’ UNM, to ‘non-specific mechanical and physical disruptors’ and now contains Mineral Oil.

Detailed advice on MoA groups and spray application strategies for implementing effective insecticide resistance management (IRM) strategies can be found in the MoA classification document. Please use product-specific recommendations for application guidance and consult a local agricultural advisor or extension services in the area for up-to-date recommendations and advice on IPM and IRM programmes.

IRAC is in the process of updating the mode of action classification document, posters, booklets and mobile application in order to reflect the changes described above.

New IRAC Resources

A number of new guidelines and posters have been developed recently and are available from the IRAC website. Some of these are highlighted below with specific links to the relevant document or poster:

- Guidelines for MoA labelling and label language
- General Lepidoptera IRM guidelines
- General sucking insect pests IRM guidelines
- Fall armyworm IRM guidelines
- Tuta absoluta IRM poster
- Codling moth IRM poster
- Diamondback moth IRM poster
- Fall armyworm IRM poster
- Planthopper IRM poster
- Bemisia tabaci resistance overview poster
- Frankliniella occidentalis IRM poster
- Leaflet for one of the most notorious stink bug pests, Euschistus heros
- IRAC short video explaining IRM (wide range of language versions available via the IRAC home page)
- IRAC short video explaining MoA (wide range of language versions available via the IRAC home page)
- A short video explaining how to control Fall Armyworm in 3-steps
- Insecticide resistance training - basic module
- Organising an integrated resistance management campaign: Advanced training module
- General Packaging and Shipping Instructions for Collected Insects

IRAC’s Global and Country Outreach Network

A common refrain within the IRAC organization is that “Resistance Management must be practiced locally”. Despite the creation, collation, and communication of insect resistance knowledge by IRAC International, ultimately, it is country growers supported by local experts and influencers, who implement IRM (Insecticide Resistance Management) strategies on their own farms. For this reason, in 2009, IRAC created a global “Diamide Working Group” and numerous country resistance action groups prior to the launch of diamide chemistry products to optimize knowledge transfer and education. The country resistance teams were comprised of agchem personnel and country gov’t, university, and industry experts. Their role was to develop a Mode of Action communication plan, create IRM guidelines for high resistance risk markets, and establish an education process to assist growers implement IRM strategies. Over a decade later the diamide-focused Country Resistance Action Groups evolved into newly formed country IRAC teams or merged with ones that had previously existed. Today, over 22 country IRAC teams exist with over 400 members. They address insect resistance issues among a broad range of insect pests and control products in their countries. These are the “local” agents of change that work to ensure alignment and adaptation of Global IRM guidelines within their countries and convince growers to adopt IRM-compliant pest control solutions.

The country IRAC teams are supported by IRAC international liaisons from the Lepidopteran, Sucking Pest, and Coleopteran crop protection working groups who assist in transferring globally developed technical knowledge to their assigned country partners. (Note: The Lepidopteran and Coleopteran working groups will in the future be merged to form a new Chewing Pest working group.) The integrated system of IRM teams has flourished into a globally connected IRM communication network with information flowing in all directions among personnel from multiple agricultural alliances. IRAC and Crop Life are proud of the country and international team members who voluntarily devote their time and skills to sustainably control insect pests throughout the world.

Dr. John Andaloro retires from IRAC

John obtained his B.S. in Agricultural Science in 1974 and a M.S. degree in entomology in 1976, both from Rutgers University and his Ph.D. in entomology from the University of Massachusetts in 1978. After completing his doctorate degree, he worked as coordinator of Vegetable IPM Programs at Cornell University's New York State Agricultural Experimental Station in Geneva, NY, from 1978 to 1982. He joined the DuPont Company in 1982 until the company's divestiture in 2017 when he then joined FMC. In both companies, John worked in various technical roles before retiring as a Global Technical Product Manager (GTPM) and Senior Research Fellow for key insecticides, namely Rynaxypyr® and Indoxacarb. In that role he led the programs focused on the technical foundation of both products, including product development, renewal efforts, life cycle management and knowledge transfer, among other activities. The GTPM role required John's interactions with a broad network with multi-disciplinary and multi-functional teams including registration and regulatory sciences, manufacturing, development, marketing, sales, etc., as well as external experts including university scientists, industry officials, and growers.

John collaborated with colleagues, GTPMs and researchers to drive FMC's programs to maintain pest susceptibility to Rynaxypyr®, Indoxacarb and other insecticides. His role in resistance management activities extended to IRAC International, where he has been an active member of the Lepidoptera Working Group and the Executive Committee. He was a founding member of the Diamide Working Group in 2009, which created resistance action teams to focus on IRM principles in over 20 countries worldwide. He also led many IRAC projects including the MoA label language alignment, Lepidoptera IRM guidelines, educational tools for *Tuta absoluta* and *Spodoptera frugiperda*, to list a few. Recently he also played a leading role in the use of Unmanned Aerial Vehicle (UAV) technology for pesticide applications of agrochemical products.

We will miss John's drive, dedication and leadership in IRAC activities, as well as his wonderful sense of humor. IRAC will continue John's belief in integrating IRM into core business principles.

Best wishes for a happy and well-deserved retirement, John!

Interesting publications

Fall army worm is currently the most serious pest on corn in Sub-Saharan Africa, and effective resistance management is crucial for sustainable control. Elisabeth Njuguna, et al. published a very comprehensive review of the fall army worm situation in Sub-Saharan Africa, including a description of the smallholder maize cropping system, yield losses and current control strategies. The authors discuss IPM approaches, like push-pull strategies, the use of bio-pesticides and natural enemies. Included are also BT-crop technology and the judicious application of insecticides. They emphasize the importance of farmer training in scouting, clean cultivation and different control options.

Njuguna, E., Nethononda, P., Maredia, K., Mbabazi, R., Kachapulula, P., Rowe, A., & Ndolo, D. (2021). Experiences and Perspectives on Spodoptera frugiperda (Lepidoptera: Noctuidae)

Management in Sub-Saharan Africa. Journal of Integrated Pest Management, 12. https://doi.org/10.1093/jipm/pmab002

A second review was written by a group from Zimbabwe and South Africa. In addition to reviewing IPM strategies the authors also provide a very detailed analysis of insecticide use patterns by small holder farmers and a detailed review of the successful use of BT – corn varieties in South Africa.

Matova, P. M., Kamutando, C. N., Magorokosho, C., Kutywayo, D., Gutsa, F., & Labuschagne, M. (2020). Fall-armyworm invasion, control practices and resistance breeding in Sub-Saharan Africa. Crop Science, 60(6), 2951–2970. https://doi.org/10.1002/csc2.20317

Adesanya et al. published an article on one of the pests which is most notorious in developing all kinds of insecticide / acaricide resistance. In addition in describing in detail the different resistance mechanism found in two spotted spider mite, the authors also show distribution maps and historic timelines for the major resistance mechanisms known. Towards the end of their article the authors take the example of hops to describe the development of a resistance management programme.

Adesanya, A. W., Lavine, M. D., Moural, T. W., Lavine, L. C., Zhu, F., & Walsh, D. B. (2021). Mechanisms and management of acaricide resistance for Tetranychus urticae in agroecosystems. Journal of Pest Science, in press, https://doi.org/10.1007/s10340-021-01342-x

There is a great interest in developing molecular diagnostic tools for insecticide resistance management. Such tools could simplify decision making to a large extent. An increasing number of molecular markers for resistance are being identified. However so far, the predictive value of molecular markers is limited. Van Leeuwen et al. investigated in which cases such tools can be reliably used to manage resistance in the field.

Van Leeuwen, T., Dermauw, W., Mavridis, K., & Vontas, J. (2020). Significance and interpretation of molecular diagnostics for insecticide resistance management of agricultural pests. Current Opinion in Insect Science, 39, 69–76. https://doi.org/10.1016/j.cois.2020.03.006

The latest up-date on the global status of Bemisia tabaci resistance and resistance management is provided by Horowitz et. al. They carried out a detailed review regarding the resistance status of different genotypes of the B. tabaci species complex. Resistance information is provided including location, year, crop and insecticide classes. Major insecticide classes are discussed in detail. The authors also emphasize different IPM technologies and farmer training.

Horowitz, A. R., Ghanim, M., Roditakis, E., Nauen, R., & Ishaaya, I. (2020). Insecticide resistance and its management in Bemisia tabaci species. Journal of Pest Science, 93(3), 893–910. https://doi.org/10.1007/s10340-020-01210-0

In their paper Carrière et al. review the roles of different stakeholders like governments regulators, technology providers, extension services, universities and farmers in resistance management in BT crops in India, Australia, USA and Brazil. By comparing the different systems and the levels of adoption of resistance management in the different countries, they identify key elements for successful resistance management.

Carrière, Y., Brown, Z. S., Downes, S. J., Gujar, G., Epstein, G., Omoto, C., Storer, N. P., Mota-Sanchez, D., Søgaard Jørgensen, P., & Carroll, S. P. (2020). Governing evolution: A socioecological comparison of resistance management for insecticidal transgenic Bt crops among four countries. Ambio, 49(1), 1–16. https://doi.org/10.1007/s13280-019-01167-0

Over the last decade, diamides (IRAC MoA Group 28) were used very successfully for the control of lepidopteran pests. Their success and therefore broad and frequent use led to resistance in some of the most destructive lepidopteran pests. In this paper Richardson et al. analyzed particularly the history of diamide resistance built up for Plutella xylostella, Tuta absoluta, Chilo suppressalis and Spodoptera frugiperda, thereby discussing different resistance mechanisms.

Richardson, E. B., Troczka, B. J., Gutbrod, O., Davies, T. G. E., & Nauen, R. (2020). Diamide resistance: 10 years of lessons from lepidopteran pests. Journal of Pest Science, 93(3), 911–928. https://doi.org/10.1007/s10340-020-01220-y