IRAC
Insecticide Resistance Action Committee
eConnection

FEATURED IRAC MEMBER:

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IN THIS ISSUE:

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 insecticide resistance news from around the world.

In this issue we have details of the latest updates to the IRAC Mode of Action Classification Scheme and the associated poster and booklet. We have a brief report from the recent IRAC International meeting in Dublin which was the 50th meeting of the full committee since IRAC was formed in 1984. We also provide details of a new IRM leaflet and video developed by IRAC and CropLife International. Finally we have news of a joint IRAC International and IRAC Brazil initiative to bring together all the relevant stakeholders including representatives from the seeds and crop protection industries to agree on insecticide resistance management guidelines in soybean, cotton and corn in Brazil. As a result of the success of this approach, IRAC is proposing to tackle other resistance hotspots using a similar approach.

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.

Recent Updates to the Mode of Action Classification

One of the charters of the MoA WG is to provide periodic updates to the MoA Classification Scheme as new information becomes available or specific requests are made. The most recent update (ver. 8.1) to the MoA Classification Scheme was completed in April of this year, with publication of an updated MoA Classification Structures poster and an updated MoA Classification booklet, now in its 5th edition.

MoA determination is often a difficult process, especially for sucking insect pests, such as aphids and whiteflies, where the clues from symptomology are frequently limited. Studies on the MoA of pymetrozine (Group 9B) have spanned two decades with data suggesting the involvement of the chordotonal organ. A recently published article (Nesterov et al. 2015) outlines a series of studies indicating that pymetrozine (Group 9B) and pyrafluquinazon (previously Group UN) perturb chordotonal organ function by modulating the vannilloid subtype of transient receptor potential channels (TRPV), thus pinpointing the target site for these insecticides. Interestingly, flonicamid (Group 9C) appears to act at a distinct but yet unidentified site .

Based on the above and other results, the MoA WG has made the following changes to the MoA Classification Scheme:

1. **Group 9** has been renamed: Chordotonal organ TRPV channel modulators and now includes pymetrozine and pyrafluquinazon (9B).
2. Flonicamid has been assigned to a new group; **Group 29**, Chordotonal organ modulators – unidentified target site.
3. Having reviewed recent data supporting interaction of bifenazate (previously **Group UN**) with Complex III of the mitochondrial electron transport system (Van Leeuwen et al. 2006, 2008, 2012), the MoA WG has reassigned bifenazate to **Group 20** (subgroup 20D).
4. Addition of a new **Group 4** insecticide, triflumezopyrim (4E), which belongs to the mesoionic class (Holyoke et al 2015, Cordova et al 2016).
5. Addition of a new Group UN insecticide, GS-omega/kappa-HXTX-Hv1a, a peptide with an undefined mode of action.

References:

Cordova D, Benner EA, Schroeder ME, Holyoke CW Jr., Zhang W, Pahutski TF, Leighty RM, Vincent DR, Hamm JC, Mode of action of triflumezopyrim: A novel mesoionic insecticide which inhibits the nicotinic acetylcholine receptor, *Insect Biochem Mol Biol*, 74, 32-41 (2016).

Holyoke CW Jr, Zhang W, Pahustski TF Jr, Lahm GP, Tong M-HT, Cordova D, Schroeder ME, Benner EA, Rauh JJ, Dietrich RF, Leighty RM, Daly RF, Smith RM, Vincent DR, Christianson LA, Triflumezopyrim: Discovery and optimization of a mesoionic insecticide for rice, In *Discovery and Synthesis of Crop Protection Products*, Maienfisch P, Stevenson TM, eds., American Chemical Society, Washington DC, pp. 367-378, (2015).

Nesterov A, Spalthoff C, Kandasamy R, Katana R, Ranki NB, Andrés M, Jähde P, Dorsch JA, Stam LF, Braun F-J, Warren B, Salgado VL, Göpfert MC, TRP channels in insect stretch receptors as insecticide targets, *Neuron* 86, 665-671 (2015).

Van Leeuwen T, Tirry L, Nauen R, Complete maternal inheritance of bifenazate resistance in Tetranychus urticae (Acari: Tetranychidae) and its implications in mode of action considerations. *Insect Biochemistry and Molecular Biology* **36**, 869-877 (2006)

Van Leeuwen T, Vanholme B, Van Pottelberge S, Van Nieuwenhuyse P, Nauen R, Tirry L, Denholm I, Mitochondrial heteroplasmy and the evolution of insecticide resistance: Non-Mendelian inheritance in action. *Proceedings of the National Academy of Sciences U.S.A.* **105**, 5980-5985 (2008).

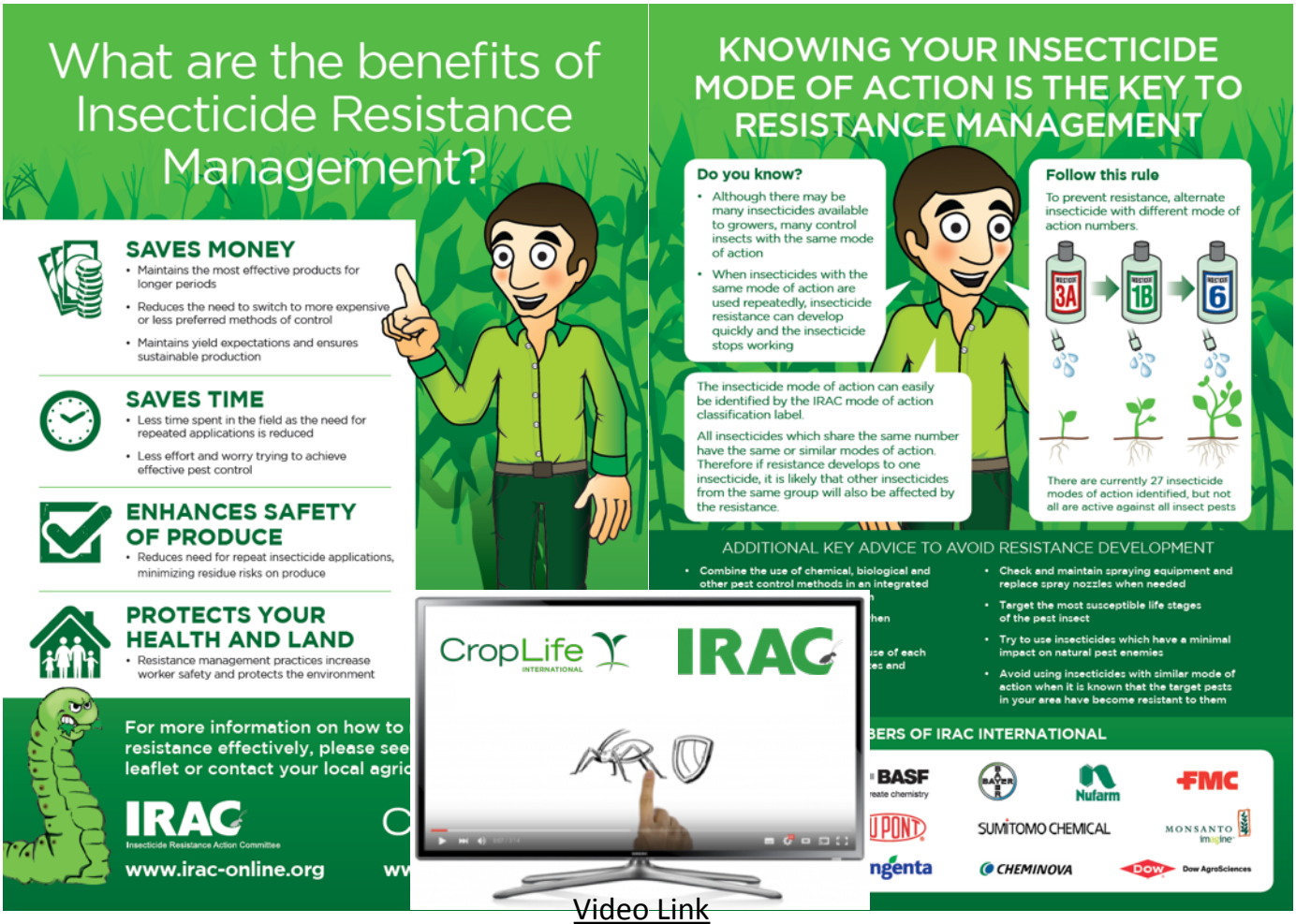
Van Nieuwenhuyse P, Demaeght P, Dermauw W, Khalighi M, Stevens CV, Vanholme B, Tirry L, Lümmen P, Van Leeuwen T, On the mode of action of bifenazate: New evidence for a mitochondrial target site. *Pesticide Biochemistry and Physiology* **104**, 88-95 (2012).

50th IRAC International Meeting, April 5-8th, Dublin, Ireland

The latest IRAC International meeting was well attended by IRAC representatives from 11 companies and many regions including Australia, Brazil, Europe, Japan and the US. There were 13 sessions held over the 4 days including various working group planning meetings and discussion forums. There were brief reviews of progress made over the last year but the main focus of the meeting was to establish goals and objectives for the various teams during 2016/17. Slide presentations and meeting outputs can be found via the Team Pages on the IRAC website

New IRAC/CropLife International IRM Leaflet and Video

Links to both of these new resources can be found on the IRAC website (http://www.irac-online.org/teams/outreach/). In due course the leaflet and video will be translated into other languages for global use.



Video Link

Development of Insecticide Resistance Management Guidelines in Brazilian Corn, Cotton and Soybean

At the beginning of 2015 IRAC International & IRAC Brazil joined forces to organize a meeting of agricultural stakeholders which included representatives from both the seeds and agrochemical industry, growers' representatives, independent experts and governmental representatives. The aim of this meeting was to develop an agreed set of resistance management guidelines for the production of soybean, cotton and corn in Brazil.

A very open and productive workshop was held in Brasilia, where various technical options for insecticide resistance management were openly discussed alongside both the practical and economic constraints associated with the production of the individual crops and also sequential cropping.

We heard how regional differences in climate, production methods, pest species and population densities impact pest management decisions. The economic and social factors behind grower's decisions were also presented to help the group understand the choices that are made when selecting pest management solutions.

IRAC International & IRAC Brazil members left this meeting armed with a greater depth of information on which to make its recommendations for practical resistance management. The next step was then to develop practical guidelines that provide a framework from which growers and their advisors could build a pest management program which not only gives short term economic benefits to the grower, but also provides longer term benefits through sustainable product use.

After many rounds of consultation and fine tuning, IRAC eventually published its Insecticide Resistance & Pest Management Recommendations in Brazilian Soybean, Cotton & Corn, which is available via both the IRAC International and IRAC Brazil websites. The document provides specific guidance on how to reduce the risk of resistance development to both insecticide chemistry and the plant incorporated proteins expressed in transgenic hybrids. It also provides examples of pest management programs for each of the three crops in order to help growers visualize how resistance management could be planned into their crop programs.

During 2016 there will be a sustained campaign lead by IRAC Brazil to communicate the advice contained in the guidelines to growers and their advisors through workshops and communication campaigns.

Based on the success of the workshops in Brazil, new initiatives focused on other insecticide resistance hotspots are being proposed by IRAC to be initiated in 2016.

IRM Recommendations Example:

Note: The word 'insecticide(s)' refers to chemical & biological insecticides which are applied as either foliar, soil or seed treatments. It does not include plant incorporated proteins (PIP) which have insecticidal activity.

IRM for Soybean (Condensed Version)

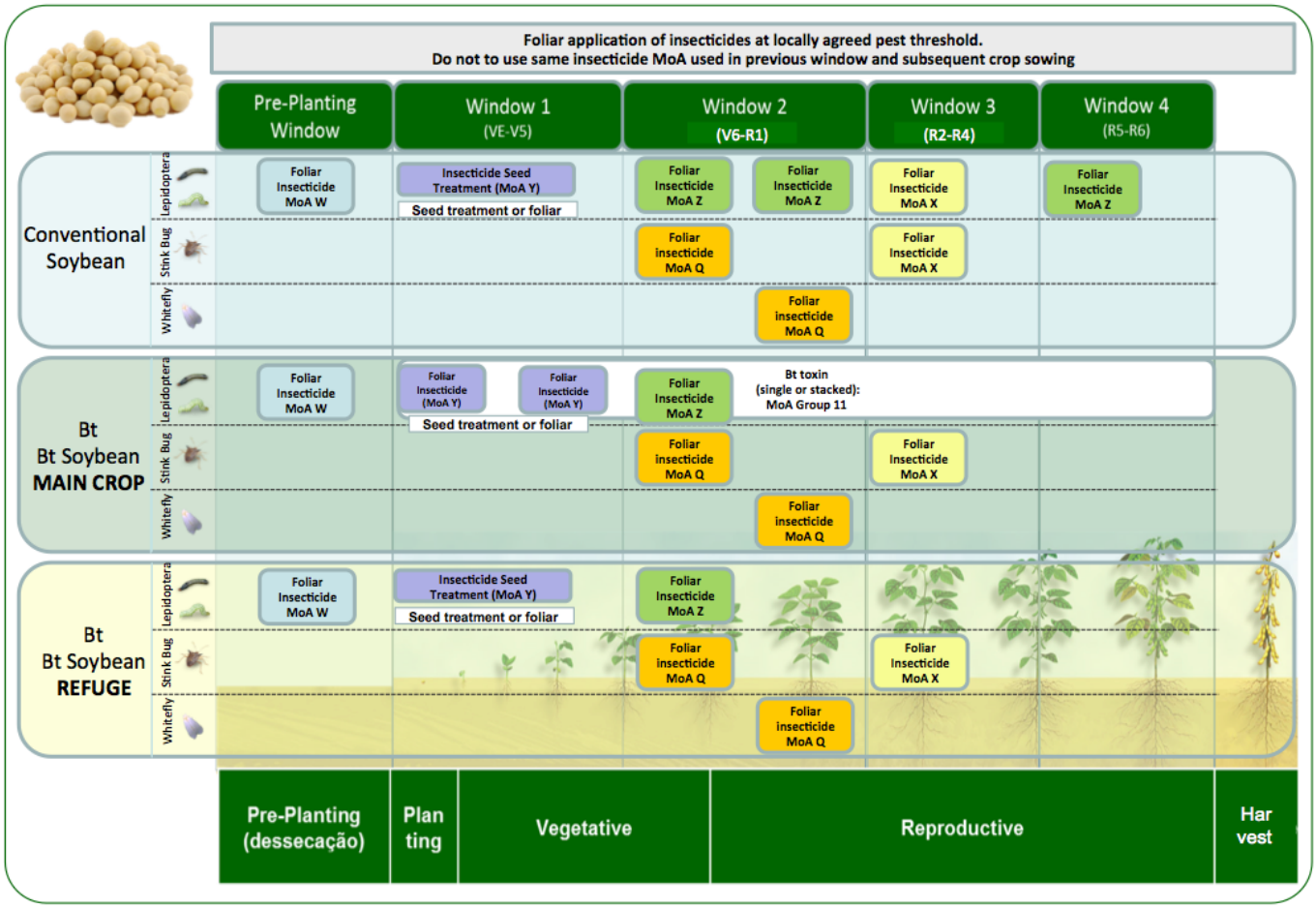
- **Manage crop post-harvest stubble & volunteers**
  Scout the field during pre-sowing burn down with a herbicide and if insects are observed in the remaining crop residues, the use of foliar applied insecticides is recommended for their control.

- **Rotate crops**
  It is recommended that subsequent or parallel crop sowings be of a different crop type. Sequential planting of the same crop can significantly increase both pest populations and the risk of resistance. Polyphagous insect pest species (e.g. *Spodoptera frugiperda*, *Helicoverpa armigera*) are particularly at risk from being exposed to insecticides and insecticidal proteins with the same mode of action across different crop plantings and special attention should be paid to minimize their exposure to insecticides and insecticidal proteins with the same mode of action.

- **Only apply insecticides at economic pest thresholds**
  Follow locally established economic pest thresholds for the application of foliar insecticides in order to optimize insecticide use. Always use labeled rates and water volumes.
- **Use windows of insecticide application**
  Use windows of application to minimize exposure of sequential generations of an insect pest species to the same insecticide modes of action. Each window should be approximately 30 days to coincide with a single generation of the target insects.
- **Rotate insecticides with different modes of action.**
  If more than one insecticide application is required during an application window then it is recommended to use an insecticide which has a different mode of action. However, multiple applications of insecticides with the same mode of action within a single window are acceptable as long as combined effects (residual activity) of the applications do not exceed the 30-day window.
- **Insecticide seed treatments**
  Seeds which have been treated with an insecticide seed coating may not provide control of insect pests for the duration of window 1 (30 days). If an additional foliar insecticide application is required in the window it is strongly recommended that the foliar insecticide be applied no later than 25 days after seeding and for best IRM practice belong to a different mode of action group to the insecticide seed coating. Insecticides with the same mode of action as the seed coating should not be used for at least 30 days after the end of the first window.
- **Insecticide mixtures**
  Insecticide mixtures may offer benefits for pest control and/or IRM when appropriately incorporated into rotation strategies with additional modes of action, but generally a single mixture should not be relied upon alone.
- **Preserve non-target & beneficial organisms**
  The use of selective insecticides with reduced impact on non-target and beneficial organisms is recommended whenever possible.
- **Avoid insecticides which have existing resistance problems**
  Consult with local experts to determine which insecticides are affected by resistance in your locality. A preference to insecticides which are not affected by resistance should be given.

Recommendations specific to soybean expressing Bt proteins

- **Refuge**
  The sowing/planting of a minimum 20% area of soybean refuge (Non-Bt)within 800m of the Bt soybean is considered mandatory. An in-field strip refuge is recommended for maximum effectiveness.
- **Use of foliar insecticides in the refuge should be minimised**
  The application of insecticides to the non-Bt refuge can reduce the resistance management benefits of sowing the refuge. Therefore it is recommended to minimize the use of insecticides applied to the refuge.
- **Follow seed suppliers guidelines on the foliar spray thresholds in the Bt crop and the refuge.**
  Under high pest pressure the application of insecticides may be necessary in both the Bt crop and the refuge crop. It is recommended to follow the seed suppliers recommendations on the appropriate foliar spray thresholds.
- **Rotate crops**
  It is recommended that subsequent or parallel crop sowings be either a non-host crop or a conventional variety of soybean, whenever feasible.



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