# Challenges and Opportunities in Resistance Management: Affected Crops, Modes of Action and Selected Hotspots

CropLife MENA Regional Hub Meeting
Amman, Jordan

July 12, 2023

***I. Billy Annan,*** *Ph.D., M.B.A.*
*Chair of IRAC International & Ag Chair, IRAC Africa*

IRAC
Insecticide Resistance Action Committee

# Presentation Outline

- Introduction of Paper: Abstract & Problem Statement
- Agriculture in Developing World
  - Uncomfortable Conversations: Opportunities, Challenges
  - Roles of Public vs. Private Entities in Promoting RM Best Practices
- *IRAC (RACs) Step into the 'Breach'*:
  - IRAC Organization: Summary of Goals, Tools and Resources
  - Examples of prog
    - MoA and Labeling Guidance
    - Communication and Education
    - Outreach Activities
- Technical Guidance for Resistance Monitoring and Resistance Management
- Newly-established IRAC Africa-Middle East Network and its Relevance
- Summary and Conclusions

IRAC

# Abstract & Problem Statement

- The developing world the significant advantages in arable land, biodiversity and other natural resources and in human resource and technical competency, and thus can play an important role in agricultural growth and productivity.
- Growth global trade in agricultural commodities has led to the fast spread of pest problems in new regions. The developing world tend to be worse off in such developments. Examples include the recent spread of the fall armyworm from the Americas to Africa and southern Asia, and diamondback moth from Asia to RoW.
- However, the developing world is often not included as equal partners in global agricultural issues and appropriate mitigations.
- IRAC is a global agrochemical technical organization. It promotes the stewardship of insect control products, to preserve important production inputs for agriculture and health, including in the developing world.

IRAC

# Agriculture in the Developing World – *The Opportunities*

1. Historically many countries developed on platform of agriculture, e.g., Brazil, China, India, USA.
2. Developing world, a.k.a. 'Global South' or 'Third World' is next frontier for agricultural growth.
   **This presentation highlights tends in Africa and Middle East, Latin America, and southern Asia.*
3. According to the World Bank (2021), agriculture is a significant avenue for addressing food security and poverty alleviation:
   - 65% of poor adults work in agriculture
   - accounts for >25% of GDP in the developing world
   - 2 to 4 times more effective in raising incomes vs. other sectors
4. Africa has ~60% of global arable land, thus with appropriate technologies can lead the next global agricultural revolution.
5. Recent data indicate that the developing world has significant role to play in agricultural productivity:
   - developing world has got richer faster
   - greatest gains in yield and profit
6. Solutions depend on raising production through technology.


IRAC

# Agricultural Systems in The Developing World – *The Challenges*

1. Increased incidence and severity of pest, disease and weed problems
   - knowledge of pests: spectrum, differences between pests & beneficial arthropods
   - availability of pest management products/facilities
2. Liberalization of global trade in agriculture has introduced of new pests and resistant populations into new regions of the world, e.g., fall armyworm and diamondback moth
3. Prevalence of pest resurgences and secondary outbreaks
4. Lack of promotion of agricultural production beyond subsistence farming.
5. Limited access to precision application methods
   - effective use of appropriate technologies, tools, and resources for greater impact
6. Limited product use support and other technical systems/services
   - access to information and proper use of pesticides, product stewardship education
7. Limited presence of agrochemical companies, such as R&D centers, manufacturing facilities, human resource development and local staffing
8. Relatively poor regulatory structures and enforcement mandates

❖ **Above- scenario poses perfect scenario for pests to develop resistance.**

IRAC

# Establishing Resistance Management Best Practices in the Developing World

## Role of Government (Countries & Development Partners)

1. Strengthening of regulatory environment and oversight
   - product registrations
   - prevention of illegal products
2. Capacity building in agriculture and agrochemicals
   - curriculum development: resources, skills and processes
   - establishment and broadening of extension services

## Role of Agrochemical Companies & Industry Groups

1. Promote proper use of insecticides
2. Provide training and information materials for:
   - Farmer associations and other value chain players (e.g., distributors, retailers, etc.)
   - Governmental organizations: extension services, policy makers
   - NGOs and other influencers in the agriculture sector
   - Educational institutions: schools, universities, etc.
3. Increased presence in developing countries, in terms of facilities and local staffing
4. Collaborations among industry groups: private, public, trade associations

IRAC

# ……and IRAC (and the RACs) Step Into The 'Breach'!

1. Global Response to a Global Problem: Insecticide resistance is a global challenge and IRAC is delivering strategic responses with local and worldwide initiatives.
2. Objective: To prolong effectiveness of insecticides, acaricides and traits by providing information and guidance that supports the implementation of resistance management strategies, countering development of resistance
3. Core Sectors: Crop Protection, Plant Biotechnology, Public Health.
4. Specialized working groups
5. Tools: (i) **MoA classification,** (ii) **Resistance monitoring,** (iii) **Technical guidance documents for resistance management,** (iv) **Communication and education on insecticide resistance,** (v) **Outreach to country groups and other stakeholders**
6. Activities & Programs: Communications, Education, Meetings, Partnerships
7. Diversity: Worldwide coverage: different cultural backgrounds and technical and experiences of members
8. Collaborations: Together with counterpart RACs HRAC, FRAC and RRAC, IRAC is sponsored by the CropLife International (CLI) stewardship program.

IRAC

# IRAC International Operating Structure

ADAMA

BASF
We create chemistry

BAYER

CORTEVA™
agriscience

FMC

Mitsui Chemicals

SUMITOMO CHEMICAL

syngenta

UPL
OpenAg™

IRAC INTERNATIONAL

Executive Committee

Steering

Outreach

Crop Protection

Plant Biotechnology

Public Health

IRAC Country & Regional Groups

| | | | | |
|---|---|---|---|---|
| IRAC Argentina | CropLife Australia | IRAC Brasil | IRAC China | IRAC India |
| IRAC Indonesia | IRAC Israel | IRAC Italy | IRAC Japan | IRAC Korea |
| IRAC Malaysia | IRAC Mexico | IRAC Morocco | IRAC Paraguay | IRAC Philippines |
| IRAC S. Africa | IRAC Spain | IRAC Taiwan | IRAC Thailand | IRAC Turkey |
| IRAC USA | IRAC Vietnam | IRAC Africa-ME | IRAC Asia | IRAC Europe |

Methods

Mode of Action

Public Health

Biotechnology

Sucking Pests

Chewing Pests

Nematodes

IRAC TASK TEAMS

IRAC

# IRAC International Update: Goals, Tools & Resources

IRAC International:

- IRAC is dedicated to prolonging the effectiveness of insecticides, nematicides and acaracides by countering resistance.
- Our tools:
  - MoA classification
  - Resistance monitoring
  - Technical guidance documents for resistance management
  - Communication and education on insecticide resistance
  - Outreach to country groups and other shareholders
- Specialized working groups

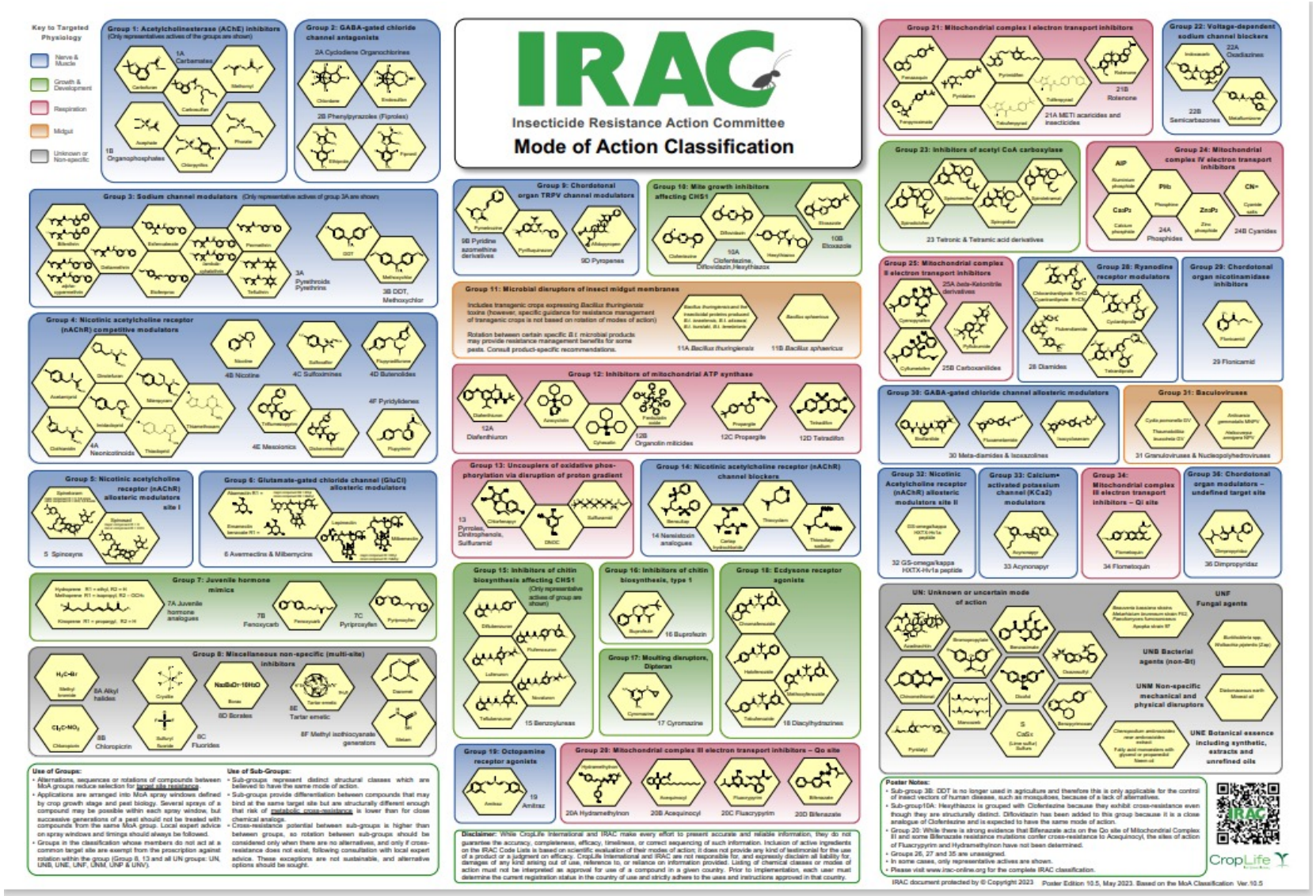
IRAC

# IRAC:
# *MoA CLASSIFICATION*

# IRAC Mode of Action Classification

- **MoA working group**

| | | |
|---|---|---|
| **22 Voltage-dependent sodium channel blockers** *See footnotes for further information on sub-grouping* | **22A** Oxadiazines | Indoxacarb |
| | **22B** Semicarbazones | Metaflumizone |
| **23 Inhibitors of acetyl CoA carboxylase** | Tetronic and Tetramic acid derivatives | Spirodiclofen, Spiromesifen, Spiropidion, Spirotetramat |
| **24 Mitochondrial complex IV electron transport inhibitors** | **24A** Phosphides | Aluminium phosphide, Calcium phosphide, Phosphine, Zinc phosphide |
| | **24B** Cyanides | Calcium cyanide, Potassium cyanide, Sodium cyanide |
| **25 Mitochondrial complex II electron transport inhibitors** *See footnotes for further information on sub-grouping* | **25A** *beta*-Ketonitrile derivatives | Cyenopyrafen, Cyflumetofen |
| | **25B** Carboxanilides | Pyflubumide |
| **28 Ryanodine receptor modulators** | Diamides | Chlorantraniliprole, Cyantraniliprole, Cyclaniliprole, Flubendiamide, Tetraniliprole |
| **29 Chordotonal organ modulators - undefined target site** | Flonicamid | Flonicamid |

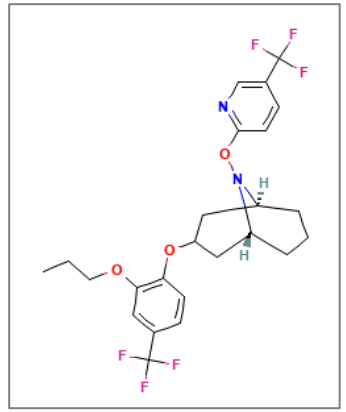


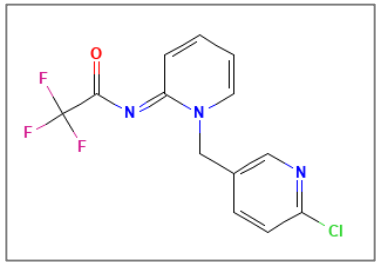
# IRAC Mode of Action Classification

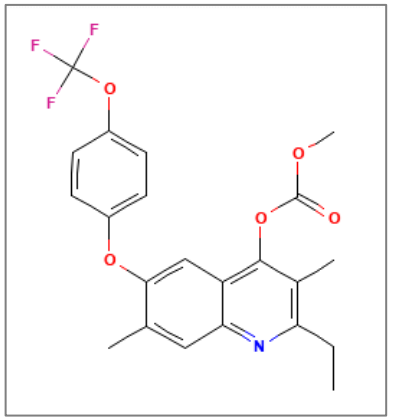
## MoA Working Group updates:

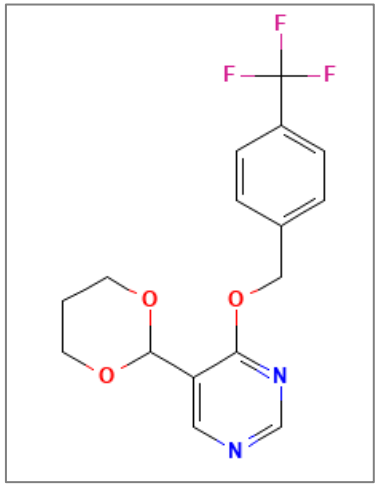
- **MoA Classification Scheme (v.10.4) & MoA Poster released on website (Dec 2022)**
  **- New MoA Groups:**
  - **Group 33:** calcium-activated potassium channel (KCa2) modulators: **'Acynonapyr'**
  - **Group 34:** METI complex III electron transport inhibitors – Qi site**: 'Flometoquin'**
  - **Group new:** Chordotonal organ modulators, undefined site: **'Dimpropyridaz'**
  - **Sub-group 4F** 'Pyridylidenes: **'Flupyrimin'**
  - **Group 30:** Isocycloseram was added
  - **Group UN (unknown MoA):** 'Oxazosulfyl' and 'Benzpyrimoxan' were added
  - **New 'targeted physiology group':** RNAi-based technologies, titled 'RNA interference mediated target suppressors' (new MoA group, added to Appendix 6 for a.i.'s pending registration): **'Ledprona'** -> Colorado Potato Beetle

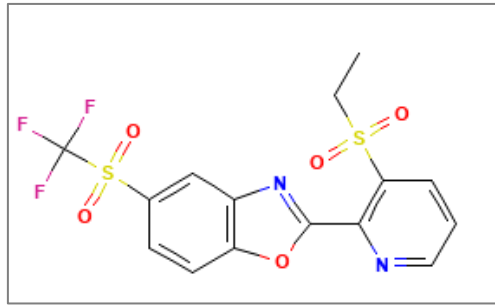
- **v.10.5 – (March 2023)** - **New MoA Group listings:**
  - **Group 29:** renamed to **"chordotonal organ nicotinamidase inhibitors"**
  - **Group 36:** A new MoA Group which contains the active **'Dimpropyridaz'** (group is named **"Chordotonal organ modulators – undefined target site"**)
  - **Dicloromezotiaz**, previously, in Appendix 6 (active ingredient pending registration), has been moved to Group 4E, Mesoinics, within Group 4, **"Nicotinic acetylcholine receptor (nAChR) competitive modulators".**
  - **New peptide, U1-AGTX-Ta1b-QA**, classified as "Unknown or uncertain MoA – subgroup **UNP (peptides of unknown or uncertain MoA)"** and has been added to the Classification Scheme, Appendix 6, pending registration











IRAC

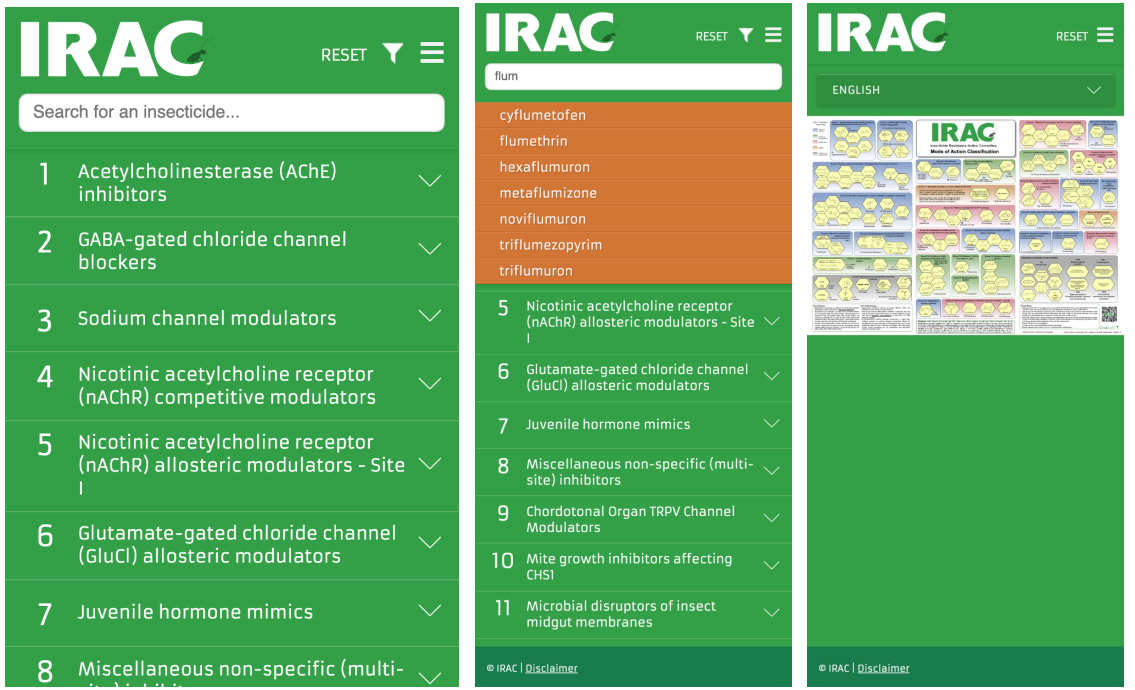
# IRAC MoA Classification

## MoA Classification Goal & Context

The IRAC Mode of Action (MoA) classification provides growers, advisors, extension staff, consultants and crop protection professionals with a guide to the selection of acaricides or insecticides for use in an effective and sustainable acaricide or insecticide resistance management (IRM) strategy.

*It is the definitive, global classification scheme on the target sites of acaricides and insecticides.*

## IRAC App



# IRAC:
# *COMMUNICATION & EDUCATION*

# Communication and Education

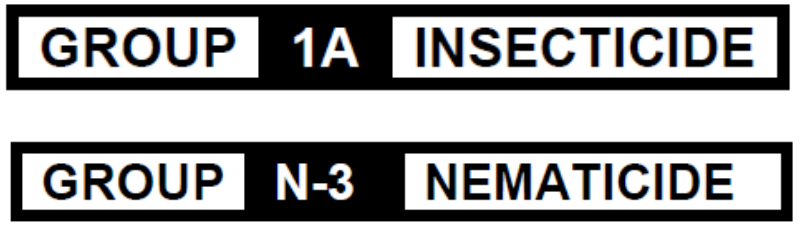

## Mode of Action Labeling

- Initiative lead by CropLife International and its country organizations with support of the RACs
- Mode of Action (MoA) information, standardized icons & RM instructions
- Member companies of CropLife International and IRAC international promised implementation.
- The initiative is progressing well with 87% of countries on track.


IRAC CropLife INTERNATIONAL

# Communication and Education

Mode of Action labeling




## Accompanying label Language

**RESISTANCE MANAGEMENT**

**Include:**

- The name of the active ingredient(s) and MoA identifier
- A statement that the product should be rotated with different modes of action using mode of action treatment windows
- Guidance to avoid treating consecutive insect generations with the same mode of action

IRAC CropLife INTERNATIONAL

# IRAC Mode of Action Classification & Label Language on RM

1. **Include an IRM section on the label, even if some country regulatory policies allow for little content.**
   a. **Example with Group 28: Where necessary, change conventional thinking of regulators and work as an industry to add Group 28 MOA icon and IRM language to country labels.**
   b. **If country does not yet allow MoA icon, then include the term 'IRAC Group 28, Diamide' in the label text; (under: general information, IRM, IPM, etc.)**

Solo products →

| GROUP | 28 | INSECTICIDE |
|---|---|---|

Example of premix products →

| GROUP | 28 | INSECTICIDE |
|---|---|---|
| GROUP | 3 | INSECTICIDE |

- ***Acceptable Diamide WG Criteria:*** *One of statements **(a)** or **(b)** must appear on the label.*

IRAC

# IRAC:
## *OUTREACH TO COUNTRY GROUPS AND OTHER STAKEHOLDERS*

# IRAC Outreach Activities to Address IRM Gaps in The World *(1)*

1. **Established country/regional support groups in the developing world**
   - Asia rice pest campaigns
   - Africa Team (new!)
2. **Partnerships with other industry groups and influencers**
   - International agricultural organizations (e.g., CLI, FAO, PR-PICA, GFRAS, country groups)
   - *GFRAS example: Provide advocacy and leadership on pluralistic and demand-driven rural advisory services for sustainable development*
   - other possible linkages with academia, professional societies (e.g., ESA), etc.
3. **IRAC communication materials**
   - E-connection newsletter, leaflets/booklets
4. **Audio-visual Aids**
   - pictograms & cartoons
   - videos, audio tapes
5. **Translation of brochures and promotional materials, e.g., MoA and IRM Videos**
   - multilingual translations into several local/regional languages
     - ✓ *existing: Arabic, Bahasa (Indonesian), English, French, Hindi, Italian, Japanese, Korean, Mandarin Chinese, Portuguese, Russian, Spanish, Tagalog (Philippines)*
     - ✓ *newest: Serbian, Swahili, Turkish*

IRAC

# IRAC Outreach Activities to Address IRM Gaps in The World *(2)*

6. **Publications/Print materials**
   - MoA classification booklets; posters of chemical structures of different MoA subclasses
   - white papers & peer-reviewed journal articles
7. **Farmer outreach (CLI communication)**
   - relaunch and disseminate IRM leaflets.
   - develop master document that can be used for translation into multiple languages
   - support for CLI and ICM consultants in the creation of a digital information platform
8. **Training modules (CP WG)**
   - pest pages, posters, booklets, guideline documents, etc.
   - upgrade and disseminate training modules
   - enhance promotional programs/accessibility to online modules and other training materials
9. **Developing a Massive Open Online Course (MOOC) for RM in Vectors – by PH WG**
   - target influencers of insecticides use and stewardship
   - collaborate with and adopt best practices from other RACs and WGs
   - collaborate with CropLife International (CLI), and CL country/regional teams
   - support consortium for vector IRM course
   - possible support for future crop/IRM MOOC

IRAC

global forum for rural advisory services
forum mondial pour le conseil rural
foro global para los servicios de asesoría rural

## Resistance management strategies

1. Integrated Pest Management (IPM)
2. Good application practices
3. Use the correct pesticide dose
4. Use good quality, genuine pesticides
5. Calibrate and maintain the application equipment
6. Mode/Site of Action (MoA) rotation
7. Double-hit strategy
8. Preservation of susceptible insects

## Development of pesticide resistance

| Practices that may prevent or avoid the development of pesticide resistance |
|---|
| • Using non-pesticide crop and pest management practices for all types of pests – insects, mites, weeds, diseases, and so on. |
| • Avoiding repeated use of the same pesticide, or pesticides with the same mode of action.<br>• Rotating pesticides with different mode/site of action. |
| • Using pesticides that target the most susceptible stages. |
| • Using selective pesticides, avoiding continual use of broad spectrum pesticides. This is not necessarily true for weeds. |
| • Applying pesticides according to the dose rates on the label. |
| • Ensuring even and adequate coverage of the target area. |
| • Using genuine products. |

IRAC

# Cooperation Among Stakeholders

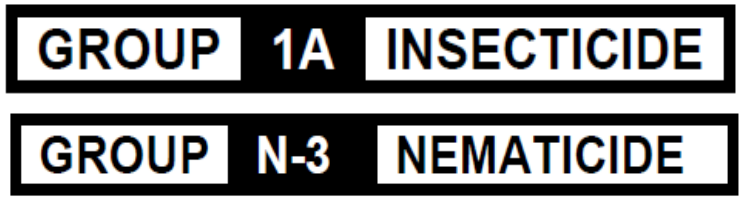
- Consistent messaging from different respected sources
- Grower groups can forge collective action
- Country and regional RACs can ensure alignment on local strategies
- IPM Centers
- Translations and local adaptation of global guidance
- Training of growers, applicators, consultants, and crop advisors
- Massive Online Open Course

➢ ***leverage IRAC resistance management expertise to benefit global agriculture***

IRAC

# Recent Examples of IRAC Success Stories

1. Promotion of IRAC MoA number and icon campaign on country labels
2. Mode of action mechanisms and rotations
   for effective resistance management
3. MoA classification for effective IRM programs (online & printed)
   - Lepidoptera: FAW training module and response
   - Sucking pests IRM guidelines
   - Nematicides MoA Classification

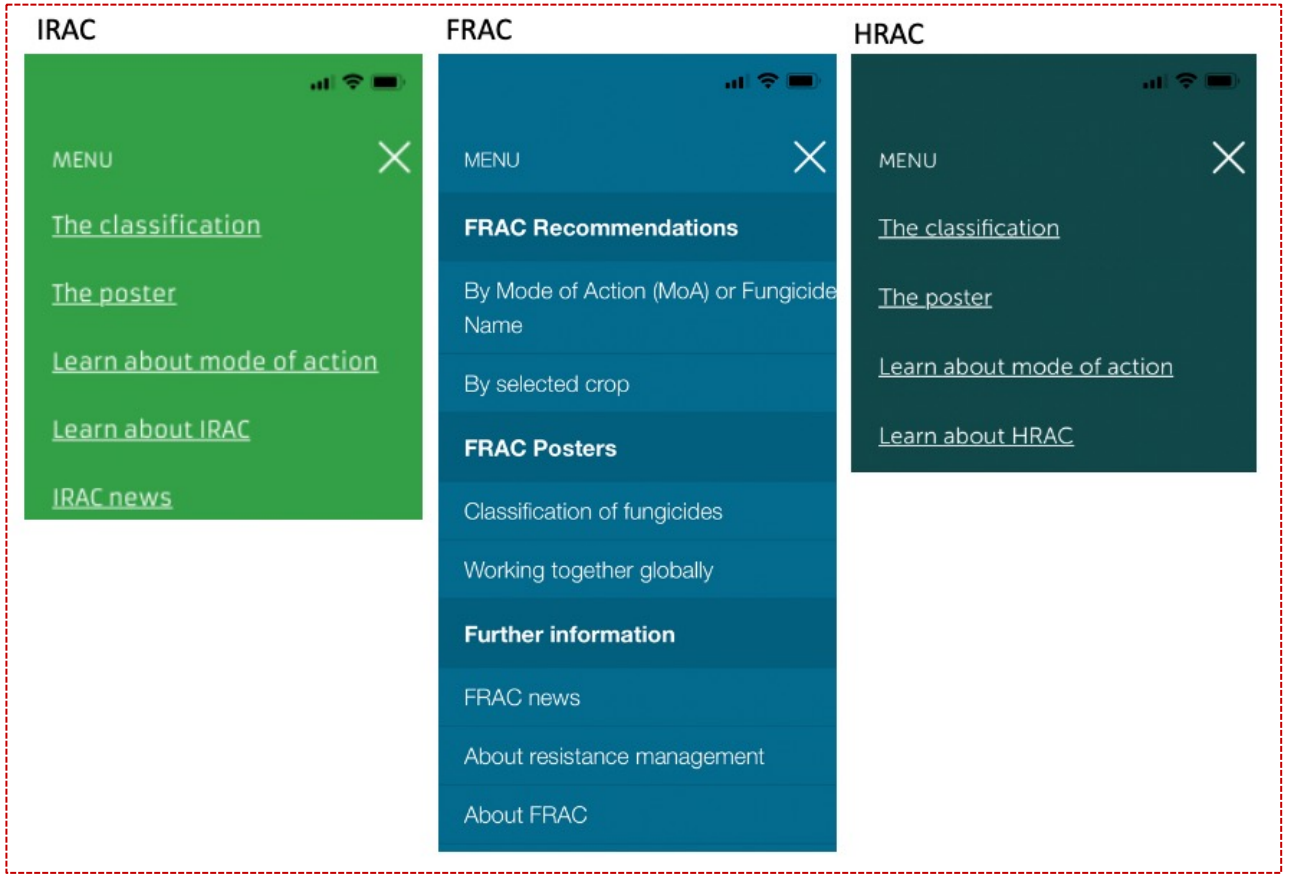



4. New pest pages (to provide training on pest biology
   and resistance status worldwide)
5. Industry & professional association meetings, *e.g.*, ESA
6. Establishment of more than ~30 functional country/regional groups,
   including the most recent – IRAC Africa-Middle East

IRAC

# Cross-RAC Collaborations: Databases & GRM App

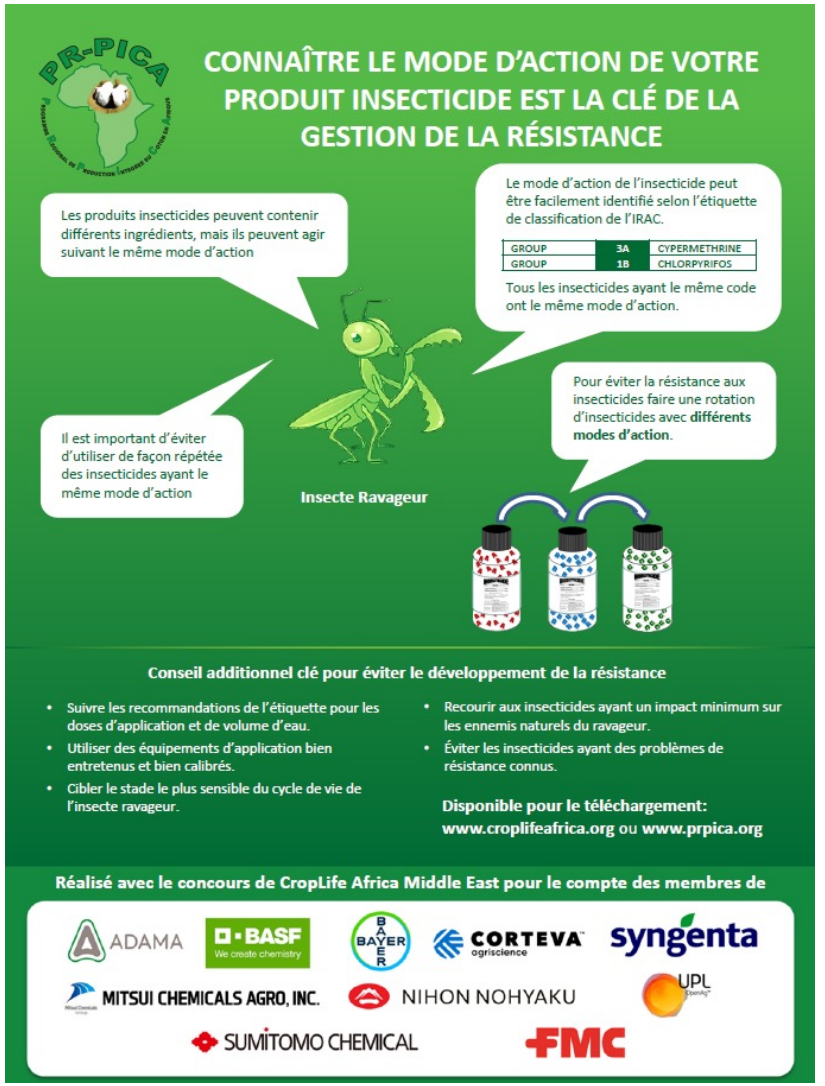
*MoA App - combined RAC GRM App. Note: IRAC, FRAC & HRAC have different levels of additional information available from the Apps, directly and via links to related websites but this could be expanded -* ***screenshots from the MoA Apps below:***




# PR-PICA

- A cotton producer initiative across 7 West African countries.
- Having seen the IRAC MoA animation were convinced of the need to introduce MoA labelling throughout the region.
- Introduced IRM training in 2021

- ** Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Mali, Senegal, Togo*




IRAC

# MANAGE FALL ARMYWORM IN 3 STEPS

IRAC Insecticide Resistance Action Committee

CropLife INTERNATIONAL

**1. Incorporate agronomic actions**

**2. Identify pest and decide when to treat**

**3. Control FAW using IRM principles**

## Implement Integrated Pest Management (IPM) Through The Season

Fall Armyworm – FAW – *Spodoptera frugiperda*



IRM – Insecticide Resistance Management

*Courtesy Ken Gray Photograph Collection (P 256), Special Collections and Archives Research Center, Oregon State University Libraries.



IRAC

# IRAC:

# *EXAMPLES OF TECHNICAL GUIDANCE FOR RESISTANCE MONITORING AND RESISTANCE MANAGEMENT*

# Examples of IRAC Guidance for Resistance Management

1. **Biotech working group**
   - FAW IRM in Bt corn
2. **Chewing Pest working group**
   - poster for cabbage stem flea beetle published; poster for tobacco budworm & RSB ongoing
3. **Crop Protection WG**
   - Role of Insecticide Mixtures and IRM; Impact of novel or unconventional use patterns for insecticides on resistance management
4. **Methods working group**
   - new methods for RSB, jassids, bedbugs; new videos for shipping insect samples; diet incorporation
5. **Nematodes working group**
   - poster for cabbage stem flea beetle published; poster for tobacco budworm & RSB ongoing
6. **Public Health working group**
   - The Resistant Mosquito: staying ahead of the game in the fight against malaria
7. **Sucking Pest working group**
   - presentations: stink bug & maize LH RM data; poster: silverleaf whitefly; IRM guidelines: cereals in Europe
8. **Resistance Management**
   - RM monitoring data sharing (guidelines and NDA template from IRAC Executive Committee)

IRAC

# IRAC:
## *NEW AFRICA-MIDDLE EAST TECHNICAL NETWORK*

# IRAC AFRICA-MIDDLE EAST TEAM

- *Goal*: ***leverage IRAC RM expertise to contribute to agriculture and sustainable food security in A-ME region***

ORGANIZATION

- Newest IRAC Group, formed in March 2021
- originally as IRAC Africa but renamed in August 2022 as IRAC Africa-Middle East
- ~25 members from different companies operating in A-ME region and global experts with interest in the region
- support from IRAC International, and CLI Stewardship (especially with Andy Ward, Director)
- recognized as IRAC Regional Team; page on IRAC website: *https://irac-online.org/countries/africa-middle-east/*
- Steering Team formed in February 2022 to serve as coordinating leadership, comprises: **Amr Moussa** (BASF), **Franck Parfait-Krah** (Bayer), **Isaac Oyediran** (Syngenta), **Noreddine Elaasri** (FMC), **Roleen LaGrange** (CL-SA), **Zaid Nabas** (Syngenta), **Vincent Gall** (Certis Belchim), **Billy Annan** (FMC/IRAC International)
- Quarterly general meetings, interspersed with Steering Team meetings, as needed
- Interest from with CL-AME since October 2022 in participation of IRAC Africa meetings, and on-going strengthened collaborations with CL-AME since February 2023 with **Evelyn Lusenaka** (Stewardship), and team: **Bakr Abdelmoneim** (ME-NA), **Robert Nofemela** (Southern Africa), **Sylvain Ouedraogo** (West Africa)

IRAC

# IRAC AFRICA-MIDDLE EAST TEAM

- *Goal*: *leverage IRAC RM expertise to contribute to agriculture and sustainable food security in A-ME region*

TECHNICAL/OPERATIONAL GOALS (SUPPORT FROM CLAME/CLI)

- Challenge with full membership attendance in meetings, CLI/CLAME can help by emphasizing to companies
- suggested hotspots/concerns for resistance management in CLAME region: ***Amrasca biguttula*** (cotton jassid) – West Africa; ***Bemisia tabaci*** (SLWF) – multiple crops/MoAs/countries; ***Myzus persicae*** (GPA) - multiple crops/MoAs/countries; ***Plutella xylostella*** (DBM) resistance on brassicas (diamides/countries?); ***Spodoptera frugiperda*** (FAW) on corn – multiple MoAs/countries; ***Tetranychus urticae*** (TSSM) - multiple crops/MoAs/countries; ***Tuta absoluta*** (TLM) on fruiting vegetables – MoAs/countries; Vectors: e.g., **mosquitoes**
- Collaborations with local and global organizations in A-ME: e.g., PR-PICA in W/Africa for cotton jassid RM
- Long term collaborations with technical subject experts in CL-ME for baseline (pest) susceptibility monitoring in and field (resistance) monitoring in key countries
- Support with funding from CLAME, CLI, PR-PICA, and other organizations, governments and public sources in A-ME region, for resistance management work of interest in target areas
- Continued support and collaborations from CLAME in other areas, e.g., training and outreach
- other support as appropriate, e.g., expertise leveraging, tech transfer, capacity building, databases, etc.

IRAC

# *SUMMARY & CONCLUSIONS*

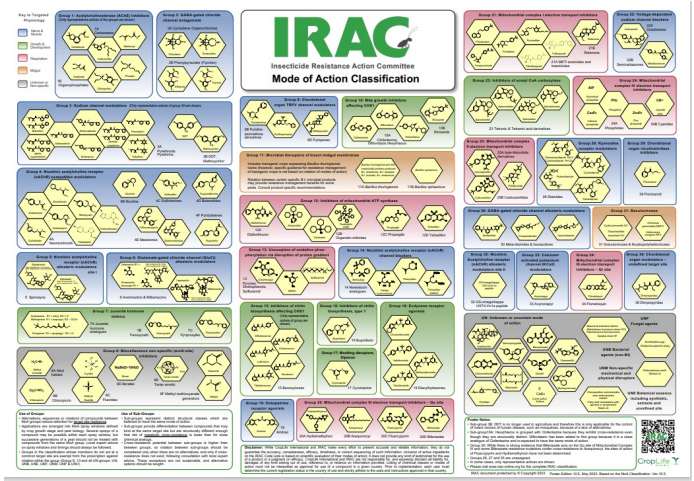
# General Summary

1. Expanding global trade and limited knowledge about pest resistance have contributed to the rapid spread of insect pest problems and even introduction of resistant pest species/ populations into new geographies, e.g., FAW from Americas into Africa & Asia.
2. Developing countries have technical capabilities to make significant contributions to global agriculture but may have limited resources, thus need partnerships.
3. It is imperative to engage pest management experts and institutions in developing world in monitoring, evaluation and mitigation of insecticide resistance issues.
4. IRAC is a global network of different companies with members having broad experiences and multidisciplinary backgrounds and collaborations with international partners.
5. IRAC/RACs are in unique position to support the implementation of sustainable resistance management practices to benefit agriculture, esp. in the developing world.
6. Agricultural institutions and policy makers must utilize the expertise of IRAC/RACs in resistance management to benefit of agriculture, especially in developing world.

IRAC

# IRAC Resources and Programs

1. **IRAC International**
   - Governance: Executive, Steering & Outreach Committees
   - Geographic Reach: ~30 Country WGs, expansion into new regions/countries
   - ~10 multinational companies, members with diverse/rich experience
2. **Technical Working Groups & Task Teams**
   - Pest-based (by crop groups): Chewing Pests, Sucking Pests, Nematodes
   - Functional: Mode of Action, Test Methods
   - Segments: Biotechnology, Crop Protection, Public Health
3. **Social media:** YouTube channel (~900 subscribers), Twitter, Facebook
4. **Meetings**
   - IRAC International: Annual Face-to-Face or Virtual teleconferences
   - Country WGs meet regularly, run local workshops & training sessions
5. **Internet App:** Mode of Action (MoA) classification
6. **Webpage and web-based resources:**
   - Selected country WGs websites
   - IRAC International: **https://irac-online.org/**




IRAC

IRAC

Insecticide Resistance Action Committee

# THANK YOU!