Session 3

International Working Group & Country Group Review

46th Meeting of IRAC International, Brussels, Belgium

Wednesday - March 30th, 2011

Codling Moth WG

Matthias Haas

CropLife INTERNATIONAL

IRAC

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Insecticide Resistance Action Committee

CM WG Team Members

WG members:	Company:	Responsible:
Matthias Haas	BCS (Chairman since 05)	D+ Benelux
Enrique Ariso	Maktheshim	South America
Andrea Bassi	DuPont (Chair until 04)	EU, Middle East, Africa
Jim Dripps	Dow	US, CDN
Eric Andersen	Cheminova	EU, Russia, Japan
Werner Heck	BASF	EU
Jean Paul Genay	Nufarm	France, EU
Narman McKinley	DuPont	US
Celine Roux	Makhteshim	France, EU
Robert Senn	Syngenta	EU, Global
Harvey Yoshida	Dow	US
Alan Porter	IRAC Coordinator	

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Codling Moth WG Activity

Group has been pretty dormant after Spring Meeting:

* Complexity of generalisation of CM situation over geographic areas

* No high urgency in RM for CM

* Agreed merger with LEP WG

Could only organise one conference call in 2010:

June 8, 2010 – Cancelled due to small participation
Nov. 22, 2010 – Group decided to go for merger

E-mail exchanges: none

Goals & SMART Objectives 2010/2011

Finalization of working documents and path forward by task-splitting **done**

- Value extraction from the Product Matrix, Expert List, Questionnaire and Literature Collection

Through 2010/11

Educational, collection and sharing of knowledge

- Collection of literature, posters, presentations papers and articles for posting in the WG website section done
- Issue of general guidance/principles for sustainable CM control abandonded

Through Q3 2010

Continue the WG visibility effort via new initiatives (e.g. mailing list, symposia) done?

- To get the IRAC CMWG known and being recognized as interlocutors for the Codling Moth experts.

Through Q4 2010

Design and support new collaborative CM resistance studies aimed at valuing unambiguous detection and validation (e.g. biochemical + suitable bioassay with “multiple” critical concentrations) no activity

- To facilitate a new standard of CM resistance studies to support the needs of new countries where CM resistance seems to be more of an issue (e.g. Bulgaria, Poland, Iran)

Through 2010/11

CMWG documents

- The expert list (Matthias, Jim, Andrea)
- The Product Matrix (Andrea, Jim)

- The Poster (Andrea, Jim)
- The Questionnaire summary spreadsheet (Robert)

- The IRAC bioassay method for CM sensitivity monitoring*,
- The CM RM guidance document (Andrea, Matthias, Eric)

* with Diamide & Methods w. groups

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The external "expert list"
Matthias

- **The CMWG wishes to inform and involve external CM resistance and crop experts**

•The expert list did not see any update since our last meeting, adding experts from the US and Canada.
•Eric reported interest for this list from participants of the last Spring meeting.

So we decided to put this list on the member's webside of IRAC.

The Matrix
Andrea, Jim

ACTIVE INGREDIENT LIST	MOA/CHEMICAL SUB-GROUP	RECOMMENDED BIOASSAY METHOD		BIOASSAY TARGET STAGE		METHOD DESCRIPTION AVAILABLE		BASELINE AVAILABLE		DIAGNOSTIC CONCENTRATION AVAILABLE		PRODUCT CONTACT NAME E-MAIL
		YES	NOT	EGGS	LARVAE	YES	NOT	YES	NOT	YES	NOT	
								INTERNAL DATA				
Carbaryl	1A Carbamates		X									
Methomyl			X									
Thiodicarb			X									
Azinphos-methyl	1B Organophosphates		X									
Chlorpyrifos			X				X		X		X	
Chlorpyrifos-methyl			X									
Malathion			X				X		X		X	
lambda-Cyhalothrin	3A Pyrethroids		X		X		X		X		X	
gamma-Cyalothrin												
beta-Cyfluthrin			X									
Deltamethrin			X									
Thiacloprid	4A Neonicotinoids	X			X	X		X		X		R. Nauen
Emamectin benzoate	6 Avermectins		X									
Fenoxycarb	7B Phenoxy-phenylethers	X		X		X		X			X	
Lufenuron	15 Benzoylureas		X		X		X		X		X	
Triflumuron			X									
Methoxyfenozide	18 Diacylhydrazines		X									
Indoxacarb	22A Oxadiazine	X			X	X		X			X	J-L Rison
Flubendiamide	28 Diamides		X									
Chlorantraniliprole		X			X	X		X			X	P C Marcon

This document is to be seen as internal working document of the CMWG. Harvey proposed to still update this list by adding new compounds like Spinetoram, or Emamectin?; if the compound has uses against CM at least in one country.

The IRAC Codling Moth Working Group: Aims & Scope

Insecticide Resistance Action Committee

www.irac-online.org

The update of the Poster has been done by Norman and Harvey

Introduction to IRAC

IRAC formed in 1984 to provide a coo…inated industry response to the development of resistance in insect and mite pests. The … …ission is to:

- Facilitate communication and edu… …nd acaricide resistance
- Promote the development of Ins… …IRM) strategies in crop protection and vector c… sustainable agriculture and improv…

IRAC International today operates in three major se… Plant Biotechnology). It comprises 13 Internation… Country/Regional Groups (India, S.E. Asia, Brazil, S. Africa, U… sees IRM as an integral part of IPM.

IRAC Codling Moth Working Group

The Codling Moth Working Group was established in 2000 to deal with increased occurrence of C. Moth resistance in the 90's. Since then the scenario has significantly changed. IRAC has reactivated the Codling Moth Working Group to tackle the issues and opportunities for improved IRM (Insect Resistance Management) as a result of the new scenario.

Insect resistance is a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species.

Insect Resistance is an example of "evolution in action", showing how selective forces can produce changes in the gene frequency of a population.

First documented case of C. Moth resistance was in 1928 in the US, to arsenite. Since then the situation has evolved in relation to the control tools available.

Effective use of semio-chemicals for Mating Disruption can be a major factor in reducing insecticide driven selection pressure.

Scope of the Codling Moth Working Group

- Gather and share updated feedback on Codling Moth resistance (industry, expert panel, fruit growers)
- Facilitate networking between the industry and the scientific/ advisory community
- Support research work aimed to standardize bioassay methods & improve their reliability
- Foster adoption of confirmatory assays on target insect stage
- Ensure a longer effective life for the available toolbox
- Provide IRM guidance and contribute to local IRM strategies, including the new chemical classes recently introduced (resistance avoidance).

Codling Moth Resistance Mechanisms & IRM

Mechanisms

Resistance to a specific insecticide can be due to different resistance mechanisms

✓Metabolic resistance (modified enzymatic activity: MFO, GST, EST)
✓Target-site resistance (KDR, MACE)
✓Reduced penetration and behavioural changes.

Electrophoretic banding pattern showing diversified esterase isoforms in OP resistant 5th instar Codling Moth larvae (Courtesy of Dr. Manicardi)

…he mechanism(s) of resistance is not characterized and in order to prevent the onset of resistance …resistance avoidance) intelligent use of MoA alternation (i.e. between consecutive Codling Moth …ther semio-chemical, bio-technical and cultural tools remains best IRM practice, since such …ize selection pressure.

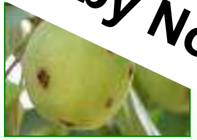
…d its diversity: a major threat

- … …odling Moth
- Can c… …but differential response between products within the same M…
- There can be dive… …ferential enzymatic activity)
- The diversity of the me… …an be significant across the different geographical areas
- Different metabolic profiles (enzyma… …ducts.

Bioassay and Monitoring for R…

Diagnosing metabolic resistance

- The analysis of the enzymatic activity (MFO, GST, EST) in a Codling Moth population is a key element for resistance evaluation
- There is a differential enzymatic activity between life-stages within the same population
- In resistant strains, the enzymatic activity may not only differ in quantitative terms, but also qualitatively (e.g. esterase isoforms)
- By itself, knowing the enzymatic profile of a given population does not allow to predict the field resistance nor the effectiveness of insecticide "X"
- Cross-resistance does not always concern all the insecticides with the same MoA. Azinphos-resistant C. Moth may be susceptible to Chlorpyrifos and viceversa.



Routine vs validatory assays

- In the last decade, large scale monitoring for field resistance mostly relied on topical application to diapausing Codling Moth larvae
- Recent authoritative studies have confirmed their validity for IGRs, but questioned their reliability for the prediction of field resistance with some neurotoxic insecticides
- By itself, significantly higher response in a routine monitoring conducted on non-target insect stage, does not allow to predict field resistance, unless validated with additional target-specific assays
- Validatory tests should include multiple insecticide concentrations.

Bioassaying the target-stage

- Resistance monitoring should be preferentially done on the target instar
- For larvicidal products, ingestion bioassays on neonate larvae (F1or F2 of the feral population) normally provide a more reliable indication of the field situation than topical application to diapausing larvae.

Scenario Changes & Trends

	2000	2010	2015
No. of MoA available for codling moth control*/**	8	10	n.a.
No. of individual insecticides available***	High	Decreasing	Fewer
Use of semiochemicals (Mating Disruption)	Minor	Moderate	Major
Microbial insecticides	Minor	Moderate	Moderate
Biological control	Minor	Minor	Minor
Regulatory pressure	Low	High	Decreasing
Food-chain pressure	Low	High	Decreasing
Field Resistance issues***/****	Moderate	Decresing	Low
Resistance knowledge and investigation tools	Moderate	Increasing	High

* four introduced in 1997-2000, two in 2007-10
** according to IRAC MoA classification (version 6.1)
*** in terms of chemical control measures, the cut-off criteria in the current revision of EU Directive 91/414 may concern 60-80% of the available insecticides, with a great impact on sustainable control
**** it'll depend on the implementation of the other factors. Assumption is that sustainable insecticide use will continue to be possible and implemented. In this respect, increased use of non-chemical tools will play a key role

Major factors affecting the current scenario vs year 2000

- Increased adoption of semio-chemicals for Mating Disruption
- Reduction of chemical toolbox due to regulatory & food-chain pressure
- Improved investigation tools for resistance detection and confirmatory assays

…secticides & MoA for Codling Moth

[illegible]	[illegible]	CHEMICAL CLASS	COMMON NAMES
[illegible]	[illegible]	Carbamates	Carbaryl, Methomyl
1B	Acetylc…	…hates	Azinphos-methyl, Chlorpyrifos, Malathion, Diazinon, Parathion, Phosmet, Phosalone etc
3A	Sodium channel modu…	[illegible]	lambda-Cyhalothrin, beta-Cyfluthrin, …rmethrin, Deltamethrin, Etofenprox, etc.
15	Chitin biosynthesis inhibitors, type 0	[illegible]	…Flufenoxuron, Lufenuron, …zuron, Triflumuron, etc
4A	Nicotinic acetylcholine receptor agonists	[illegible]	…d
22A	Voltage dependant Na^+ channel blockers	Oxadiazine…	[illegible]
5	Nicotinic acetylcholine receptor allosteric activators	Spinosyns	…toram
18	Ecdysone receptor agonists	Diacylhydrazines	Tebufenozide, Methoxyfenozide
7B	Juvenile hormone mimic	Phenoxyphenoxy-ethylcarbamate	Fenoxycarb
6	Chloride channel activators	Avermectins	Emamectin-benzoate
28	Ryanodine receptor modulators	Diamides	Flubendiamide, Chlorantraniliprole

- The toolbox is not empty. Ten different modes of action are currently available for control of Codling Moth, whose two are novel. Although efficacy level may vary, all of them are relevant to ensure the MoA diversity needed for sustainable control
- The available toolbox should be locally qualified with the no. of authorized MoA/products, the year of consistent introduction for C. Moth control and the relative efficacy level provided.

Designed & produced by IRAC Codling Moth WG, Setember 2008, Poster Ver. 1.0
For further information visit the IRAC website: www.irac-online.org

The CM Questionnaire/Survey

Regional Survey of Codling Moth Resistance

Designed for given region

Basic Field data in **XXX Country** :

1. Planted area of pomefruits : 62 000 ha
2. Area treated against Codling Moth : 55 000 ha
3. 2 generations of CM, in average (1 in North of France, 3 in South of France).
4. Timeframe of recommended CM – control :
   - South-East of France : 3-4 appl/ May , 3-4 appl/June, 3 appl/July, 3 appl/August
   - South-west of France : 3 appl/ May , 3 appl/June, 2-3 appl/July, 2-3 appl/August
   - West / North of France : 3 appl/ May , 2-3 appl/June, 2 appl/July, 2 appl/August
5. Economic threshold of infestation : 2%

The internal company feedback resulted in reports for 14 of 15 the originally prioritized countries! There is hardly any external feedback!

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CM RM guidance document (Andrea, Matthias, Eric)

- **Kind of general guidance (see neonics, diamide)**
- **A draft available for circulation later in 2010?**

Idea was adandonded due to complexity of CM situation in different geographies

Literature and article collection Werner

- **Literature & article collection (methods etc.) for posting in IRAC website dedicated space (through 2Q 09)**

A significant number of papers, presentations and other tech info has been collected since Aug. 08

- **Circulate & review draft of diet-incorporated method (suitable for larvicidal CM insecticides). Through 2Q 09**

(In agreement with the Method and Diamide teams)

IRAC bioassay method for CM sensitivity monitoring

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www.irac-online.org

IRAC Susceptibility Test Methods Series

Version: 3.2

Method No: 017

Details:

Method:	IRAC No. 017	 *Cydia pomonella larvae and damage Photographs Courtesy of: DuPont Crop Protection* 
Status:	Proposed	
Species:	Codling Moth *(Cydia pomonella)*	
Species Stage	Larvae (L1)	
Product Class:	This method is specifically recommended by the IRAC Diamide Working Group for evaluating the susceptibility status of **diamide insecticides (IRAC MoA 28).** This method is also suitable for the following insecticide classes (IRAC MoA class): Organophosphate (1B)* Pyrethroid (3A)* Neonicotinoids (4A)* Spinosyn (5)* Avermectin (6)* Juvenile Hormone Mimics (7A)** Fenoxycarb (7B)** Benzyl urea (15)** Diacylhydrazine (18)** Indoxacarb (22A)* Metaflumizone (22B)* Pyridalyl (un)*	

Comments:

CMWG final decision on merger Nov 22-2010 concall minutes

Merger with the Lepidopteran Working Group

- **The members participating and (beforehand the excused members) agreed that we aim for a merger with the Lepidopteran WG.**
- A respective proposal will be notified to the executive of IRAC by Matthias and we shall finally decide on details on the IRAC Spring meeting (March 28th to 31st, 2011).
- For handover a reasonable time frame shall be set up (6 months up to a full year 2011).

We said we should be "driving" CM resistance studies...????
Andrea

…we raised the value of unambiguous detection and validatory procedures: should we sponsor scientific projects/agreements *e.g*.:

- - IRAC to facilitate access to quality resistance validation (enzyme / bioassay) to the less developed countries (i. e. Balkans, Middle East) with quality EU labs

- - Rather, IRAC to design and support cross-country collaborative studies with a new architecture?

Other possible studies (2nd priority)?

- -Measuring the role of Mating Disruption in reducing the incidence of enzymatic cross-resistance vs solo chemical programmes