Strategies
for
Managing Insecticide Resistance
in the
Codling Moth
(*Cydia pomonella L*)

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I R A C

INSECTICIDE RESISTANCE ACTION COMMITTEE

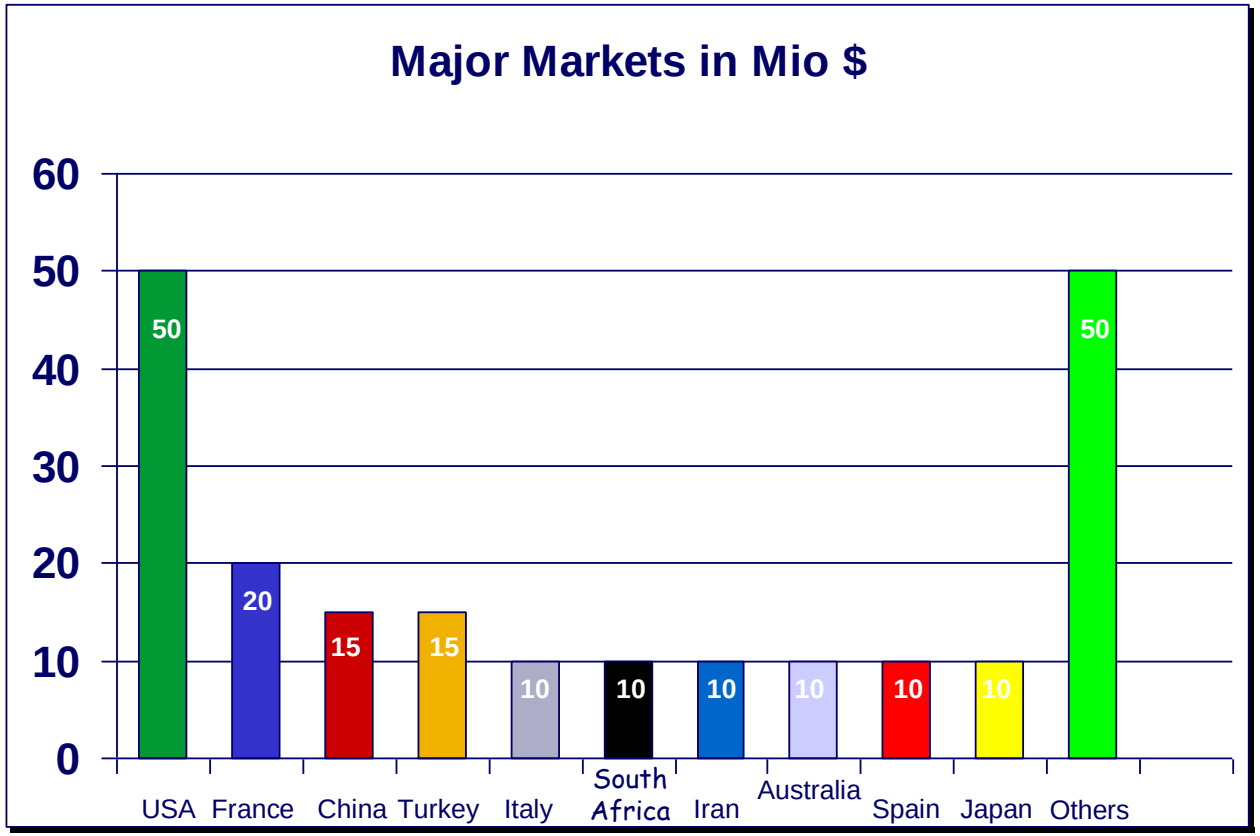
Topics

- Codling moth – it importance
- Factors influencing the resistance to CM
- Chemical, Bio-technical and non-chemical toolbox
- Current recommended control strategies
- IRAC‘s plan for a CM Symposium on RM

Cydia pomonella, a key pest in fruits & nuts

Larval damage

Adult



CM: ca 40% of pome fruit market

Regional records (IRAC survey) of resistant populations in the codling moth

	OP	SP		IGR
IRAC MoA classification	MoA 1B - AChE esterase inhibitors	MoA 3A - sodium channel modulators		MoA 7C - JH mimics MoA 15A - Chitin biosynth. Inh. MoA 18A - Ecdysone agonists
Australia	x			
Canada	x			
USA	x			
Netherlands				x
South Africa	x		x	
Germany	x		x	x
Italy	x		x	x
France	x		x	x

Factors linked to the development and incidence of resistance in Cydia pomonella (1)

- Codling moth – through its key pest status – accounts for a substantial proportion of total pesticide use in pome fruit production
- Local climatic and cropping conditions that allow three generations per year, encourage the development of high moth populations and, consequently, of severe fruit infestation
- The very low economic damage threshold levels (fruit damage 1% - 2 % is generally regarded as commercially unacceptable) motivates intensive insecticide programs
- The overlapping of several codling moth summer generations hampers the optimum timing of control measures and impedes particularly the use of selective technologies

Factors linked to the development and incidence of resistance in Cydia pomonella (2)

- The reliance on broad-spectrum insecticides, that may affect the balance of naturally ocurring beneficial organisms (antagonists) is not compatible with the implementation of sustainable control programs

- The exclusive use of insecticides belonging to the same MOA-classification (e.g. oganophosphates, synthetic pyrethroids, chitin biosynthesis inhibitors) increases the risk of selecting for resistance
- The misuse of products (dose rates, timing and method of application) as well as the mismanagement of the orchards (lack of adequate prognostic methods and inappropriate agronomic practices) and - last but not least - ...
- Insufficient information and communication to and at the grower level are main factors limiting the development of rational pest management and contributing to the onset of resistance

Products representing innovative insecticide chemistry:
Opportunities for building flexible strategies in sustainable codling moth management and resistance avoidance

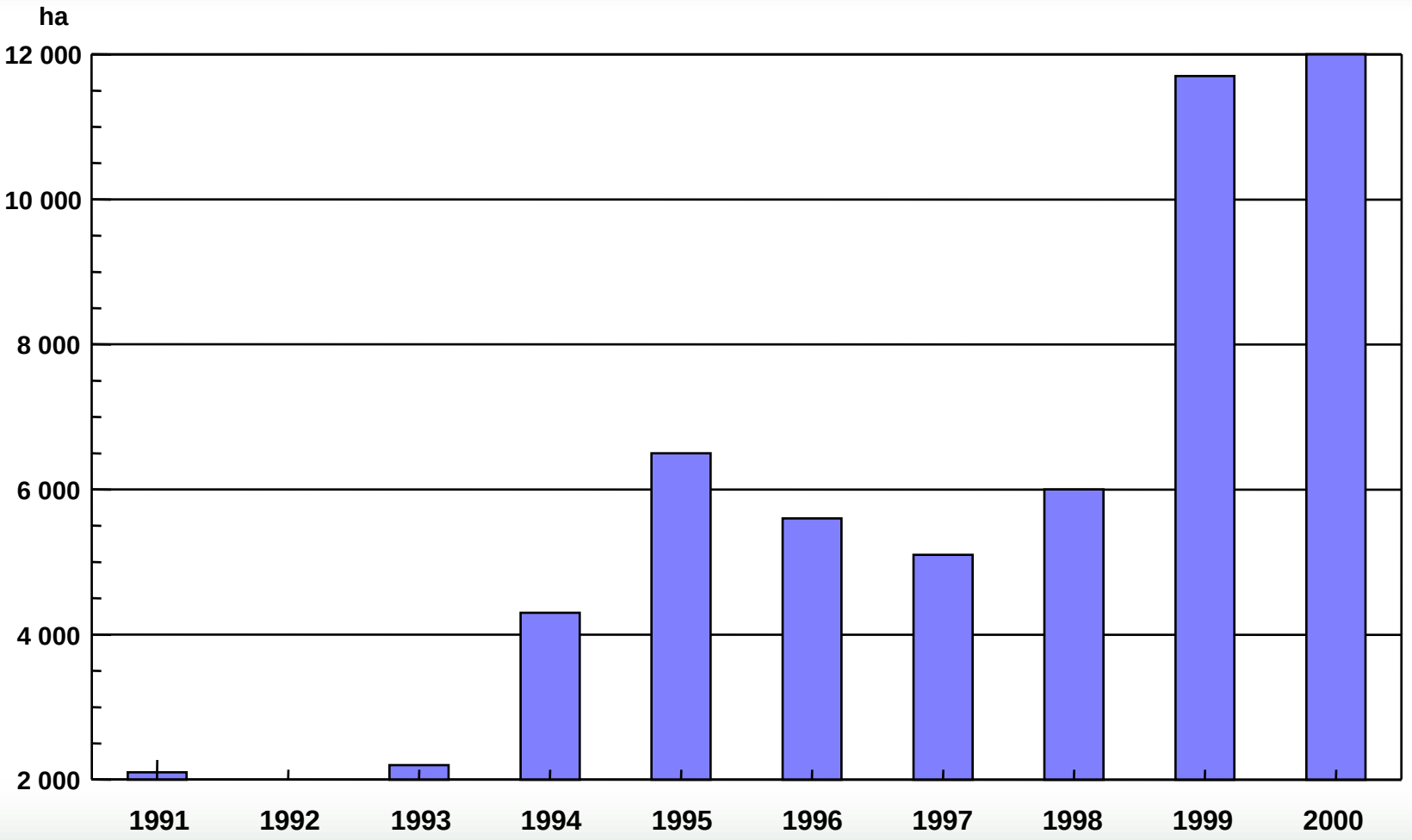
chemical class	common name	primary target site	MOA group	activity spectrum	product status
neonicotinoids	thiacloprid acetamiprid	Nocotinic AcCh reseptor agonist	4 A	broad-spectrum homopteran and lepidopteran insects	registration / commercial introduction phase
oxadiazines	indoxacarb	voltage dependant sodium channel blocker	22 A	broad-spectrum lepidopteran insects	registration / commercial introduction phase
hydrazides	tebufenozide methoxyfenocide chromafenozide	ecdyson agonists	16 A	broad-spectrum lepidopteran insects	registration / commercial introduction phase
phenoxy-phenylethers	fenoxycarb	juvenile hormon mimic	7B	tortricidae	commercial

Op's, Pyrethroids, Acylureas

Depending on regional conditions and the national status of product registration, a variable range of products can be offered to the grower

MOA	Chemical class	France	Germany
1B	organophosphates	azinphos-m, diazinon, diethion, fenthion, formothion, malathion, methidathion, parathion-m., parathion-e., phosmet, phosalone	parathion-m.
1A	carbamates	carbaryl, methomyl	-
1B + 3A	organophosphate + synth. Pyrethroid	fenitrothion + esfenvalerate, oxydemeton-m. + betacyfluthrin	-
3A	synth. Pyrethroids	alphamethrin, betacyfluthrin, cyfluthrin, bifenthrin, cypermethrin, deltamethrin, fenpropathrin, lambda-cyhalothrin, tau-fluvalinate	betacyfluthrin, cyfluthrin
7	Juvenil hormon mimics	fenoxycarb	fenoxycarb
15 A	chitin biosynthesis inhibitors	diflubenzuron, flufenoxuron*, hexaflumuron, triflumuron *cross-resistance status under research	-
16	ecdyson agonists	tebufenozide	

Acreage of apple orchards treated with the mating disruption technique against codling moth, South Tirol 1991 – 2000 (Waldner)



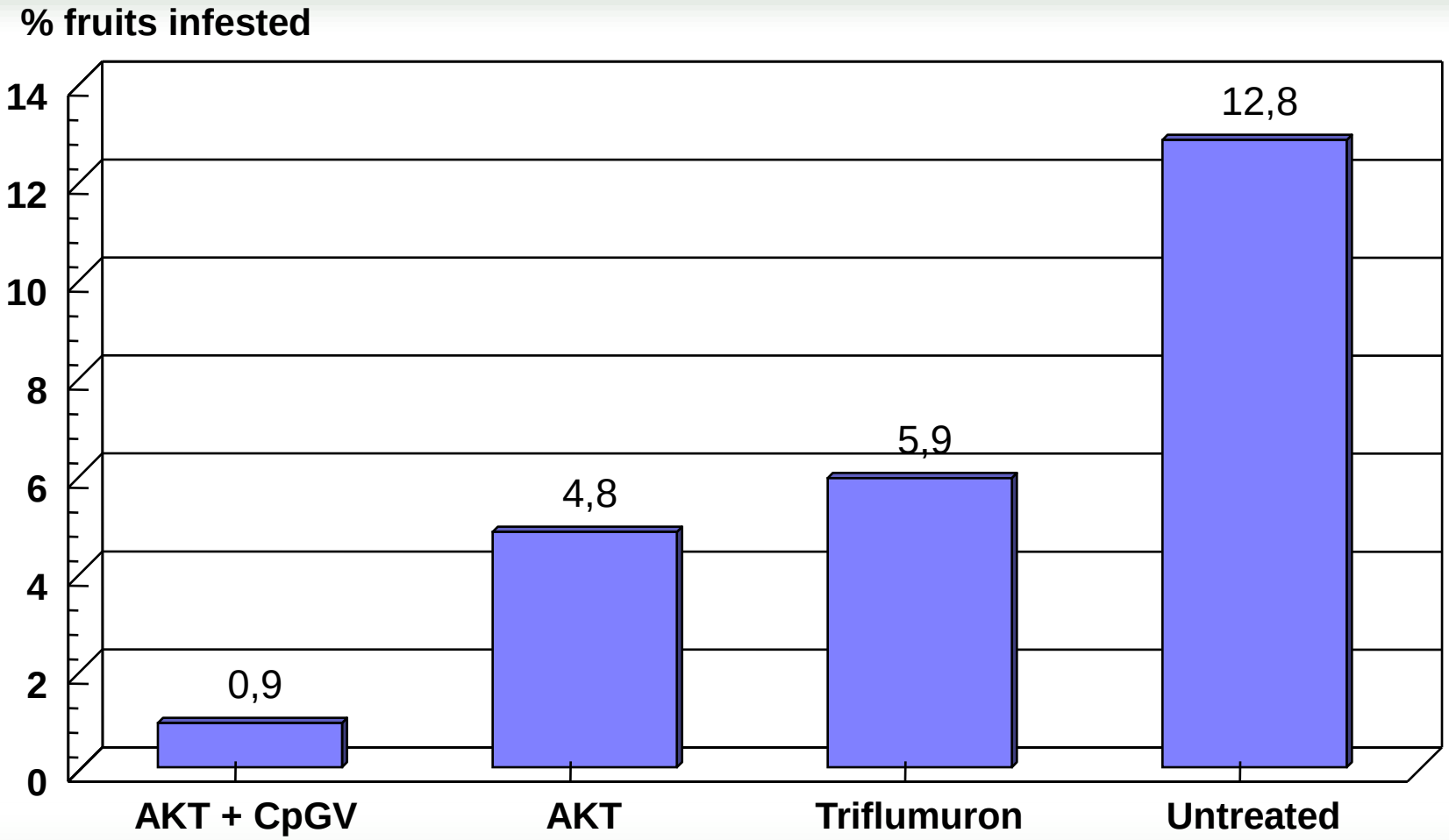
Factors affecting the success of Mating Disruption Technique (MDT)

Many factors affecting performance

- **population density**
- **product / dispenser → pheromone release**
- **crop, size (canopy, height) of trees**
- **orchard size, shape, isolation**
- **application → dispenser placement**

- **very selective products → secondary pest**
- **technical expertise → regular monitoring, damage rating**

Additive effect of granulose virus (CpGV) and pheromones (Attract and Kill Technique, AKT), Grosssachsen 1998



source: E. Dickler, European Apple Symp., 2001

Advantages versus disadvantages of codling moth granulosis virus (CpGV) on pome fruit orchards

Advantages
excellent fit for resistance management within IFP
high selectivity, efficacy
safe to beneficials
pre-harvest interval 0 days
common application technique
mixes well with other pesticides
no environmental restrictions
no drift problems
high user safety

Disadvantages
high spray frequency due to the lack of UV-stability
economic threshold can be exceeded under higher infestation pressure
high cost level
very selective against codling moth calls for additional action for control of other pests
technically demanding

source: E. Dickler, 2000

Cultural- and monitoring methods in resistance prevention

- **Apply adequate cultural methods to alleviate the population build-up:**
  - removal and destruction of pruning remains
  - make use of ground cover management (green-covered soil surface)
  - select the cropping system best adapted to the location

- **Use monitoring methods to predict the development of codling moth populations and the optimum application timing of the most appropriate product or technique under the given conditions**
  - computer-based modelling devices
  - trunk bands
  - pheromone traps
  - direct counting of eggs and / or larval stages

INRA/SPV: CM management strategies: France
strategic options / recommended product alternations (G 1)

B. Sauphanor et al., supported by IRAC

status of codling moth control in year 1	control of 1st. generation (G1) in year 2
no resistance problem year 1(G2) acceptable control damage G2: < 2%	**alternate MOA group used against 1st and 2nd. generation year 1** **1 B2:** 'soft' OP's (phosmet, phosalone, phosphamidon) **7 B :** JHM's (fenoxycarb) **16 A :** EA's (e.g. tebufenozide) **15 A :** CBI's (flufenoxuron) **1 A :** carbamate (e.g. methomyl) **23 A :** virus (CpGV)
resistance suspected year 1 or lack of evidence acceptable control damage G2 < 2%	**1 B1** : larvicide strategy: OP's (azinphos-m, chlorpyrifos + dimathoate, parathion) **23 A :** virus (CPGV), spray sequence (2 applications) **15 A** : ovicide strategy: CBI's (flufenoxuron), spray sequence (3 applications)
resistance suspected year 1 or lack of evidence inadequate control damage G2 > 2%	**1 B1 :** larvicide strategy: OP's (azinphos-m, chlorpyrifos + dimethoate, parathion) **or** **15 A :** CBI (flufenoxuron), spray sequence (max. 3 applications)

INRA/SPV CM management strategies: France
strategic options / recommended product alternations (G 2)

B. Sauphanor et al., supported by IRAC

status of codling moth control 1st Gen in in year 2	control of 2nd. Generation (G2) in year 2
no resistance problem year 2 (G 1) **acceptable control** **damage G1: < 3% or** **damage G1: > 3%** due to unsufficient contro lof G2 in year 1	**alternate MOA group used against G1 / year 2 and G2 / year 1** **1 B2:** 'soft' OP's (phosmet, phosalone, phosphamidon) **at peak egg hatch** or **1 B1:** OP's (azinphos-m, chlorpyrifos + dimethoate, parathion) **on high population**
resistance suspected or lack of evidence **damage G1 < 3%**	**1 B1:** OP's (azinphos-m, chlorpyrifos + dimethoate, parathion) **during high- risk period** **exclude MOA groups 15 A** (CBI's except flufenoxuron), 1 B2 ('soft' OP's), 7 B (fenoxycarb), 16 A (EA's), 3 A (SP's)
resistance suspected or lack of evidence **damage G1 > 3%**	**1B1:** OP's (azinphos-m, chlorpyrifos + dimethoate, parathion) **during the whole risk period**

RAC: CM resistance management strategies: Switzerland
Strategic options / recommended product alternations (G 1/G 2)

PJ. Charmillot et al., supported by IRAC

status of CM control	1st. generation	2nd. generation
no special advice	24 A/B: Mating disruption	24 A/B: Mating disruption
	or	or
	Attract & Kill	Attract & Kill
	23 A: CM GV	
	7 B: juvenile hormon mimics	7 B: juvenile hormon mimics
	15 A: chitin biosynthesis inhibitors	15 A: chitin biosynthesis inhibitors
	16 A: ecdysone agonists	16 A: ecdysone agonists
	22 A: sodium channel blocker	22 A: sodium channel blocker

summary

- **resistant** populations of **codling moth** have been detected in **many countries** most serious in **SE-France**
- **all available tools** of codling moth control have to be implemented in **sustainable strategies** for managing resistance in codling moth.
- New insecticides, representing different **innovative chemistries** under registration **but registration** in fruits most **difficult**
- **IRAC** is keen to work together with **scientific** and **advisory community**

The Mission of IRAC

www.plantprotection.org/IRAC

secure a prolonged effective life of reliable insecticides and acaricides

- provide potential users with guidelines that convey technically and environmentally sound practices in sustainable pest control, resistance prevention and management on key target pest species
- conduct worldwide surveys on the occurrence of suspected or proven resistance being reported from key pests in essential crop areas, organize the updating of a valid resistance database
- collect, revise and publish existing bioassay methods, develop new bioassays, which serve to establish reliable programs for monitoring pest suceptibility
- contribute funding to research organisations and field projects outside industry
- **support and sponsor research projects, seminars, symposia and workshops according to current needs**
- promote and patronize education, communication and collaboration between all those - inside and outside industry - involved in crop production and insect control

IRAC will organise an

International Codling Moth Symposium

to be held within the

VIIth. European Congress of Entomology

Tessaloniki, Greece, Oct 7-13, 2002

objective

review and discuss status on CM resistance and IRM strategies

http://www.helexpo.gr/ece.

Thanks

IRAC is pleased to continue to work together with the **scientific** and **advisory community**