Insecticide Resistance Action Committee

Sucking Pest WG

Michael Klueken & colleagues,
September 17th

content

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Anti-trust Reminder

- All IRAC meetings are held under anti-trust rules and regulations.
- Regulations are developed under guidence from Croplife International
- All discussions should be technical discussions and NOT commerical.
- Do not talk about individual products (active ingredient or mode of action only)
- Do not talk about prices, marketing strategies,etc.
- If you have any concerns – please stop the conversation and consult with IRAC Brazil or IRAC International colleagues.
- A copy of the anti-trust guidelines can be provided to those requiring a copy.

Antitrust Law Reminder

for all CropLife International meetings

"IRAC Committees and IRAC Members should be aware that while some activities among competitors are both legal and beneficial to the industry, group activities of competitors are inherently suspect under the antitrust laws.

Agreements or combinations between or among competitors need not be formal to raise questions under antitrust laws, but may include any kind of understanding, formal or informal, secretive or public, under which each of the participants can reasonably expect that another will follow a particular course of action.

All IRAC Members have a responsibility to see that topics, which may give an appearance of an agreement that would violate the antitrust laws, are not discussed during meetings, conference calls or in any other forum.

It is the responsibility of each member in the first instance to avoid raising improper subjects for discussion and the purpose of the Antitrust Guidelines is to assure that participants are aware of this obligation"

....

IRAC-Sucking Pest WG Team structure – 2015

- BASF representative: Lixin Mao (BASF-internal discussion)

Team structure as of September, 2015:

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		TOTALS	13

NOTE: To avoid spam, only team members within each team can use the specific team email address

IRAC-Sucking Pest WG Objectives – 2015

Goals	Objectives	Timeline

Short term actions to minimise spread of resistant pests	• *Myzus persicae* Follow-up with "implementation" of IRM Guidelines in Southern EU
	• *Bemisia tabaci* monitoring program (PROMIP)
	• *Sitobium avenae* review last year's alert for Mainland EU for PYR-resistance (in view of few MOAs)
	• *Aphis gossypii* (neonicotinoid target site resistance)
	  ▪ Initiate local IRAC team in South Korea
	  ▪ Develop IRM recommendations for Korea as template for future use
	  ▪ Finalize / review poster: globally & local Korean language version
		2015
		Q2 2015
		Q3 2015
		
		Q2 2015
		Q2 2015
		2015

Prepare IRM guidelines for pests with, or at risk of developing resistance in the **mid term**	▪ *Euschistus heros*, in Brazil (e.g. IRAC01, 03, 04)
	  ▪ Follow up with monitoring efforts in Brazil e.g. PROMIP/IRAC-BR,
	  ▪ Method validating and implementation (review vial test to IRAC approved methods)
	• *Bathycoelia distincta* Support research efforts in RSA (suspected PYR-resistance)
	• *Diaphorina citri*
	  ▪ Finalize and publish the Leaf Dip method for IRAC Groups 01, 03, 04, 05, 06
	  ▪ Validate and publish a Flush tube systemic test for IRAC Groups 23 and 28
	• *Bemisia tabaci (T. vaporariorum)* updated poster version incl. new MOA guidelines
	• *Group 4 IRM Guidelines.* Review and finalize – update global document in view of new subgroupings
	• *Lygus sp* USA Cotton engage with IRAC US to assess need for action
	
	• fruit fly species (pyrethroids-resistant olive fly suspected, Greece): 1. Summarize current resistance situations for diptera, 2. Exchange about methodology, 3. Pro-actively release IRAC recommendations, highlight value of current options / prevent use restrictions
		
		Q2 2015
		Q3 2015
		2015
		
		Q2 2015
		Q4 2015
		2015
		Q1 2015
		2015

Prepare for future Sucking Pest problems **long term** (avoiding resistance development)	▪ *Tetranychus sp. (mites), Diaphorina citri , Nilapavarta lugens, Dichelops melacanthus (stinkbugs)*
	  ▪ Collect reports on monitoring studies and publications, follow up field failures
	▪ *Aphis gossypii* (neonicotinoid target site resistance)
	  ▪ Monitor complaints globally and report liaise with researchers
		
		2015
		
		2015

M. persicae – new data 2015

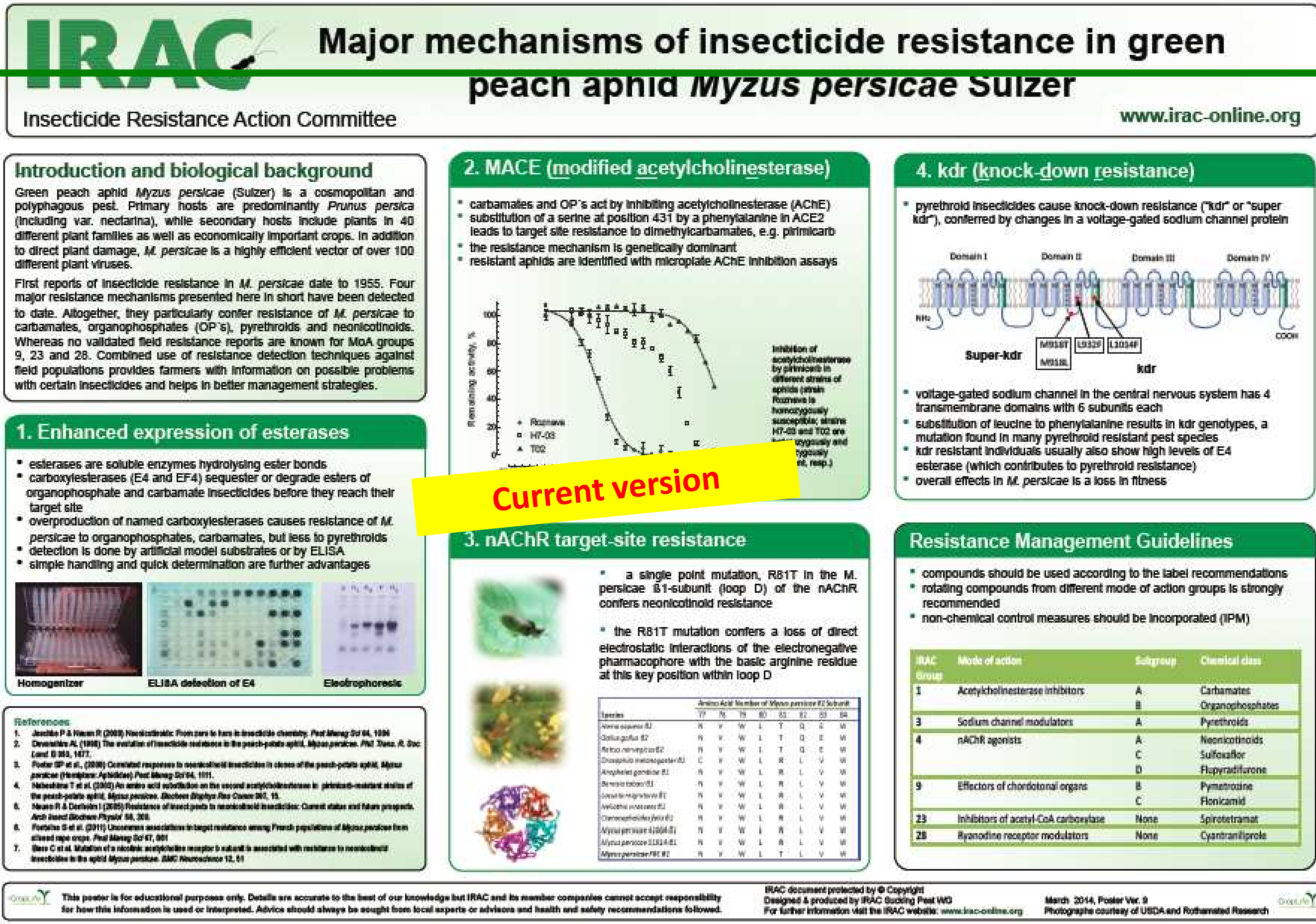
Steve has circulated an example, incl. methods, that can be used to inform local company representatives in Southern-Europe (esp. in ITA, ESP and FRA).

We believe it is important to follow-up *M. persicae* populations not only on their winter host (stone fruits), but also on **summer hosts or other secondary hosts.** This can include vegetables, tobacco, and broad acre crops (e.g. oil seed rape, sugar beet, potato).

It is not too late for 2015, because populations in summer and autumn might be exposed to further IRAC Gr. 4 a.i.'s potentially selecting further for resistance.

➔ Did everyone send reminder mail to local company representative?
➔ Did Syngenta (or Bayer) received samples?
➔ Any suggestion, when new results be available?

M. Persicae – new poster version 2015



Current version

Principales mecanismos de resistencia a insecticidas en el pulgón verde del melocotonero, *Myzus persicae* (Sulzer)

IRAC E S P A Ñ A

Comité de Acción contra la Resistencia a Insecticidas

www.irac-online.org

Introducción y datos biológicos

El pulgón verde del melocotonero, *Myzus persicae* (Sulzer) es una plaga polífaga y cosmopolita. Su hospedador primario es *Prunus persicae* (incluyendo nectarinas), mientras que los secundarios incluyen plantas de 40 familias diferentes, entre las cuales se encuentran cultivos económicamente importantes. Además de los daños directos, *M. persicae* es un vector muy eficiente de más de 100 virus distintos de plantas.

Los primeros casos de resistencia a insecticidas en *M. persicae* datan de 1955. Hasta la fecha se han detectado cinco mecanismos de resistencia, los cuales presentamos brevemente en este póster. Estos mecanismos confieren resistencia de *M. persicae* a carbamatos, organofosforados (OFs), piretroides y neonicotinoides. No se conocen casos de resistencia verificados en campo al resto de ~~los~~ grupos de MdA. El uso combinado de técnicas de detección de resistencias en las poblaciones de campo proporciona información sobre posibles problemas con algunos insecticidas y

1. Nivel elevado de esterasas

- Tipo de Resistencia: Metabólica.
- Afecta a: **Carbamatos**, **OFs** y en menor grado a **piretroides**.
- Las esterasas son enzimas solubles que hidrolizan enlaces éster.
- La sobreproducción de carboxilesterasas (E4 y EF4) por parte *M. persicae* genera resistencia a estos insecticidas, cuyos enlaces éster son capturados o degradados antes de alcanzar su sitio de acción.

2. Nivel elevado de la monooxigenasa citocromo-P450

- Tipo de Resistencia: Metabólica.
- Afecta a:.
- Qué son…
- Qué provocan…

New darft suggestions by IRAC-ESP

3. Modificación de la acetilcolinesterasa (AChE de sus siglas en

- Tipo de resistencia: Sitio de acción.
- Afecta a: **Carbamatos** y **Organofosforados** (OFs).
- En condiciones normales la AChE degrada la acetilcolina para el buen funcionamiento del sistema nervioso de *M. persicae*.
- Los Carbamatos y OFs inhiben el funcionamiento de la AChE, lo que provoca la sobreestimulación y sobreexcitación del pulgón.
- La modificación de la estructura de la AChE, por sustitución de una serina en posición 431 por una fenilalanina, provoca que su acción no sea inhibida por estos insecticidas, por lo que el Sistema nervioso del pulgón puede funcionar perfectamente.

4. Modificación del Receptor nicotínico de la AcetilColina (nAChR de sus siglas en

- Tipo de resistencia: Sitio de acción.
- Afecta a: **Neonicotinoides** (NNI).
- En condiciones normales el nAChR fija a la acetilcolina para el buen funcionamiento del sistema nervioso de *M. persicae.*
- Los NNI se fijan al nAChR en lugar de la acetilcolina, lo que no permite el normal funcionamiento de la transmisión nerviosa.
- La modificación de la estructura del nAChR (por mutación R81T en la subunidad ß1 del bucle D de *M. persicae*), provoca que éste ya no reconoce al insecticida que se fijaba a él, por lo que el sistema nervioso del pulgón puede funcionar perfectamente.

5. kdr o super kdr (resistencia “knock-dow

- Tipo de resistencia: Sitio de acción.
- Afecta a: **Piretroides**.
- En condiciones normales los canales de sodio dependientes del voltaje regulan la entrada y salida de iones Na+ de los axones, proceso necesario en la transmisión nerviosa del pulgón.
- Los piretroides bloquean estos canales de sodio, provocando…..
- Los cambios en la proteína del canal de sodio dependiente del voltaje (la sustitución de leucina por fenilalanina da lugar a genotipos kdr) provocan…
- Los individuos con resistencia kdr por lo general también muestran altos niveles de esterasa E4 (que contribuye a la resistencia a piretroides).

Referencias

1. Jeschke P & Nauen R (2008) Neonicotinoids: From zero to hero in insecticide chemistry. *Pest Manag Sci* **64**, 1084
2. Devonshire AL (1998) The evolution of insecticide resistance in the peach-potato aphid, *Myzus persicae. Phil. Trans. R. Soc. Lond.* B **353**, 1677.

Directrices de prevención de resistencia

- Se recomienda alternar compuestos de diferente modo de acción. (no repetir aplicaciones consecutivas).
- Se recomienda no utilizar un mismo modo de acción más de una vez por ciclo de cultivo.
- Si se observa un descenso significativo de los niveles de control de *M. persicae, se recomienda dejar de emplear los insecticidas de este modo de acción.*
- En las aplicaciones pre-florales en frutales, se recomienda la utilización de aceite solo o en mezcla con aficidas**.
- Emplear sólo productos autorizados, siguiendo las instrucciones de etiqueta. Ver poster tuta / medidas alternativas

* Observar limitaciones abejas (ver etiqueta)

M. persicae puede ser resistente a estos insecticidas en algunas zonas. Consultar con los técnicos locales

**Confirmar la disponibilidad de registro

Modos de Acción (MdA) autorizados en España contra *M. persicae* (Julio

Grupo principal/ Punto de acción primario	Subgrupo químico o materia activa representativa
1 Inhibidores de la acetilcolinesterasa.	1A Carbamatos. 1B Organofosforados.
3 Moduladores del canal de sodio.	3A Piretroides / Piretrinas.
4 Agonistas del receptor nicotínico de la acetilcolina (nAChR)	4A Neonicotinoides. *(4D Flupiradifurona).*
9 Moduladores de los órganos cordotonales	9B Pimetrozina. 9C Flonicamid.
23 Inhibidores de la acetil CoA carboxilasa	Derivados de los ácidos tetrónico y tetrámico
UN Compuestos de modo de acción desconocido o incierto	Azadiractín

(Sustancias en gris entre paréntesis): Aquellas presentadas para su registro en España pero todavía sin autorización de uso concedida.

Basado en póster diseñado por IRAC Sucking Pest WG

Para más información visite la web de IRAC: www.irac-online.org

March 2014, Poster Ver. 9

Fotografías cortesía de USDA y Rothamsted Research

B. tabaci:
action: new poster version, covering all MOAs

The most recent poster is October 2008.
The new version should cover

- all MOAs and may
- possibly incorporate *Trialeurodes vaporarium* as well as *Bemisia tabaci*?

IRM recommendation for HLB-vector control ACP:
action: add IRAC gr. 4D Flupyradiflurone

IRAC
Insecticide Resistance Action Committee

The Asian citrus psyllid, *Diaphorina citri*:
'Insecticide Resistance Management' is the Basis of a Successful IPM Program

www.irac-online.org

Introduction and Biology

The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama (Fig. 1a.), is the insect vector associated with the bacteria *Candidatus* Liberobacter asiaticus and C. L. americanus. These bacteria are suspected to be the causal agents of Huanglongbing (HLB) in Asia and America. Trees infected with the bacterial pathogen begin to show symptoms such as early fruit drop and mottled leaves anywhere from 5 months to 3 years after infection. Even during this asymptomatic period, plants can also be source of inoculum, hence the need to manage the vector even if the trees are not showing symptoms (Fig. 1b). Once the trees are infected, their production rapidly declines rendering the infected trees unproductive in a few years.

Fig. 1: (a.) Adult of *D. citri* feeding on a young orange leave. (b.) HLB-infected trees: asymptomatic (left) and symptomatic (right). Notice fruits on the ground, leaf coloration, and dieback are more prominent on the symptomatic plant.

Citrus psyllids lay their eggs on the inner-side of unfolding leaves which protect the eggs and early nymphs from adequate insecticide contact, rendering applications of non-systemic insecticides inefficient to manage nymphs. Psyllids develop through 5 nymphal instars, taking between 15 and 47 days to become adults, depending on environmental conditions. Nymphs acquire the bacteria, and the adults vector the disease to uninfected plants and to plants that are already infected. Re-infestation increases the bacterial titer in already diseased plants. Adults are considered to be the preferred target for foliar insecticide applications since they vector the bacteria. Systemic soil insecticide target nymphs and adults for the first 2 years after planting, after that period, trees are too big for the current chemistries to be effective.

Resistance to Insecticides

Various levels of insecticide susceptibility have been reported in Florida, USA (Table 1). Although the resistance ratios are not high in comparison to those of other pests, it is important to be vigilant to prevent the onset of resistance for this pest. The results in table 1 are correlated with elevated levels of detoxifying enzymes in both adults and nymphs collected in the field. However, ACP carrying HLB were shown to be more sensitive to insecticides than non-infected psyllids. In Brazil, no tolerance has been reported

Table 1: Highest Resistance Ratio 50 (RR_{50}) values observed on various wild population of *D. citri* in Florida in 2010. (Tiwari et al. 2011)

	imidacloprid	chlorpyrifos	thiamethoxam	malathion	carbaryl	spinetoram
RR50 adults	35X	18X	15X	5X	3X	2X
RR50 nymphs	4X	3X	No tested	No tested	3X	6X

Integrated ACP Management Guidelines

- Protect nursery plants under netting and use only stock that is certified as HLB-free.
- Transport infected nursery stock according to government regulations.
- Protect young and non-bearing trees with rotation of soil applied systemic insecticides (MoA 4 and MoA 28). In older trees, soil applied systemic insecticides may not work.
- Rotate soil-applied insecticides with foliar sprays of other modes of action. Rotation of different modes of action is key to resistance management.
- Management of adults during dormant season is key to maintain low populations for the rest of the year.
- Use locally defined monitoring methods and intervention thresholds to make spray decisions. Notify manufacturers of any product performance failures immediately.
- Use and protection of bio-control agents is encouraged as part of the IPM programs and to reduce the risk of insecticide resistance development.

Management Plan Example

Figure 2: Management plan and opportunities for MoA rotation used for citrus psyllid based on plant phenology. The rotation uses various MoA which are registered and labeled for control of citrus psyllids. The rotations and number of MoA might vary according to the number of products registered in each country.

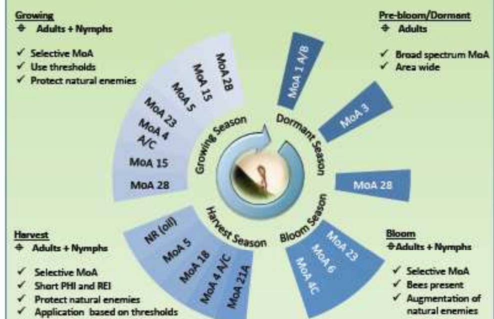


Table2: Modes of action registered for ACP management. Pest and Resistance management should be based on an appropriate rotation of these MoA

Modes of action registered for ACP management			
1 A&B: AChE Inhibitors	4: nAChR agonist	15: Inhibitors of chitin biosynthesis type 0	23: Inhibitor of aCoA carboxylase
2B: GABA antagonists	5: nAChR allosteric activators	18: Ecdysone receptor agonist	28: Ryanodine receptor modulators
3: Sodium Channel modulator	6: Chloride channel activator	21A: Mitochondrial complex 1 electron transport inhib.	NR: Horticultural oils

Relevant Literature

Poltronieri, A.S. 2013. Bases para o manejo da resistência de *Diaphorina citri* (Hemiptera: Liviidae) ao inseticida neonicotinoide imidacloprid em pomares de citros. PhD thesis. Escola Superior de Agricultura Luiz de Queiroz. Universidade de São Paulo. http://www.teses.usp.br/teses/disponiveis/11/11146/tde-16052013-162931/pt-br.php

Rogers, M.E., P.A. Stansly, L.L. Stelinski. 2012. 2012 Florida Citrus Pest Management Guide: Asian Citrus Psyllid and Citrus Leaf Miner . IFAS –University of Florida . ENY-734 . http://edis.ifas.ufl.edu/in686

*Tiwari, S., R.S. Mann, M.E. Rogers, L.L. Stelinski. 2011. Insecticide Resistance in Field Populations of Asian Citrus Psillid in Florida. Pest Management Science 67: 1258-1268

Vanaclocha. P., H. A. Arevalo, A.B. Fraulo, G. Snyder, and P. A. Stansly. 2011. Citrus Greening Bibliographical Database. University of Florida. http://swfrec.ifas.ufl.edu/programs/entomology/hlb_db.php

* Provisional method used by IRAC to evaluate insecticide susceptibility by Asian citrus psyllid

IRM recommendation for HLB-vector control ACP:
action: comparison of methods

<u>Leaf-dip method</u> (expect for IRAC group 23)

- is on the web page
- Validated by BASF (BRA) for Imidacloprid and Thiametoxam (2014)
- but no new data expected to come

<u>Flush tube systemic method</u> (e.g. for IRAC Groups 23 and 28)

- Method description by Juan
- a few changes by Steve (&colleagues) and by Lixin
- not yet final - by when to publish?

<u>Further validation / comparison is needed:</u>

- incl. other MOAs – which?
- who can do by when?

tomato-potato psyllid, *Bactericera cockerelli*:
action: draft method for contact/systemic MOA?

Juan mentioned that we need to find a method for the tomato-potato psyllid, *Bactericera cockerelli.*

Considerations for the use of neonicotinoid pesticides in management of *Bactericera cockerelli* (Šulk) (Hemiptera: Triozidae)

CrossMark

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ABSTRACT

Bactericera cockerelli is a pest on multiple solanaceous crop plants and is the sole vector for the bacteria *Candidatus* Liberibacter psyllaurous. When the pathogen is present, feeding by these psyllids results in 'vein greening' disease in peppers and tomatoes, and "zebra chip" disease in potatoes. Currently, management is based entirely on the application of pesticides, including two neonicotinoid compounds. Populations of *B. cockerelli* collected in southern Texas in 2006 and 2012 were examined for reduced susceptibility and behavioral responses to imidacloprid.

Tests comparing imidacloprid and thiamethoxam demonstrated that both can reduce nymph numbers in the field, but retention and effective periods vary among application methods and compounds. In addition, imidacloprid and thiamethoxam are both sensitive to the amount of water applied during irrigation. Collectedly, these results suggest that imidacloprid is unlikely to be effective in controlling *B. cockerelli* in south Texas. Moreover, its use needs to be carefully considered in other locations even where resistance has not yet been detected. Finally, thiamethoxam may be useful, but careful attention must be paid to irrigation and rainfall level, application method, and timing of application.

Arising sucking pest resistance problems: *Aphis gossypii*

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The mutation in nicotinic acetylcholine receptor β1 subunit may confer resistance to imidacloprid in *Aphis gossypii* (Glover)

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[1] *Department of Plant Protection, Shandong Agricultural University, Taian, Shandong 271018, P.R. China.* [2] *Cotton Research Center, Shandong Academy of Agricultural Sciences, Jinan, Shandong 250100, P.R. China. *e-mail:wky@sdau.edu.cn*

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Abstract

Neonicotinoid insecticides, such as imidacloprid, are selective agonists on the insect nicotinic acetylcholine receptors - their molecular target site, which are used extensively to control a variety of different pest species. Just like other classes of insecticides, resistance to neonicotinoids is a significant threat, which has been identified in several pest species, including the cotton aphid, *Aphis gossypii* (Glover), a major cotton pest in many parts of Asia. A 66.49-fold imidacloprid-resistant *Aphis gossypii* strain was established in our work after selection for 60 generations. Analysis of the cDNA sequence of the nicotinic acetylcholine receptor (nAChR) α1, α2, α3, α4-1,α4-2, β1 subunits and the functional extracellular region (ranging from loop A to the 1st transmembrane domain) of the nicotinic acetylcholine receptor α5 subunit from the resistant strain revealed a single point mutation in the loop D region of the nAChR β1 subunit causing an arginine to threonine substitution (R81T). This mutation has been identified to be a key determinant of neonicotinoid binding to nAChRs and this amino acid change results in reduced sensitivity to neonicotinoids, which confers a vertebrate-like character to the insect nAChRs. This result indicated that in cotton aphids the single mutation (R81T) might confer imidacloprid resistance.

- **Korea – NNI failure reports and** problem is apparently spreading nationwide: Korea publication equivocal. Sampling in 2013 by Bayer, results nya.
- **Japan** – No new reports since 2012. (Miazaki, Southern Kyushu, 3 *Aphis gossypii* populations from Cucumber and Pepper with signifcant **loss of control** to 5 neonicotinoids but less to ACETAMIPRID and THIACLOPRID Dr Matsuura, July 2012.)
- **China** – R81T subsititution (like in Myzus) **produced in the lab** after 60 generations exposure to IMIDACLOPRID in *Aphis gossypii*
- **Spain –** some isolated reports, but nothing confirmed
- **Brazil –** no issues reported, so not on IRAC BR priority list. Mainly use ACETAMIPRID + CARBOSULFAN also in mixtures amogst others
- **USA –** isolated reports from Jeff Gore but no detection of resistance – 8X NNI shift in LA, MS, AR
- **Australia** - Grant Heron – *Aphis gossypii* resistance to NNIs has **not increased in 2011/2012 season.** R-factors below typical R81T levels, no evidence of mutation
  - ➢ **Other reports from countries/companies??**
  - ➢ **Action for 2014** – Monitor NNI performance in all countries. Continue to use bioassays.

IRAC

Insecticide Resistance Action Committee

DRAFT v2 19/2/15

Cotton Aphid

(*Aphis gossypii*)

Introduction

The cotton aphid (*Aphis gossypii*) is a highly polyphagous pest, which has a host range which includes many commercially grown agricultural and horticultural plant species.

Important crops attacked by the cotton aphid include; pepper, tomato, eggplant, watermelon, cucumber, squash, pumpkin, citrus, potato and cotton.

The cotton aphid has a short life cycle (5 days to maturity) and is highly fecund, producing around 3 offspring per day. It feeds by inserting its stylet into the plant phloem tissue and damage is caused by either direct sap loss, transmission of a wide range of plant viruses and by encouraging the growth of sooty moulds on the honeydew secretions it produces.

Treatment with insecticides has been the primary control option for growers, with systemic or vapour active insecticides often more favoured. Biological control agents are also an important control method for this pest.

Resistance Mechanisms

Table 2: List of documented *Aphis gossypii* resistance mechanisms for key insecticides.
(Individually resistant aphids may express single or multiple mechanisms of resistance to one or more insecticide groups. Where resistance is known to be restricted to a particular insecticides or chemistry sub-groups this is highlighted).

IRAC Mode of action group	Mode of Action
Group 1: Acetylcholinesterase inhibitors	S431F mutation in *p-ace gene* (pirimicarb, triazamate & omethoate)
	A302S mutation in *p-ace gene*
	F139L mutation in o-ace gene (Organophosphate)
	Elevated levels of an undefined carboxylesterase
	Elevated levels of an undefined P450 monoxygenase
Group 2: GABA gated chloride channel agonists	Elevated levels of an undefined P450 monoxygenase
Group 3: Sodium channel modulators	L1014F mutation in domain II of the *para*-type voltage gated sodium channel gene
	Elevated levels of an undefined carboxylesterase
	Elevated levels of an undefined P450 monoxygenase
Group 4: Nicotinic acetylcholine receptor agonists	R81T mutation in the Beta-1 sub-unit of the nACh receptor
	Elevated levels of undefined carboxylesterase

Target site resistance mechanism

Metabolic based resistance mechanism

Resistance Status

Insecticide Resistance has been recorded in cotton aphids since the mid-1960's, when organophosphate, carbamate and cyclodiene organochlorines were utilised to control this aphid in a wide range of crops.

Resistance to carbamates and organophosphates have been widely reported in many of the key crops globally and therefore the performance of Group 1 insecticides can not be assured for the control of this pest. As a result, the use of Group 1 insecticides should only be considered if aphid sensitivity has been confirmed.

Resistance to pyrethroids (Group 3) and organochlorine cyclodiene (Group 2) insecticides has also been reported in a number of countries and crops and although their perfomance can not be assured they may still provide a useful tool in pest management. It is recommended that insecticide applicators monitor the performance of these products and consult with local crop advisors on their use for cotton aphid control.

There have been a small number of reports of resistance to nicotinic acetylcholine receptor agonist insecticides (group 4) in cotton (e.g. Australia, China & USA) and cucurbits & vegetables (e.g. Japan & Korea). In regions where group 4 insecticide resistance has been reported then other control options not affected by resistance should be given priority in aphid control programs.

Resistance to flonicamid has only been reported in *Aphis gossypii* samples collected from peppers in Korea and resistance in other regions is not known.

Table 1: Insecticide modes of action which are registered for the control of aphids and known resistance.
(Not all insecticides groups will be registered for use in all regions and crops. Consult with local advisors on product availability)

IRAC Mode of action group	Mode of Action	Insecticide Chemistry	*Known resistance*
Group 1: Acetylcholinesterase inhibitors	1A	Carbamates	XXX
	1B	Organophosphates	XXX
Group 2: GABA gated chloride channel agonists	2A	Cyclodiene organochlorines	XX
	2B	Phenylpyrazoles (Fiproles)	
Group 3: Sodium channel modulators	3A	Pyrethroids	XX
Group 4: Nicotinic acetylcholine receptor agonists	4A	Neonicotinoids	X
	4C	Sulfoxaflor	(x)
	4D	Flupyridifurone	
Group 9: Modulators of chlordotonal organs	9B	Pymetrozine	
	9C	Flonicamid	(x)
Group 12: Inhibitors of ATP synthase	12A	Diafenthiuron	
Group 19: Octopamine agonists	19	Amitraz	
Group 25: Inhibitors of acetyl CoA carboxylase	23	Tetronic & Tetramic acid derivatives	
Group 28: Ryanodine receptor modulators	28	Diamides	

XXX = widespread reports of resistance, XX = resistance reported in several locations, X = isolated instances of resistance, (x) = rare cases of resistance reported.

The information presented in this table is based on peer-reviewed published reports of field collected populations of *Aphis gossypii* being isolated at a specific time and location before being tested for insecticide susceptibility. Insecticide resistance is a dynamic process, and therefore, the information provided does not reflect the current status of insecticide resistance in all countries or locations.

Resistance Management

As there is little or no evidence of cross-resistance amongst the groups insecticides used for cotton aphid control, it is recommended that the rotation of effective insecticides with different modes of action are used to provide insect control, whilst at the same time reducing the risk of insecticide resistance from developing. The following should be considered when designing an insect control program for cotton aphid:

- Plan ahead. Determine when in a typical season insecticides applications are likely to be needed and plan for the rotation of insecticides with different modes of action, avoiding the consecutive use of products belonging to the same mode of action group (including seed treatments). Plan for contingencies in case extra applications are needed due to untypical pest infestations. Consider the presence of other insect pests that may occur in the crop and require insecticide treatments.
- Determine which insecticides are most effective for controlling each pest during each application timing. If the presence of other pests which over-lap with cotton aphid, consider using pest specific insecticides rather than broad spectrum insecticides, which may increase unnecessary resistance selection pressure for either or both pests.
- Evaluate the current insecticide resistance situation in the area (consult local crop advisors and experts). Avoid using insecticides already affected by resistance where possible.
- Consider the impact of the insecticides on non-target insects and natural predators, especially during early season applications, where maintaining natural predators can reduce the need for later sprays.
- Consider the use of insect-resistant plant varieties and the use of biological control agents.
- Always follow insecticide label instructions for application timings, volumes and concentrations.

Susceptibility Monitoring

The susceptibility of the cotton aphid and other aphid species can be conducted by using leaf dip assays, as described in the IRAC approved method No. 019.

Further details on this methodology and other susceptibility monitoring methods can be found on the IRAC website: www.irac-online.org

Poster designed and produced by the IRAC Sucking Pest WG, January 2015 Photograph courtesy of Syngenta Crop Protection. IRAC document protected by © Copyright. Further details may be found at www.irac-online.org

CropLife INTERNATIONAL

Aphis gossypii, Korea:
action: reviving & extending the local activities

Next steps:

Focus on a most critical crop to develop IRM recommendations (cucurbits/peppers) and ask them directly for the information that is needed, e.g.:

Annual cropping cycle information (duration of crop from seedling transplant to harvest/crop removal), parallel or sequential planting.

Aphis pest timings (when aphids are normally present in the crop) and of other pest timings.

Available pest control options based on modes of action & any restrictions based on those.

Biological & cultural control methods.

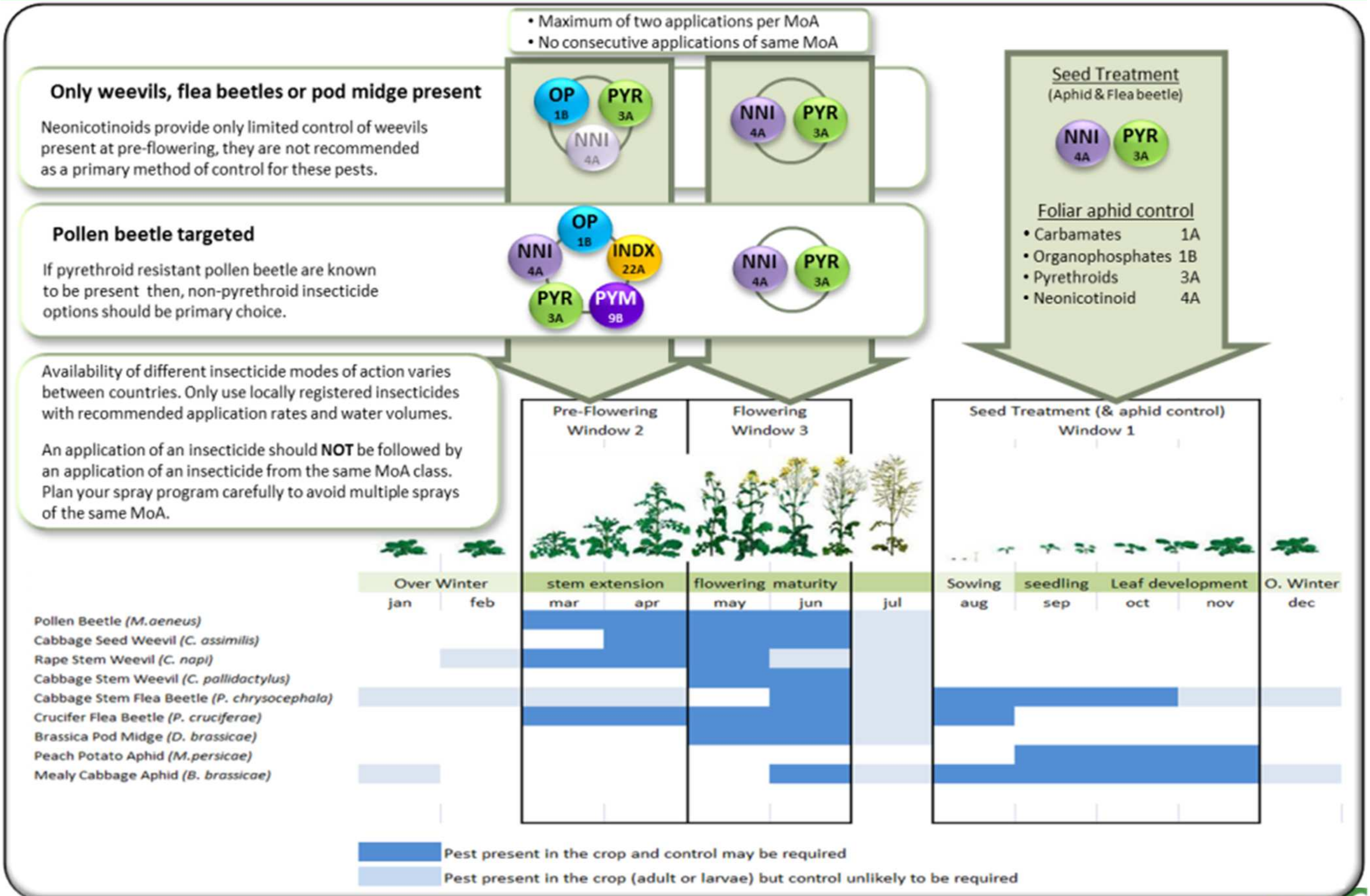
With this information, we may produce an IRM draft ourselves and then ask the Korean colleagues to challenge it.

Subsequently, a 2-step approach for further meetings is probably recommendable:

1st smaller group tel con (agrochemical companies), 2nd adding large distributors and research institutes (probably in Korean language)

Aphis gossypii, Korea:

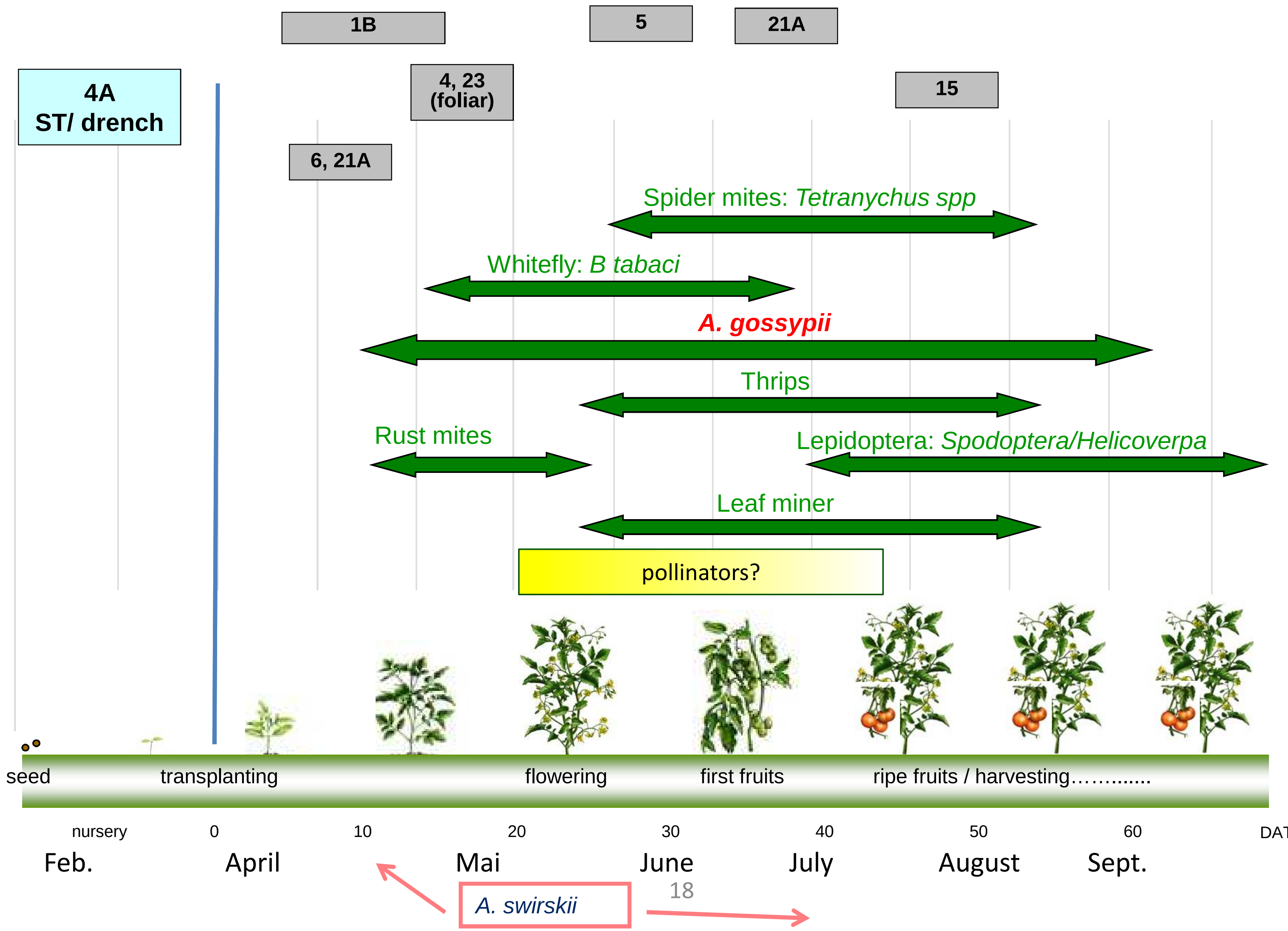
action: suggest a spray prg. / window approach…



IRAC

Aphis gossypii, Korea:

action: challenge local team for completeness of spray prg.



PYR-resistance Sitobium avenae in UK country information spread to region

2013: Cereal, UK, *Sitobium avenae*
IRM recommendations by IRAG UK (issued 2012)

Sitobion avenae (grain aphid)
Key pest in both summer and autumn when virus transmission is significant

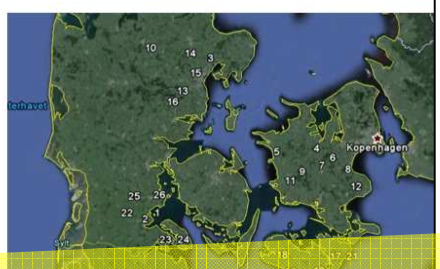
Integrated management of BYDV

- Seed treatments with neonicotinoids (2013 : EU Commission restricton: winter seeded cereal use only)
- Grass weed and cereal volunteer control
- Avoid early sowing in September
- Monitor aphids flying into cereal crops in Autumn
- Effective timing of foliar insecticide applications
- Use full rates of insecticides
- Control failures: send aphid samples to Rothamsted/Dewar CP
- If pyrethroid control was poor, then switch to other mode of action
- Alternatives registered in Autumn include pirimicarb (1A) and chlorpyrifos (1B)

Acknowledgements to
Dr B. Parker and IRAG UK

2013: Cereal, *Sitobium avenae* pyrethroid resistance monitoring – new results from Denmark

- 26 populations across Denmark for tested for kdr mutation (L1014F)
- The results demonstrate that no individuals carried the mutation.
- Thus, it appears that target-site resistance (kdr) to pyrethroids hasn't spread to Denmark yet.



Acknowledgements to: F. Abt, E. Daum, and J. ... Syngenta Crop Protection Switzerland

IRAC
Insecticide Resistance Action Committee
www.irac-online.org

Pyrethroid resistant grain aphids – a challenge for cereal growers in Northern Europe.

Recent surveys of the grain aphid (*Sitobion avenae*) in the United Kingdom and Ireland have revealed the presence of pyrethroid resistant aphids. If they spread, these resistant aphids could present a new challenge to cereal growers in other parts of Europe.

The grain aphids have been identified as being resistant by an adaption of the sodium channel, which forms part of nervous system in insects and is the site of action of the pyrethroid insecticides. This modification at the target site of pyrethroids is known as the L1014F *kdr* mutation. The mutation is well known in other agricultural and public health pests such as the green peach aphid (*Myzus persicae*) and house fly (*Musca domestica*). What is different to other species is that in this case all the aphids have been found to be heterozygous (single copy) for the resistance allele.

Although the aphids have been demonstrated as having only a relatively low level of resistance to pyrethroid insecticides (up to 40 times less susceptible than insects without the mutation) this shift in sensitivity has been shown to reduce the performance of pyrethroid sprays when the percentage of resistant aphids reach high enough levels. Since their first detection in 2011, resistant aphids have been identified in several English and Irish counties, but the frequency of resistant individuals has not been high enough to cause problems everywhere. Control problems have mainly been focused around Suffolk, Norfolk and Cambridgeshire. Surveys in other European countries have shown that resistant aphids are much rarer in mainland Europe, with only a small number of resistant grain aphids found in parts of Germany and none found in limited surveys of France and Denmark.

The grain aphid is only one of the key species of aphid considered to be pests of cereal crops in Europe. There is currently no indication of pyrethroid resistance in the other species, which include the bird-cherry oat aphid (*Rhopalosiphum padi*), the rose-grain aphid (*Metopolophium dirhodum*) and further eastwards in Europe, the Russian wheat aphid, (*Diuraphis noxia*) and the Spring green aphid (*Schizaphis graminum*).

The resistant grain aphids currently present a challenge to farmers in the UK and Ireland and the concern is that the problem may spread to other areas of Europe. At present, there are few registered insecticides with different modes of action available to farmers (seed treatment or foliar applications) for the control of cereal aphids. This makes it difficult to rotate insecticides with different modes of action, which is the most commonly recommended form of resistance and pest management. In the UK the only other foliar applied insecticides apart from the pyrethroids are organophosphates and carbamates which share the same mode of action (IRAC Group 1). In other countries other insecticide modes of action such as chlordotonal organ modulators (IRAC Group 9) and nicotinic acetylcholine receptor agonists (IRAC Group 4) are available. The situation might get more difficult, if further uses are restricted or insecticides are banned from the market.

If you observe the reduced performance of pyrethroid insecticides against cereal aphids in your region, please work with either your local plant protection organization or pyrethroid manufacturer to determine whether resistance is the cause of the problem and encourage them to report their findings to IRAC.

Resistance management advice for the UK provided by the Insecticide Resistance Action Group (IRAG) can be found at: www.pesticides.gov.uk/Resources/CRD/Migrated-Resources/Documents/I/IRAG_Grain_Aphid_Guidance_Sept_2012.pdf, whilst more details on the mechanisms of resistance can be found in: Foster *et al.* A mutation (L1014F) in the voltage-gated sodium channel of the grain aphid, *Sitobion avenae*, is associated with resistance to pyrethroid insecticides. Pest Management Science (2013) DOI 10.1002/ps.3683.

Russel (Michael):

- started on the cereals recommendations
- sent it to European colleagues to check the biology.
- its progressing and I will work a bit more on it after the Resistance 2015 conference.

IRAC

Olive Fruit Fly:
action: set up a core team

Generally, SP WG participants showed interest to cover and work on specific dipteran topics in our meetings on an ad-hoc basis.

- Should other individuals e.g. of Lep.-WG be included as well?

Next steps might follow, e.g.:
1. Summarize current resistance situations vs. PYR
2. Exchange about methodology
3. Pro-actively release IRAC recommendations, highlight value of current options / prevent use restrictions.

Stinkbug – PYR resistance in South Africa: action: finalize contract

Research efforts for two-spotted stinkbug *Bathycoelia distincta* in macadamia (suspected PYR-resistance) are funded by IRAC in 2015:
Discussions are going on about the actual project definition and design of the contract with IRAC.

- The research is performed by Gerhard Nortje
- Jan Van Vuuren is the contact partner for IRAC-SP WG.

IRAC INDIA:
action: kick-off for sucking pests topics?

IRAC INDIA (Nigel Godel, Lepidopteran Working Woup):

- they are resuming activity
- on September 10th: hold a face to face at the Bayer office in Mumbai
- Nigel provided already:
  - Latest revised Guideline decided by IRAC Global for the countries
  - Latest update on global activities which can be shared with group.
  - Guidance us on the objectives and expectation of global IRAC team from India
- Nigel will send further material next months, incl. 2014 Lep. group summary, which contains the overview of activities, 2015-16 smart objectives and challenges

➔ **Is there any other specific guidance from <u>Sucking Pest working group</u> and encouragement we can provide to the new IRAC India team?**

Insecticide Resistance Action Committee

Thanks to the IRAC SPWG team and external consultants for their support to manage global Sucking Pest Resistance!