Insecticide Resistance Action Committee

Sucking Pest WG

Michael Klueken & colleagues,
50th IRAC International Meeting,
Dublin April 5-8th, 2016

CropLife

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"
….

- **All IRAC meetings are held under anti-trust rules** and regulations.
- Regulations are developed under **guidance from CropLife** International
- All discussions should be **technical discussions and NOT commercial**.
- **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 colleagues or CropLife International.
- A **copy of the anti-trust guidelines** is typically provided before each meeting/conference call.

Objective of the meeting

50th IRAC International Meeting, Dublin April 5-8th, 2016

This was to make sure that IRAC members were aware of the past years activities early in the meeting and then be inspired to propose new impactful activities and projects for the coming year. The same format will be followed in 2016, but we have attempted to shorten the time reflecting on past activities and focus on planning for the year ahead.
what they would like to achieve as members of IRAC. What activities do they feel would be a benefit for the company and for global pest management.

1. **The development and communication of practical IRM guidelines**. We have made great progress in this area over the last few years and I understand that **IRAC's efforts to provide practical advice** have been appreciated by many who have in the past challenged IRAC's effectiveness. However, there are many agricultural, horticultural and urban environments which are challenged by insecticide resistance issues and many where our guidance would be valuable.

2. **Effective promotion of insecticide resistance management to growers and grower advisors**. Much of the criticism of IRAC in the past has been that its outputs have been technical in nature and focused away from growers/pesticide applicators. We have made **significant efforts to provide more grower centric materials** and I encourage you to continue in this trend.

IRAC

content

10:00-10:30:

- Welcome, introduction, reminder of antitrust guidelines and Minutes of last tel con
- Team structure 2016, selection of new team leader, scheduling tel cons in 2016
- *Sitobion avenae* – Pyrethroid resistance in EU
- Olive Fly resistance to pyrethroids suspected in Greece, further fruit fly species

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- Objectives 2016
- any other business; spider mites?, Lygus?, rice plant hoppers?

IRAC-Sucking Pest WG Team structure – 2015

- ADAMA representative: Tamar Danon replaced by Diane Reynolds
- BASF representative: Lixin Mao
- NUFARM representative: Marie-Pierre Plancke replaced by Brian Duggan
- SYNGENTA: Steve Skillman stepped out, remaining representative Russell Slater

Team structure as of March, 2016:

Names	Email Address	Company	Sucking Pests
Alan Porter	aporter.apa@gmail.com	IRAC	✓
Brian Duggan	brian.duggan@au.nufarm.com	Nufarm	✓
Diane Silcox Reynolds	diane.reynolds@us.adama.com	ADAMA	✓
Eric Andersen	Eric.Andersen@cheminova.com	FMC	✓
Imre Mezei	imezei@dow.com	Dow	✓
Juan M Alvarez	Juan.M.Alvarez@dupont.com	DuPont	✓
Lixin Mao	lixin.mao@basf.com	BASF	✓
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Luis Pavan	lapavan@dow.com	Dow	✓
Michael Klueken	michael.klueken@bayer.com	Bayer	①
Ralf Nauen	ralf.nauen@bayer.com	Bayer	✓
Russell Slater	russell.slater@syngenta.com	Syngenta	✓
		Total no of members = 63 + 6 guests/observers	12

SP WG Activities: 2014 – 2016

Date	No. of participants	Meeting structure
17.-20.03.2014	10	F2F in RTP, USA
22.07.2014	8	Conference call
09.09.2014	9	Conference call
27.10.2014	10	Conference call
17.12.2014	7	Conference call
19.02.2015	10	Conference call
14.04.2015	9	Conference call
09.07.2015	10	Conference call
14.-17.09.2015	8 + 2	F2F Rothamsted, UK
25.11.2015	8	Conference call
23.03.2016	8	Conference call
07.04.2016	8 + 2 (?)	F2F Dublin, IRL

Participation had been very constant for the past years, with active contribution from eight companies:

- ADAMA, BASF, Bayer, Cheminova, Dow, DuPont, Nufarm, Syngenta.

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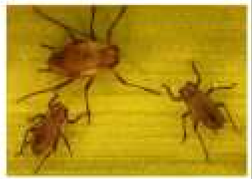
***Sitobion avenae*:**
alert is available in 3 languages in EU

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

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)

Sitobion avenae (grain aphid)



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.

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Insecticide Resistance Action Committee
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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.

... Group (IRAG) can be found at: ... Grain_Aphid_Guidance_Sept_2012.pdf, ... 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 (...) DOI 10.1002/ps.3683.

Russell & Michael:

- Renewal and release of further warnings for Mainland EU seem appropriate: as new results were reported at two different monitoring sites in lower Saxony (GER) with homozygote aphid found (more details to come).
- Include the Management plan example on the back side of a new alert version.

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Sitobion avenae in EU:

action: include management example in renewed alert

Timings would be different across EU (north – south, east- west) & best management is related to monitoring of pest & pest timings, and products.

Next steps:

1. Merge both documents and
2. Russell to present the draft to IRAC executive team


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

		SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
		WINDOW 1								WINDOW 2			
Crop & Pest Timings	WINTER CEREALS				OVERWINTERING								
	SPRING SOWN CEREALS												
	Rhopalosiphum padi												
	Sitobion aveane												
	Metopolophium dirhodum												
	Oulema melanopus												
	Zabrus tenbrioides												
	Cicadellidae**												
	Virus transmission***												
Insecticide options (Not all options available in all countries)	Seed/Soil applied INS.:	OP & Carbamates, **Group 1** NAChR agonists, **Group 4**											
	Foliar applied INS.:	Pyrethroids, **Group 3**								OP & Carbamates, **Group 1** Pyrethroids, **Group 3** NAChR agonists, **Group 4** Flonicamid, **Group 29** See note 1			
IRM recommendations		If a foliar pyrethroid was used during the previous summer for the control of aphids, avoid using a foliar pyrethroid again in the autumn if possible. If pyrethroid resistant grain aphids (*S.avenae*) are known to be present at the location, the use of pyrethroid insecticides is not recommended (Group 3).								If more than one insecticide application is required, do not use the same mode of action consecutively. If leaf beetles are a common occurance in your region, then it is recommended to reserve pyrethroid treatments for controlling this pest and use alternate modes of action for controlling aphids. If pyrethroid resistant grain aphids (S.avenae) are known to be present at the location, the use of pyrethroid insecticides is not recommended (Group 3).			manage volunteer cereals (e.g. plowing, herbicides application) to break the "green bridge" between summer cereals and new sowings in autumn
Pest management examples (Examples presented are only to demonstrate IRM principles are other options are available)	Example 1	Group 4 Seed Treatment								Group 3 foliar			
	Example 2		Group 3 foliar							Group 4 foliar	Group 29 foliar		
	Example 3	Group 4 Seed Treatment		Group 3 foliar						Group 1 foliar		Group 29 foliar	
	Example 4	Group 1 Seed Treatment								Group 3 foliar		Group 4 foliar	

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Olive Fruit Fly: What's up in fruit flies?

<u>Update from Eric & colleagues:</u>

<u>From Spain I have the following information from my Spanish colleague:</u>
In Spain there is no official body monitoring resistance in *Dacus oleae*. The source of this information are organizations such as CSIC and UPCT who are working in general with resistance against insects on different crops.

<u>From Italy I have the following information from my Italian colleague:</u>
In Italy there are no reports of resistance in *Dacus oleae* towards pyrethroids. In Italy there is a very limited use of pyrethroids in olive.

<u>Source :</u>
ANTONIO GUARIO Puglia Region
NICOLA MORI Padova University

In Italy there are no reports/studies of monitoring of resistance of *Dacus oleae* populations towards Dimethoate.

Review

Insecticide resistance in Tephritid flies

John Vontas [a,*], Pedro Hernández-Crespo [b], John T. Margaritopoulos [c], Félix Ortego [b], Hai-Tung Feng [d], Kostas D. Mathiopoulos [c], Ju-Chun Hsu [e,*]

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ABSTRACT

Tephritid flies attack a large variety of fruits, which constitute highly-priced commodities in many coun tries. Insecticides have been used extensively for their control.
Although resistance development in fruit flies has not kept pace with that in other insects, possibly du to their high mobility and tendency for wide spatial dispersal, recent studies have indicated that selectio pressure has now reached the point where resistance is detectable in the field and control may therefor become problematic. The status of resistance to the commonly used insecticides in the most significan Tephritid pests, such as the Mediterranean fruit fly *Ceratitis capitata*, the oriental fruit fly *Bactrocera dor salis*, the olive fly *Bactrocera oleae* and the melon fly *Bactrocera cucurbitae*, is reviewed. Emphasis has bee placed on the resistance mechanisms that have been elucidated at the biochemical and molecular level Prospects for using this knowledge alongside genomic information in Tephritidae to develop novel strat egies of potential practical importance for resistance management are discussed.

27 April, 2016

IRAC

Olive Fruit Fly:
action: set up a core team & summarize current situation?

- Generally, SP WG participants showed interest to cover and work on specific dipteran topics in our meetings on an ad-hoc basis.
- Luis G. and Eric set-up a core team, incl. participants of other working groups e.g. Sucking Pest WG, Lepidopteran WG, Method WG.
- Focus area will be most probably Southern EU:
  - incl. e.g. POR, ITA, ESP, GRC.
  - But Olive fruit fly is present from California, USA to Baja California, Mexico, too. In the US, Luis & colleagues have not heard about resistance problems, yet. They are usually lower intensity crops, so not so many applications are made.

Next steps :

1. Summarize current resistance situations vs. PYR
2. Exchange on methodology
3. Pro-actively release IRAC-recommendations, to highlight the value of current options / prevent use restrictions in EU.

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Myzus persicae (2014):

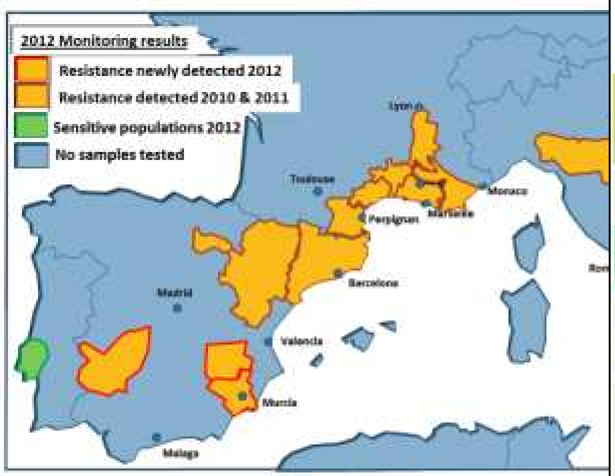
Neonicotinoid resistance management guidelines for Stone Fruits

IRAC IRM Guideline 2014 Page 1 Final 12th Feb 2014

Myzus persicae neonicotinoid resistance management guidelines for Stone Fruits in Southern Europe, IRAC SPWG, 2014

This is an update of the resistance alert and management recommendations issued in January 2013 by the IRAC Sucking Pest Working Group. It concerns specifically the appearance of neonicotinoid resistance in green peach aphid (*Myzus persicae*) in the peach orchards of southern France and north-eastern Spain and Northern Italy in 2010. The resistance is based on a target-site mutation which strongly affects neonicotinoid efficacy[1,2]. The results of surveys from 2010 to 2012 confirmed the spread and presence of neonicotinoid-resistant aphids in many of the stone fruit orchards of southern France, Spain and Italy [1-4].

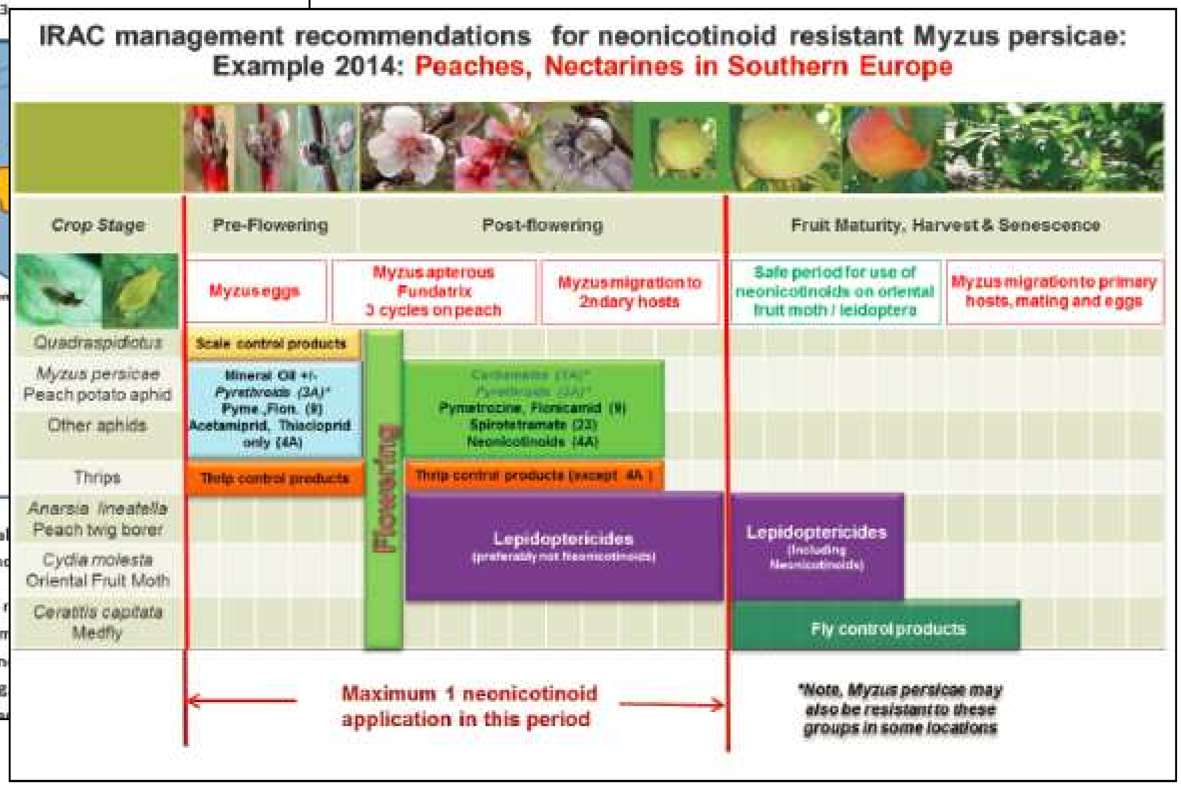
Map of the region showing areas where target site resistance to neonicotinoids was detected in *Myzus persicae* collected from stone fruit orchards from 2010 to 2012. No reports from new regions have been received to date in 2013



IRAC have worked with local agricultural ministry officials, and entomological
the UK, to provide the following advice for the 2014 season in stone fruits, no

Where no loss of performance to neonicotinoids has been experienced, it is r
one neonicotinoid application per crop cycle against *Myzus persicae* to minin
intensification of the resistance and maintain effectiveness of the neonicotin
and local guidelines, this single spray may be pre-flowering or post-flowering

- Guideline well perceived at IRAC level
- SP WG agreed to
  - update the guidelines for new cases
  - continuously monitor populations on primary and secondary hosts



M. persicae – new 2015 data coming-in

action: report results in more detail

- **Imre** reported about 12 samples collected from stone fruit sites in ESP, FRA, ITA, and 1 from BEL-vegetables (see table): no resistance was found.

- **Ralf** reported about last year samples obtained from more than 100 sugarbeet sites in Belgium/Netherlands, assessing for several mutations, e.g. L1014F, M918L/T, R81T and S431F. Ralf is going to compile all data and will share within the team.

- Monitoring activities in France are supported by officials: e.g. ANSES is studying NNI resistance in oil seed rape (contact is through **Gerard Huart**, ADAMA France).

COUNTRY	LOCATION	PRO-VINCE	MpB1F1S/ MpB1TMR	MpB1F1R/ MpB1TMR
2015			amplifies wild type	amplifies mutation
Spain	Seros		+	+
Spain	Flix	Tarra-gona	+	-
France	Loriol		+	+
Spain	Alguerri	LLEIDA	+	+
Spain	Albesa	LLEIDA	+	-
Spain	Bell-lloc dÚrgell	LLEIDA	+	+
Italy	Querceto		+	+
Italy	Querceto		-	+
Italy	Capannaguzzu		+	-
Spain	Rincón de Soto	La Rioja	+	-
Spain	Rincón de Soto	La Rioja	+	-
France	Anadiag		+	-
Belgium	vegetables		+	-

- **Luis Pavan** reported from Brazil, that the Group 4 insecticide resistance of *M. persicae/nicotianae* in tobacco is not a very important problem, yet. But he supports general monitoring efforts and he will further check details of ongoing activities.

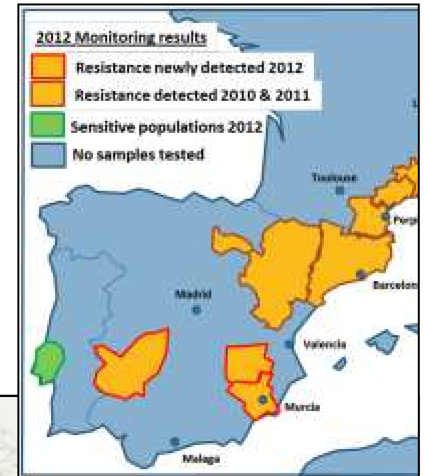
- **Russell** reported about Italian samples around peach sites, where R81T in some homo.-/ heterocygotes where found.

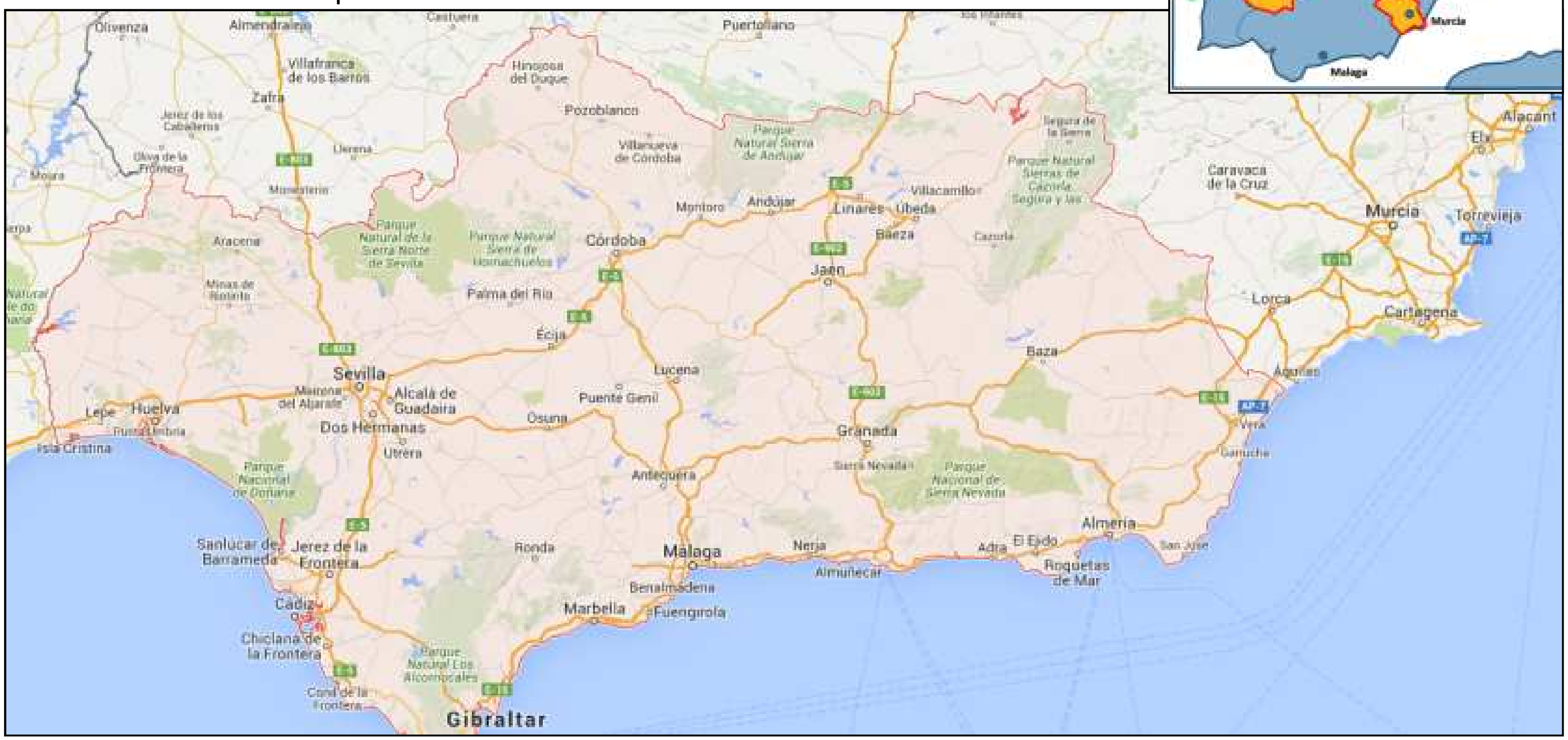
M. persicae – new res. case in west Andalusia:
action: report results in more detail

Russell reported on pepper and eggplant (grown under plastic in west Andalusia), which have a percentage of the population carrying either the heterozygous or homozygous form of the R81T resistance mutations.

- R-strains 'jump' from Peach to secondary host is one of the main worry - But until now no **any record or positive sample has been communicate**.
- Not so worried for the special site, lower intense vegetable production (vs. Murcia),
- They grow early varieties of peach / nectarines flowering in February (no winter at all)
- Could be a small local spot? According to BCS data: not yet spread Andalusia-wide

➔ Russell will further assess and report back to team.





27 April, 2016

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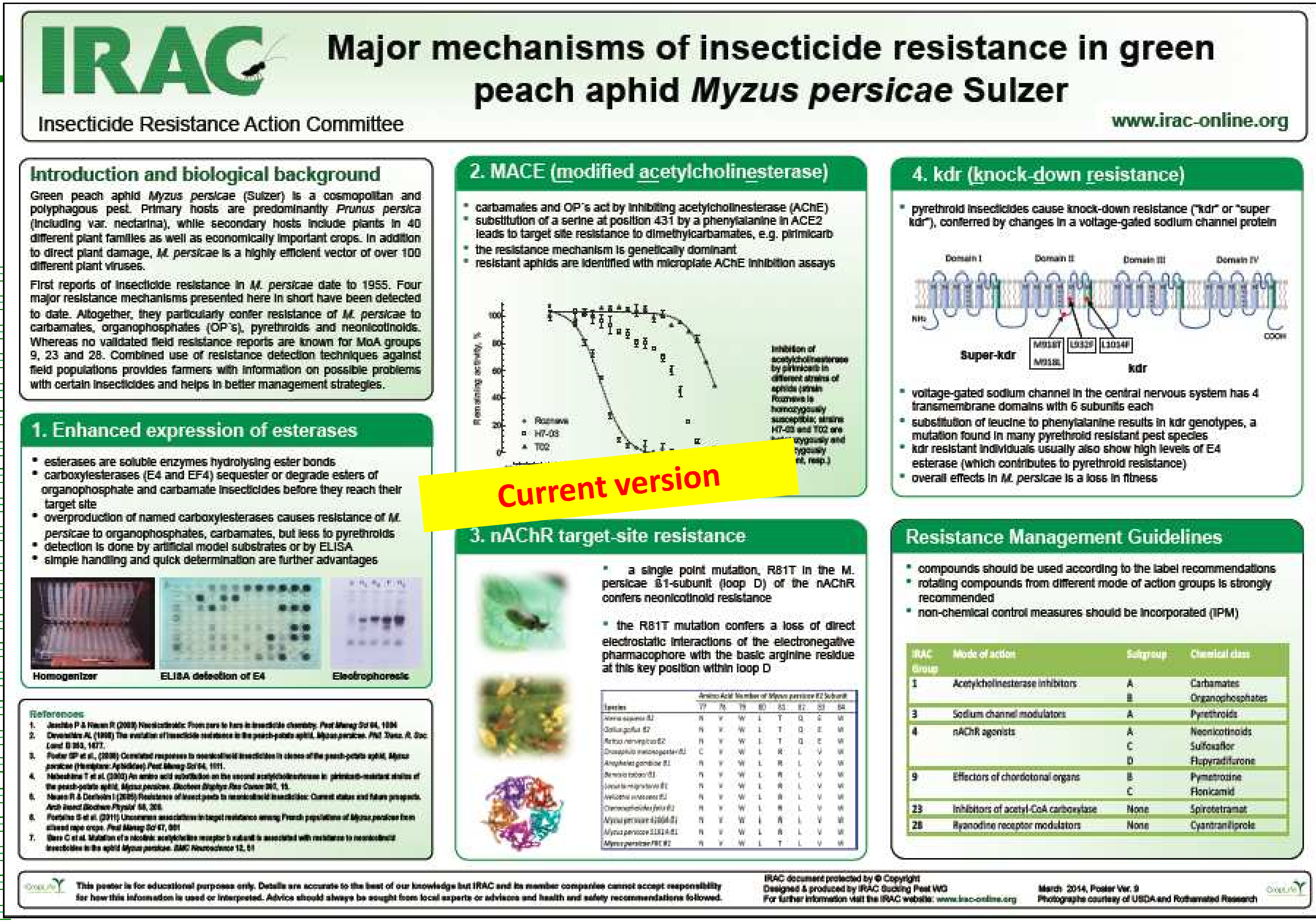
M. persicae – new res. case in west Andalusia: action: intensify monitoring

Action:

- José María López (sucking pests coordinator in IRAC-ESP) will collect samples of aphids in peppers of Murcia, which is adjacent to areas of peach during the months from Feb to April. They try to collect enough of this and some other sites.

- Intensify communication with local company representatives:
  - to better understand results and resistance details
  - to better understand growing conditions in (western) Andalusia
  - to coordinate monitoring efforts in Andalusia
  - to pre-discuss a IRAC advice (needs to be reviewed locally)

M. persicae – current poster version 2014



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Insecticide Resistance Action Committee

Major mechanisms of insecticide resistance in green peach aphid, *Myzus persicae* (Sulzer)

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Introduction and biological background

Green peach aphid *Myzus persicae* (Sulzer) is a cosmopolitan and polyphagous pest. Primary hosts are predominantly *Prunus persicae* (including var. nectarina), while secondary hosts include plants in 40 different plant families as well as economically important crops. In addition to direct plant damage, *M. persicae* is a highly efficient vector of over 100 different plant viruses.
First reports of insecticide resistance in M. persicae date to 1955. Five major resistance mechanisms presented here in short have been detected to date. Altogether, they particularly confer resistance of *M. persicae* to carbamates, organophosphates (OP´s), pyrethroids and neonicotinoids. Whereas no validated field resistance reports are known for the other MoA groups. Having a good knowledge of resistance mechanisms, that affect each insecticides group, and the cross-resistance pattern helps in better management strategies.

1. Enhanced expression of esterases

- Resistance type: **Metabolic.**
- Concerned group: **Carbamates**, **OP's** and less to **pyrethroids**.
- The esterases are soluble enzymes hydrolysing ester bonds.
- The overproduction of carboxylesterases (E4 and EF4) by *M. persicae* causes resistance to named insecticides, whose ester bonds are sequestered or degraded before reaching its target site.

2. Enhanced expression of P450 monooxygenases

- Resistance type: **Metabolic.**
- Concerned group: ~~**Neonicotinoids**~~ **nAChR agonists** (NNI).
- The P450 monooxygenases are a diverse class of enzymes with many functions, ranging from biosynthesis to xenobiotics metabolism.
- The enhanced expression of P450 CYP6CY3 monooxygenase by *M. persicae* causes reduced susceptibility to these insecticides.
- The *M. persicae* populations that contain both high level of the P450 enzyme and the modification of the nicotinic acetylcholine receptor (nAChR) (see mechanism 4) show high resistance to neonicotinoids.
- over-expression of CYP6CY3 alone has little or no impact on neonicotinoid activity under field conditions (Steve Foster)

Ralf There is definitely no evidence published yet that members outside Groups 4A and 4B are affected by CYP6CY3 over-expression. It is a very strong resistance mechanism against nicotine, and tested neonicotinoids are much less affected. However, it is not enough to impair field efficacy at recommended label rates, lack of any field relevance of CYP6CY3 in the absence of R81T was the reason why it was not included in the previous version of the poster

References

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.

3. MACE (modified acetylcholinesterase)

- Resistance type: **Target site**.
- Concerned group: **Carbamates** (dimethyl-carbamates).
- Under normal conditions, the acetylcholinesterase (ACE) degrades acetylcholine to the proper functioning of the nervous system of *M. persicae*.
- Carbamates and OP´s act by inhibiting ACE action, which causes a nervous overexcitation, resulting in aphid death.
- The ACE modification, by substitution of a serine at position 431 by a phenylalanine, causes that the dimethylcarbamates, e.g. pirimicarb, triazamate (still used?) and organophosphates, e.g. dimethoate, can not inhibit the ACE, which confers resistance to these carbamates.

4. nAChR target-site resistance

- Resistance type: **Target site**.
- Concerned group: **nAChR agonists** ~~**Neonicotinoids** (NNI)~~.
- Under normal conditions, the acetylcholine binds to nAChR for normal transmission of nerve impulse.
- ~~NNIs~~ **nAChR agonists**bind to nAChR instead of acetylcholine, causing a continuous stimulation and subsequent insect death.
- The modification of the nAChR structure (by R81T mutation in the *M. persicae* ß1 subunit of loop D), causes the**nAChR agonists** ~~NNIs~~ can not bind, so the aphid nervous system can work perfectly.
- The *M. persicae* populations that contain both this nAChR mutation and enhanced expression of P450 enzyme (see mechanism 2) show high resistance to **nAChR agonists** ~~neonicotinoids~~. Imre: *better NNIs as concerned group than the whole Group 4 as so far only NNIs are known to be affected. It can be mentioned in the text that there is a variability within the group.* Ralf: all Gr.4 are affected by R81T ß1

5. kdr (knock-down resistance)

- Resistance type: **Target site**.
- Concerned group: **Pyrethroids**.
- Under normal conditions, the sodium channels regulate the Na+ ions entry and exit of axons, process involved in nerve transmission.
- Pyrethroids bind to sodium channels, causing them to remain open, resulting in a nervous overstimulation and aphid death.
- Different mutations (kdr or super kdr) in the sodium channel gene confer resistance to pyrethroids in *M. persicae* populations.
- kdr resistant individuals usually also show high levels of E4 esterase (see mechanism 1), which contributes to pyrethroid resistance.

Resistance Management Guidelines

- Rotating compounds from different mode of action groups is strongly recommended.*
- No using the same mode of action more than once per crop cycle (agreed with IRAC Spain?) (alternatively, not repeat in successive applications) is recommended.
- ~~If a significant decrease in control levels of *M. persicae* is observed, it is recommended to stop using insecticides of this mode of action.~~ If resistance to a group of insecticides is known to be present in the area of application then the further use of this insecticide group is not recommended until a return to susceptibility can be demonstrated (or something similar).
- In pre-flowering applications on fruit trees, the use of oil alone or mixed with aphicides is recommended.**
- Use only authorized products according to the label recommendations and limitations.

* *M. persicae* can be resistant to some insecticides in certain zones. Consult a local agricultural advisor.
**Check the availability of registration.

Modes of Action (MoA) authorized in Spain against *M. persicae* (November

Main Group/ Primary Site of Action	Chemical Sub-group or exemplifying Active Ingredient
1 Acetylcholinesterase (AChE) inhibitors.	1A Carbamates. 1B Organophosphates.
3 Sodium channel modulators.	3A Pyrethroids / Pyrethrins.
4 Nicotinic acetylcholine receptor (nAChR) competitive modulators.	4A Neonicotinoids. 4D Butenolides ~~(Flupyradifurone)~~.
9 ~~Modulators of~~ Chordotonal Organs TRPV cannel modulators.	9B Pymetrozine. ~~9C Flonicamid~~.
23 Inhibitors of acetyl CoA carboxylase.	Tetronic and Tetramic acid derivatives ~~(Spirotetramat)~~.
29 Chordotonal organ modulators – undefined target site.	29 Flonicamid
UN Compounds of unknown or uncertain MoA.	Azadirachtin.

(Grey substances in brackets): Those submitted for registration in Spain but not yet granted authorization for use.

content

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- Olive Fly resistance to pyrethroids suspected in Greece, further fruit fly species

10:30-11:00:

- *Myzus persicae* – Gr. 4 resistance in EU
    - updates of resistance monitoring
    - renewal of poster and
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- *Aphis gossypii*, Korea
- *Bemisia tabaci*, new Poster and IRM recommendations in Brazil

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- RSA – Stinkbugs – PYR resistance
- *Diaphorina citri*, Asian Citrus Psyllid – Methodology validation
- *Bactericera cockerelli – monitoring, methodology*

11:30-12:00:

- Review of IRAC-web pages
- Objectives 2016
- any other business; spider mites?, Lygus?, rice plant hoppers?

Arising sucking pest resistance problems: *Aphis gossypii*

WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.10 (2): 1227-1230. 2012 *www.world-food.net*

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

Xu-Gen Shi [1], Yu-Kun Zhu [1], Xiao-Ming Xia [1], Kang Qiao [1], Hong-Yan Wang [2] and Kai-Yun Wang [1*]

[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*

Received 18 February 2012, accepted 30 April 2012.

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

Aphis gossypii, Korea:
action: finalize update & translate to local language

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 secreations 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 23: 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

CropLife

Aphis gossypii, Korea:
action: extending the local IRM-activities

It is really difficult to get a clear insights how resistance is handled locally!

Step-wise approach:

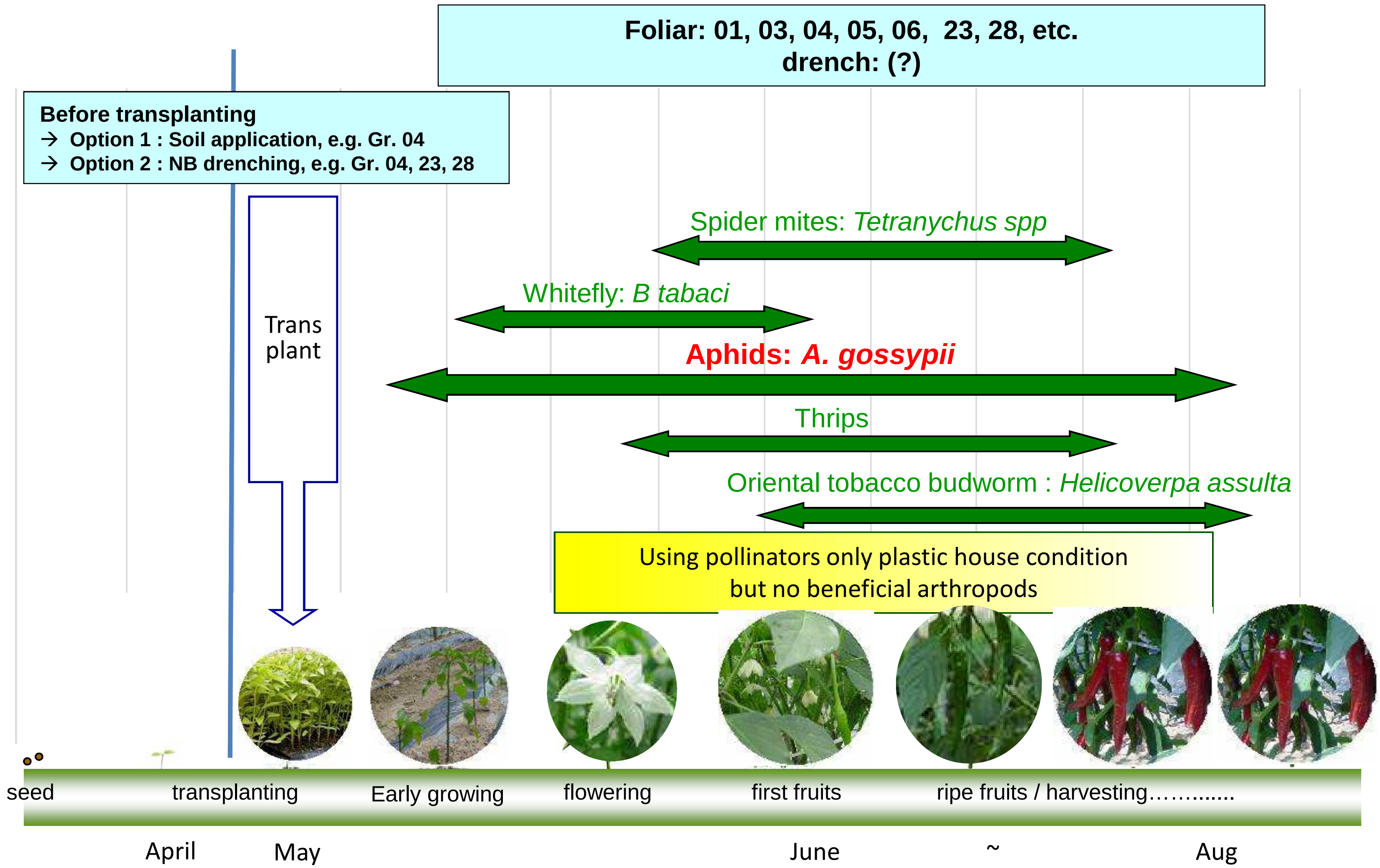
1. Intensify local lepidopteran/Diamide team and extent to other companies

2. Focus on a most critical crop to develop IRM recommendations, e.g. cucurbits/peppers and ask them directly for local information:
   - Annual cropping cycle information (duration of crop from seedling transplant to harvest/crop removal), parallel sets or sequential planting.
   - Aphid 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, and Biological & cultural control methods.

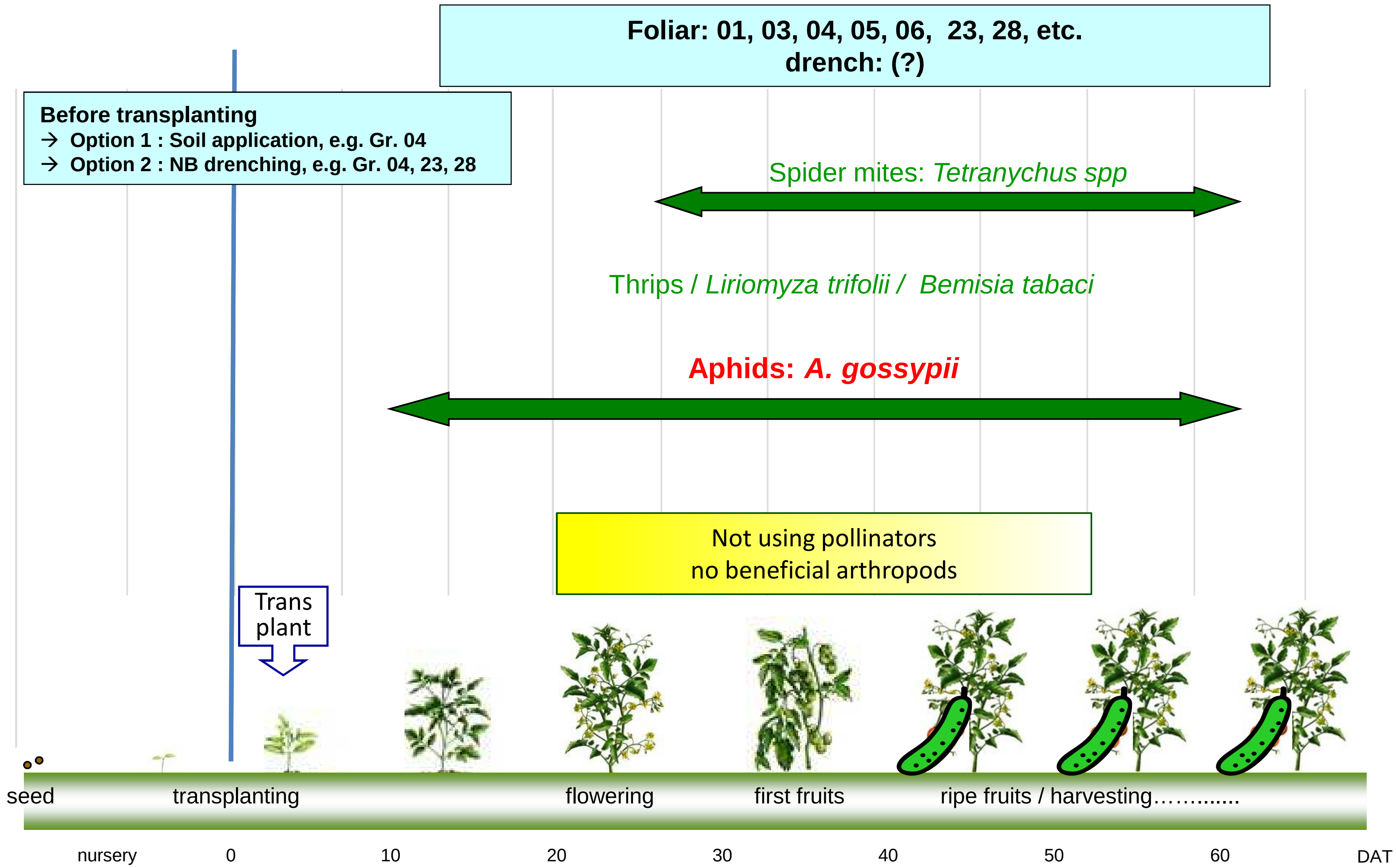
3. With this information, we may produce an IRM draft ourselves and then ask the Korean colleagues to challenge it.

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

Aphis gossypii and other important pests on protected peppers in Korea:

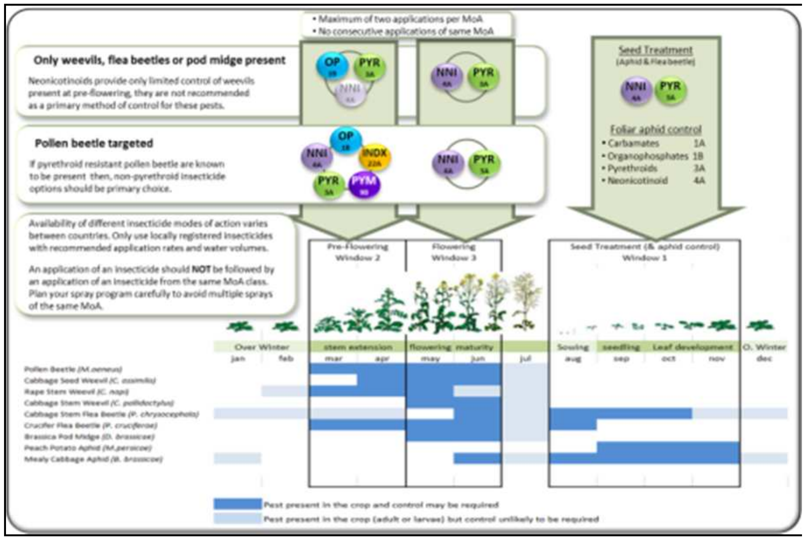


Aphis gossypii and other important pests on protected cucurbits in Korea:



Aphis gossypii, Korea:
action: suggest a management plan & challenge local colleagues

It is really difficult to get a clear insights how resistance is handled locally!



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IRAC

content

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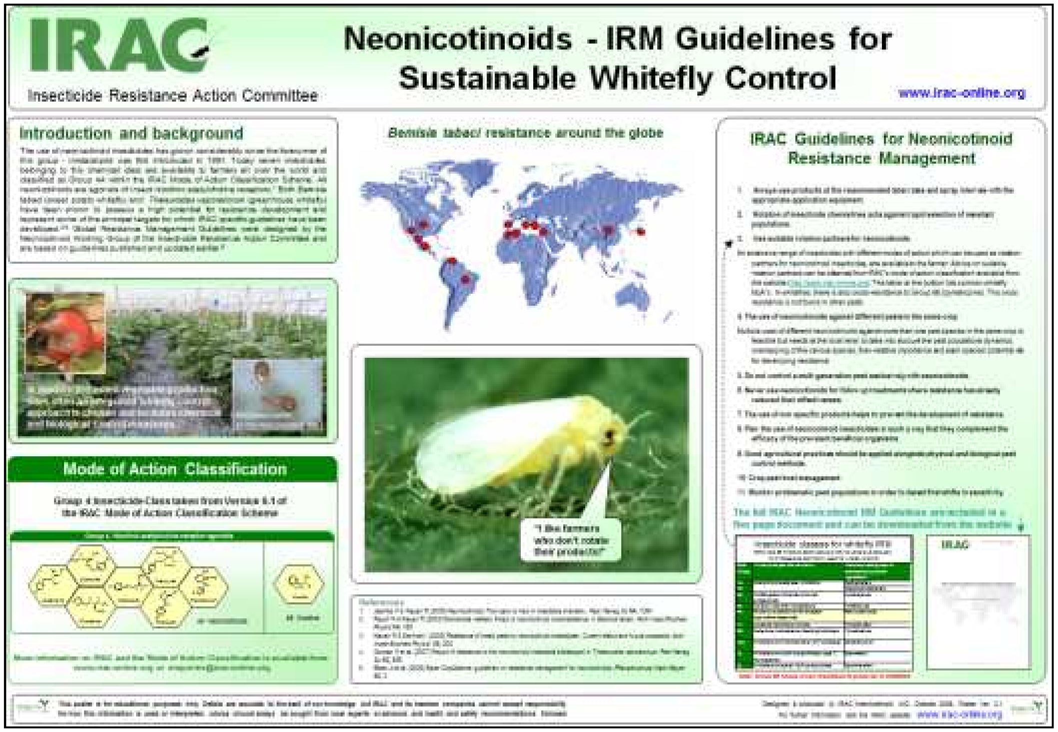
- *Bactericera cockerelli – monitoring, methodology*

11:30-12:00:

- Review of IRAC-web pages
- Objectives 2016
- any other business; spider mites?, Lygus?, rice plant hoppers?

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



The most recent poster (c.f. above) is October 2008.
Ralf is working on a new version that would cover

- all current MOAs (e.g. Azadirachtin, P450-IMD?)
- -if feasible- incorporate *Trialeurodes vaporarium* as well as *Bemisia tabaci*?

B. tabaci: monitoring & method comparison, BRA

action: share results, compare methods

- 2013 – Base Line Characterization* (4 a.i.)
- 2014 – Field Monitoring (4 a.i.)
- 2015 – Field Monitoring (5 a.i.)
- 2016 – - Methodologies Comparison,
  - Susceptible Populations Comparison,
  - Field Populations Sampling
  - Field Monitoring (6 a.i**.)

* Using IAC/ESALQ/USP susceptible population and PROMIP methodology

** Buprofezin, Imidacloprid, Spiromesifen, Pyriproxyfen, Cyazypyr, Thiamethoxam

Tabela 1. População suscetível de referência de mosca-branca, *Bemisia tabaci* biótipo B.

Produto	Estágio	CL_{50} (mg i.a. L^{-1}) (95% I.C.)
1. Applaud 250 (buprofezina)	ovo	> 5.600
	ninfa	6,42 (4,23-8,20)
2. Evidence 700 WG (imidacloprido)	adulto	130,75 (114,2-148,8)
3. Movento (espirotetramate)	adulto	78,46 (70,9-86,4)
	ninfa	24,55 (20,8-28,6)
4. Oberon (espiromesifen)	ninfa	15,84 (11,17-20,25)
5. Mospilan (acetamiprido)	adulto	52,8 (45,5-60,6)
	ninfa	2,3 (2,0-2,5)
6. Tiger 100 EC (piriproxifen)	ovo	0,02 (0,01-0,02)
	ninfa	11,5 (4,6-23,4)
7. Actara 250 WG (tiametoxam)	adulto	58,2 (51,9-64,3)
	ninfa	57,5 (51,6-64,1)
8. Polo 500 WP (diafentiuron)	adulto	156,7 (145,7-168,0)
	ninfa	46,1 (43,2-48,8)
9. Benevia (Cyantraniliprole)	adulto	3,30 (2,92-3,70)
	ninfa	0,98 (0,88-1,09)
10. Focus WP (Clotianidina)	adulto	84,70 (79,23-90,30)
	ninfa	106,46 (75,0-169,6)

The base lines were conducted for the key stages according to the product characteristics as described above.

- Methodologies Comparison*

PROMIP		IRAC Inter
- Drybeans	versus	- Cotton
- 25'		- 20'
- 5"		- 20"
- Upside Down		- Upside to Up
- "Abaxial"		- "Adaxial"
- 48 / 72 hs		- 48 / 72 hs

- Susceptible Populations Comparison*
  – IAC/ESALQ/USP versus - IB São Paulo

* without costs for IRAC-BR WFWG members

IRAC

B. tabaci:
action: how to design IRM strategies, incl. NNIs

2016
- Methodologies Comparison – in progress
- Susceptible Populations Comparison – in progress
- Field Populations Sampling
  - 5 from soybean – in progress
  - 5 from tomato – Q2
  - Field Monitoring Bioassay (5 a.i.) – Q3

2017
- Analyse and, if appropriate, implement field trials in the same area where the populations were collected to be used as a reference (lab bioassay vs field performance)

IRAC
Comitê de Ação à Resistência a Inseticidas
Brasil

White Fly Work Group

Current Company Members:

Arysta LifeScience, Bayer, DuPont, Nufarm, Sumitomo Chemical, syngenta

2016 Investiment:

Field Populations Sampling - US$ 15,000.00

Lab Studies / Bioassay - US$ 24,000.00

In cooperation with PROMIP

Promoting IRM since 1997

<u>Method comparison:</u>
- IRAC is open to adapt to the best practice and to adjust IRAC method #015 => Lixin to further exchange with “Methods WG”

<u>Monitoring 2015/2016:</u>
- Field monitoring in 2016 continues on adults and nymphs, including buprofezin, pyriproxyfen, spiromesifen (primarily targets nymphs) and neonicotinoids (resistance expressed in adults/pupae only)
- The field monitoring in 2016 will incorporate the methods used to establish the base lines.

- Still, we need to better understand <u>how to designing IRM strategies</u> including neonicotinoids (based on the data provided by PROMIP)

content

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Euschistus heros:
Monitoring 2014/2015, soybean, topical bioassay

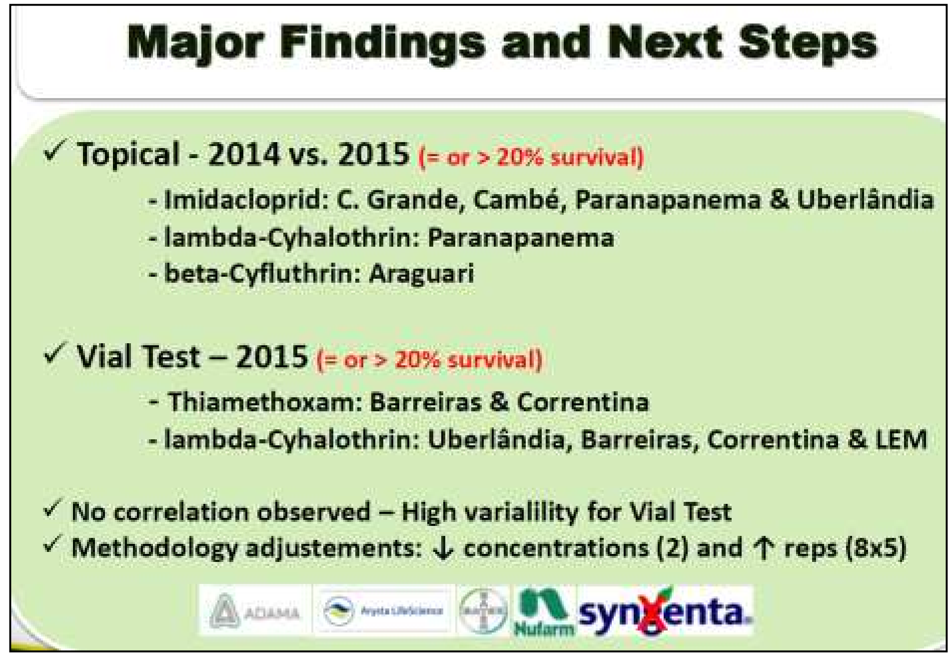
PRODUCTS

	Ingrediente Ativo	Grupo Químico	Modo de Ação	Empresa
01	acefato	organofosforado	grupo 1B	Arysta
02	tiametoxam	neonicotinóide	grupo 4A	Syngenta
03	imidacloprido	neonicotinóide	grupo 4A	Adama, Bayer, Nufarm
04	lambda-cialotrina	piretróide	grupo 3A	Syngenta
05	beta-ciflutrina	piretróide	grupo 3A	Bayer
06	imida+beta	neonic. + piretróide		Bayer

MONITORING
(Topical)

	Ingrediente Ativo	Empresa	Concentração Diagnóstica (CI_{99}) (mg i.a. / L H_2O)
01	acefato	Arysta	3.200
02	tiametoxam	Syngenta	32
03	imidacloprido	Adama, Bayer, Nufarm	180
04	lambda-cialotrina	Syngenta	560
05	beta-ciflutrina	Bayer	1.800
06	imida+beta	Bayer	320

Euschistus heros:
Monitoring for 2015/2016



<u>Stink Bugs Work Group Brazil:</u>

- It was decided to run just vial tests in 2015/16 season
- Most of the populations (12) were collected and tests realized
- High mortality observed for 2 - 3 populations
- Source of mortality: related to the stink bugs manipulation/handling?
  from sampling to test set up and evaluations
- Action in place to more harmonize methodology across sites (different technicians running tests across BRA)
- Areas/sites with high mortality will be subject to new sampling and tests
- No final data available yet
- Plans to run field trials in the area/site where vial tests are conduct are under analysis

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- *Euschistus heros*, Brazil Monitoring program, method discussions
- RSA – Stinkbugs – PYR resistance
- *Diaphorina citri*, Asian Citrus Psyllid – Methodology validation
- *Bactericera cockerelli – monitoring, methodology*

11:30-12:00:

- Review of IRAC-web pages
- Objectives 2016
- any other business; spider mites?, Lygus?, rice plant hoppers?

Stinkbug – PYR resistance in South Africa:
follow-up: progress report

Research efforts for two-spotted stinkbug *Bathycoelia distincta* in macadamia (suspected PYR-resistance) are funded by IRAC for 1st year: 2015-2016. The contract has been finalized and signed, incl. remarks made by the SP-team.

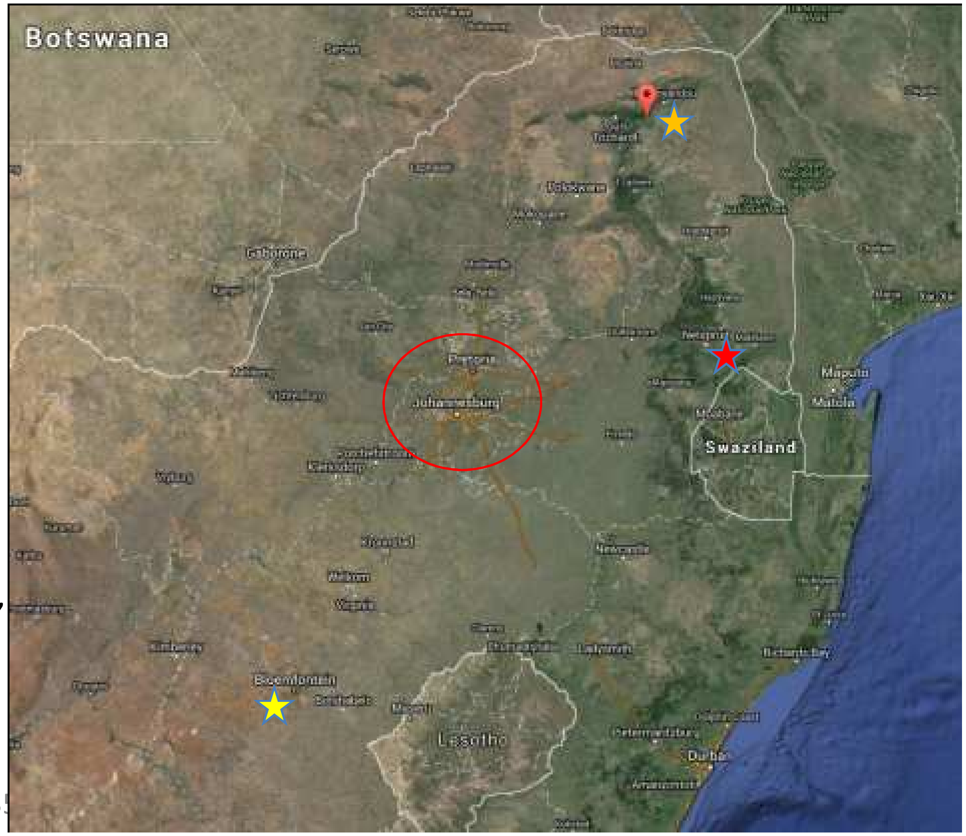
- The sucking pest team as well as IRAC South Africa keeps an eye on the progress of the project aiming at developing IRM recommendations together with the UFS based on available information.

- Colony selection sites: **Levubu region** - Levubu incl. control colony (“orange star”), but most colonies from **Nelspruit area** (“red star”), with support of the Agricultural Research Counsil - Intsitute for Tropical and Subtropical Crops (ARC-ITSC) in Nelspruit

- A dedicated person has been appointed to conduct daily collection in orchards at the Nelspruit ARC.

- All collected material will be sent to the main research site at University of the Free State at Bloemfontein via courier and supplement the existing colonies.

- The research is performed by Gerhard Nortje, supervised by Devilliers Fourie, in Bloemfontein, window persons for IRAC are:
  - Tanya Zais & Andrew Bennett (both IRAC-RSA),
  - Jan van Vuuren (established local contacts),
  - Russell Slater/Michael Klueken (SP WG).



Stinkbug – PYR resistance in South Africa:
follow-up: progress report

SPECIFIC OBJECTIVES DURING REPORTING PERIOD

- Prepare facilities on-site at the UFS to accommodate planned bio-assay trials

- Establish macadamia trees under greenhouse conditions to serve as fresh food source for colonies to be used in trials:
    - Drought in Dec. also affected the nursery trees,
      but new foliage available now to maintain several colonies

- Establish breeding colonies of *Bathycoelia distincta* adults to act as control and breeding population for conducting pesticide bio-assays
    - Due to severely drought in Mpumalanga region End of 2015, very low population densities (not enough individuals collected), but in January situation changed and many new egg packages were available for research studies.

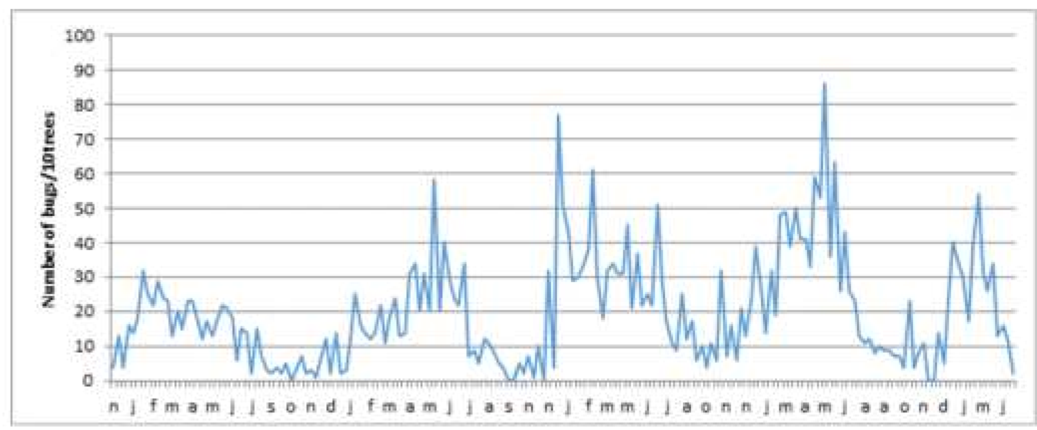


Figure 1: *B. distincta* population peaks recorded over several years from macadamia in the Nelspruit region. (Data courtesy of Dr. S. Schoeman, ARC-Nelspruit)

content

10:00-10:30:

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IRM recommendation for HLB-vector control ACP:
action: add new poster to IRAC web pages

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
RR_{50} adults	35X	18X	15X	5X	3X	2X
RR_{50} 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, US-related

Figure 2: Management plan example derived from USA-FL 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 (NR: Horticultural oils)			
1 A&B: AChE inhibitors	4: nAChR agonist	7C: Juvenile hormone analogues	21A: Mitochondrial complex 1 electron transport inhib.
2B: GABA antagonists	5: nAChR allosteric activators	15: Inhibitors of chitin biosynthesis type 0	23: Inhibitor of aCoA carboxylase
3: Sodium Channel modulator	6: Chloride channel activator	18: Ecdysone receptor agonist	28: Ryanodine receptor modulators

Relevant Literature

Politoniari, 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 Psyllid in Florida. Pest Management Science 67: 1258-1268

Vanaclocha. P., H. A. Arevalo, A.B. Paulo, 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

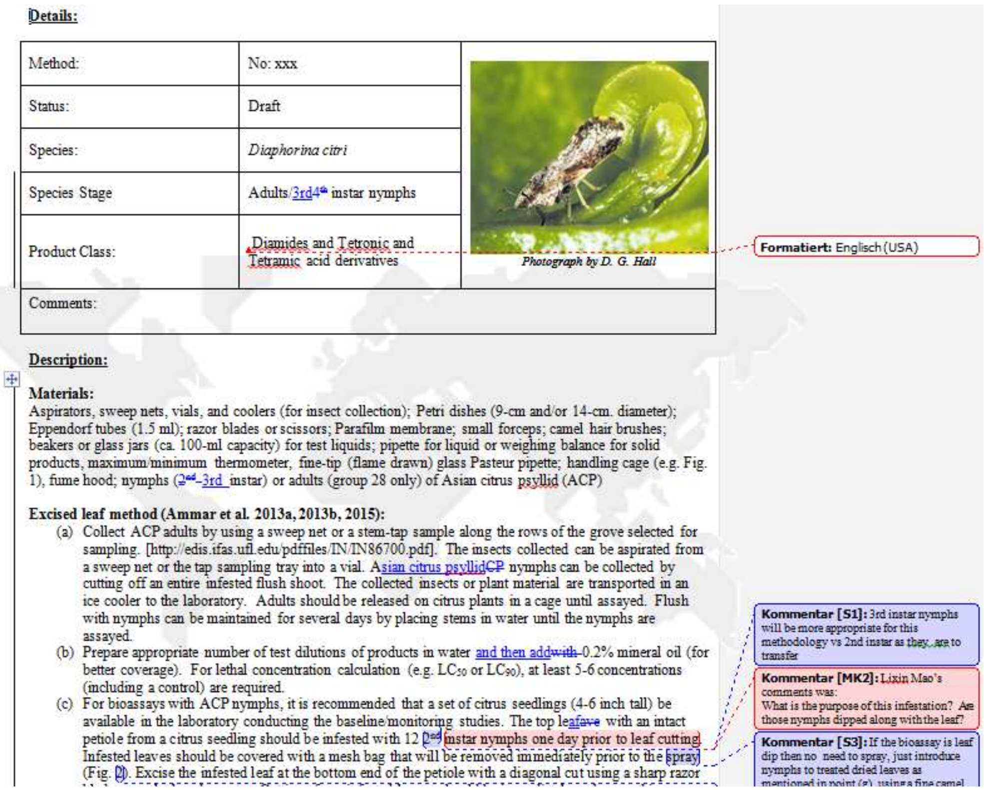
IRM recommendation for HLB-vector control ACP:
action: comparison of methods

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

- is published on the IRAC web pages
- Validated by BASF (BRA) for IMD & TMX in 2014
- but no new data observed in 2015

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

- to reflect special features of <u>systemic and slower acting</u> active ingredients, e.g. incl. IRAC groups 23 (spirotetramat) and 28 (cynantraniliprole),
- the draft description is in progress related to Ammar et al. (J. Econ. Entomol. 1–6, 2015)
- We agreed: a better understanding and that further validation is needed:
  - Lixin suggested method validation (and comparison?) in BRA could be done, but timeline is easier to handle during off-season.
  - Diana to check access to researchers in USA



Details:

Method:	No: xxx	
Status:	Draft	
Species:	*Diaphorina citri*	
Species Stage	Adults/3rd4th instar nymphs	
Product Class:	Diamides and Tetronic and Tetramic acid derivatives	*Photograph by D. G. Hall*
Comments:		

Formatiert: Englisch (USA)

Description:

Materials:
Aspirators, sweep nets, vials, and coolers (for insect collection); Petri dishes (9-cm and/or 14-cm. diameter); Eppendorf tubes (1.5 ml); razor blades or scissors; Parafilm membrane; small forceps; camel hair brushes; beakers or glass jars (ca. 100-ml capacity) for test liquids; pipette for liquid or weighing balance for solid products, maximum/minimum thermometer, fine-tip (flame drawn) glass Pasteur pipette; handling cage (e.g. Fig. 1), fume hood; nymphs (2nd–3rd instar) or adults (group 28 only) of Asian citrus psyllid (ACP)

Excised leaf method (Ammar et al. 2013a, 2013b, 2015):

(a) Collect ACP adults by using a sweep net or a stem-tap sample along the rows of the grove selected for sampling. [http://edis.ifas.ufl.edu/pdffiles/IN/IN86700.pdf]. The insects collected can be aspirated from a sweep net or the tap sampling tray into a vial. Asian citrus psyllidCP nymphs can be collected by cutting off an entire infested flush shoot. The collected insects or plant material are transported in an ice cooler to the laboratory. Adults should be released on citrus plants in a cage until assayed. Flush with nymphs can be maintained for several days by placing stems in water until the nymphs are assayed.

(b) Prepare appropriate number of test dilutions of products in water and then addwith 0.2% mineral oil (for better coverage). For lethal concentration calculation (e.g. LC_{50} or LC_{90}), at least 5-6 concentrations (including a control) are required.

(c) For bioassays with ACP nymphs, it is recommended that a set of citrus seedlings (4-6 inch tall) be available in the laboratory conducting the baseline/monitoring studies. The top leafave with an intact petiole from a citrus seedling should be infested with 12 2nd instar nymphs one day prior to leaf cutting. Infested leaves should be covered with a mesh bag that will be removed immediately prior to the spray (Fig. 2). Excise the infested leaf at the bottom end of the petiole with a diagonal cut using a sharp razor

Kommentar [S1]: 3rd instar nymphs will be more appropriate for this methodology vs 2nd instar as they are to transfer

Kommentar [MK2]: Lixin Mao's comments was:
What is the purpose of this infestation? Are those nymphs dipped along with the leaf?

Kommentar [S3]: If the bioassay is leaf dip then no need to spray, just introduce nymphs to treated dried leaves as mentioned in point (g) using a fine camel

- We discussed if it would make sense to test not only IRAC group 23 and 28 ai.'s, but also to compare with previously tested once (leaf-dip method), e.g. sulfoxaflor, flonicamid, abamectin, zeta-cypermethrin. The team would like to come back to this at the F2F meeting.

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

John Trumble (UC Riverside) produced the attached **drench** method based on which has been validated by John's team and results were published

- foliar method was taken from the Proceedings of a recent zebra chip meeting
- additional validation needed for those classes that have not been tested yet
- agree on a revised method / pass it to the Methods WG for approval / publication

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

CrossMark

Sean M. Prager*, Beatriz Vindiola, Gregory S. Kund, Frank J. Byrne, John T. Trumble

Department of Entomology, University of California, Riverside, USA

A R T I C L E   I N F O

Article history:
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Resistance
Soil drench
Drip application
Zebra chip

A B S T R A C T

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.

27 April, 2016

IRAC

content

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- Review of IRAC-web pages
- Objectives 2016
- any other business; spider mites?, Lygus?, rice plant hoppers?

IRAC web pages: review

- “News” – add ACP-poster,
- “minutes” -
  exchange 17.9.2015,
  add 23.11. and 29.3.
- “contact” – update the list of team members
- “documents” – add objectives 2015,
- “guidelines” = O.k.
- “poster” –
  Remove *B. tabaci* poster (2008),
  exchange ACP (2014),
- “presentations” – add Sucking Pest Team Update 2015 (&2016)
- “publications” = O.k.

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- any other business; IRAC-INDIA? spider mites?, Lygus?, rice plant hoppers? *Aonidiella aurantii* (Methods)?

IRAC-Sucking Pest WG Objectives – 2015

Goals	Objectives	Timeline	STATUS
Short term (“alert”) actions to minimise spread of resistant pests	• *Myzus persicae* Follow-up with “implementation” of IRM Guidelines in Southern EU	2015	Done
	• *Bemisia tabaci* monitoring program (PROMIP)	Q2 2015	Done
	• *Sitobium avenae* review last year’s alert for Mainland EU for PYR-resistance (in view of few MOAs)	Q3 2015	Done/ongoing
	• *Aphis gossypii* (neonicotinoid target site resistance)		
	▪ Initiate local IRAC team in South Korea	Q2 2015	Ongoing
	▪ Develop IRM recommendations for Korea as template for future use	Q2 2015	Pending
	▪ Finalize / review poster: globally & local Korean language version	2015	Pending
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,	Q2 2015	Done
	▪ Method validation and implementation (review vial test to IRAC approved methods)	Q3 2015	Done/ongoing
	• *Bathycoelia distincta* Support research efforts in RSA (suspected PYR-resistance)	2015	Done
	• *Diaphorina citri*		
	▪ Finalize and publish the Leaf Dip method for IRAC Groups 01, 03, 04, 05, 06	Q2 2015	Done
	▪ Validate and publish a Flush tube systemic test for IRAC Groups 23 and 28	Q4 2015	Ongoing
	• *Bemisia tabaci (T. vaporariorum)* updated poster version incl. new MOA	2015	Ongoing
	• *Group 4 IRM Guidelines.* Review and finalize – update global document in view of new subgroupings	Q1 2015	Done
	• *Lygus sp* USA Cotton engage with IRAC US to assess need for action	2015	Done
	• Fruit fly species (pyrethroids-resistant olive fly suspected, Greece): 1. Summarize current resistance situations, 2. Exchange about methodology and 3. Pro-actively release recommendations (highlight value of current options / prevent use restrictions)		Ongoing
Prepare for future Sucking Pest problems **long term (avoidance)**	▪ *Tetranychus sp.* (mites), *Nilapavarta lugens,* bugs/stinkbugs *(Dichelops melacanthus)*		
	▪ Collect reports on monitoring studies and publications, follow up field failures	2015	Done/ongoing
	▪ *Aphis gossypii* (neonicotinoid target site resistance)		
	▪ Monitor complaints globally and report liaise with researchers	2015	Done/ongoing

IRAC-Sucking Pest WG Objectives – 2016

Goals	Objectives	Timeline
Short term (“alert”) actions to minimise spread of resistant pests	• *Myzus persicae* Follow-up with “implementation” of IRM Guidelines in Southern EU	2016
	• *Bemisia tabaci* monitoring program (PROMIP/IRAC-BRA): how to design IRM strategies?	Q2 2016
	• *Sitobium avenae* review last year’s alert for Mainland EU for PYR-resistance (in view of few MOAs)	Q2 2016
	• *Aphis gossypii* (neonicotinoid target site resistance)	
	▪ Develop IRM recommendations for Korea as template for future use	Q2 2016
	▪ Finalize / review poster: globally & local Korean language version	Q3 2016
Prepare IRM guidelines for pests with, or at risk of developing resistance in the **mid term**	▪ *Euschistus heros*, check on MOA IRAC 01, 03, 04, with PROMIP/IRAC-BRA	
	▪ Follow up with monitoring efforts: how to design IRM strategies?	Q2 2016
	▪ Method validation and implementation (review vial test to IRAC approved methods)	Q3 2016
	• *Bathycoelia distincta* Support research efforts in RSA (suspected PYR-resistance)	2016
	• *Diaphorina citri* Validate and publish a Flush tube systemic test for IRAC Groups 23 and 28	2016
	• *Bactericera cockerelli* Activate monitoring, validate and publish a method, notably for IRAC 04	2016
	• *Myzus persicae*	
	▪ updated IRM Guidelines for new cases (Andalusia, ESP)	Q2 2016
	▪ the poster, incl. new MOA with IRAC ESP	Q3 2016
	• *Bemisia tabaci (T. vaporariorum)* updated poster version, incl. new MOA	Q3 2016
	• Fruit fly species (pyrethroids-resistant olive fly suspected, Greece): 1. Summarize current resistance situations, 2. Exchange about methodology and 3. Pro-actively release recommendations (highlight value of current options / prevent use restrictions)	2016
Prepare for future Sucking Pest problems **long term (avoidance)**	▪ *Tetranychus sp.* (mites), *Nilapavarta lugens,* bugs/stinkbugs *(Dichelops melacanthus)*	
	▪ Collect reports on monitoring studies and publications, follow up field failures	2016
	▪ *Aphis gossypii , Myzus persicae, M. nicotianae* (neonicotinoid target site resistance)	
	▪ Monitor complaints globally and report liaise with researchers	2016

Motivate team to work on prioritized activities, provide validated methods to researchers and summarized information to growers and influencers for control options and strategies (sucking pest-related)

IRAC INDIA:
action: follow-up for sucking pests topics

IRAC INDIA:

- IRAC-India is resuming activities (after 3years) and has hold a face to face on September 10th 2015 at the Bayer office in Mumbai.
- Focus is on lepidopteran control strategies, incl. latest revised guideline (decided by IRAC Global for the countries)
- They received latest update on global activities and on possible objectives and expectation of the global team from India
- Possible sucking pest issues:
  Jassids in cotton and BPH in Rice. What other sucking pests?

Nigel Godley (IRAC International Country Group Liaisons for India):

- Latest revised Guideline decided by IRAC Global for the countries
- Latest update on global activities which can be shared with the group
- Guidance us on the objectives and expectation of global IRAC team from India (incl. global 2015-16 smart objectives and challenges)

➔ **any specific guidance from Sucking Pest WG?**
➔ **Follow-up and encourage for sucking pest topics to the new IRAC India team**

IRAC

Insecticide Resistance Action Committee

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