IRAC

Insecticide Resistance Action Committee

Coleoptera WG
2014/16

50th IRAC International Meeting, Dublin

April 5-8th, 2016





Coleoptera WG Team Members

April 2014	April 2015	April 2016
Alan Porter (IRAC)	**Alan Porter (IRAC)**	**Alan Porter (IRAC)**
Anil Menon (BASF)	**Anil Menon (BASF)**	**Anil Menon (BASF)**
Ben Bolton (Nufarm)	*Gerald Huart (ADAMA) Chair*	**Brian Duggan (Nufarm)**
Gerald Huart (ADAMA) Chair	**Imre Mezei (Dow)**	**Chaoxian Geng (Dow)**
Imre Mezei (Dow)	*Magali Gravouil (DuPont)*	**Imre Mezei (Dow)**
Magali Gravouil (DuPont)	*Marie-Pierre Plancke (Nufarm)*	**Jan Elias (Syngenta)** *Vice-Chair*
Michel Sarazin (FMC)	*Faustine Fournie (FMC)*	**Niels Jacob Jakobsen (ADAMA)**
Ralf Nauen (Bayer)	**Ralf Nauen (Bayer)**	**Ralf Nauen (Bayer)** Chair
Russell Slater (Syngenta)	*Russell Slater (Syngenta)*	**Udo Heimbach (JKI)**
Udo Heimbach (JKI)	**Udo Heimbach (JKI)**	**Sacha White (ADAS UK)**
Steve Ellis (ADAS UK)	**Sacha White (ADAS UK)**	
N = 11 (8 companies)	**N = 11 (8 companies)**	**N = 10 (6 companies)**

Coleoptera WG Activities

- **conference calls / meetings**

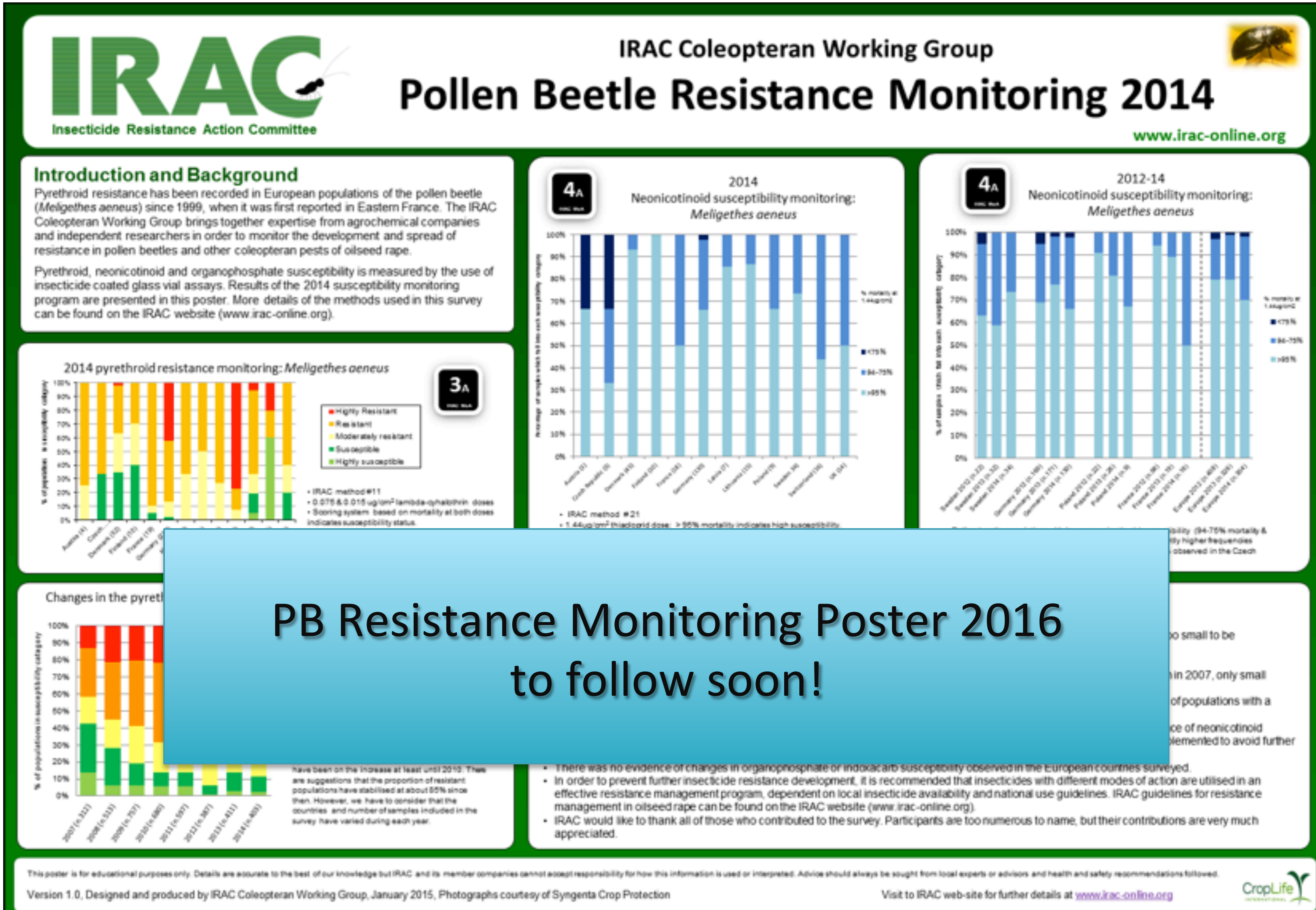
Date	Number of participants	Purpose
07.03.2014	3	CC
17.07.2014	5	CC
29.08.2014	5	CC
11.02.2015	7	CC
16.04.2015	9	CC
17.09.2015	5	F2F (RRes)
07.04.2016	(5)	F2F (Dublin)

Thanks to Russell

Thanks to Gerald

IRAC

PB Resistance Monitoring Poster 2015



PB Resistance Monitoring Poster 2016
to follow soon!

IRAC

Coleoptera WG – Methods update

IRAC

Insecticide Resistance Action Committee
www.irac-online.org

IRAC Susceptibility Test Methods Series

Version: 2 (March 2014)

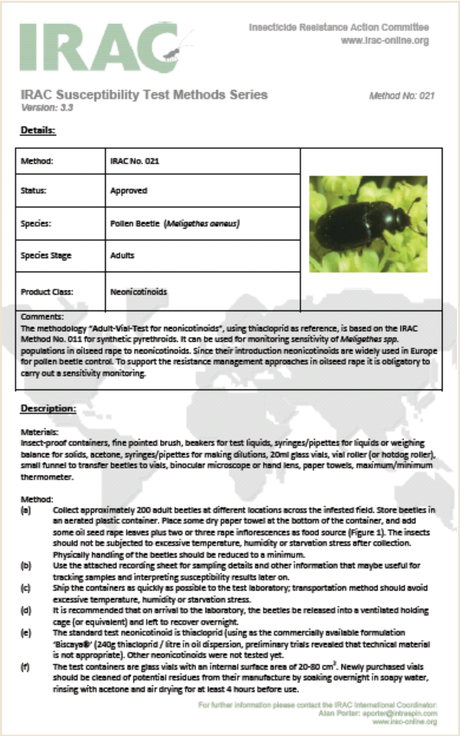
Method No: 025

Details: Vials can be stored at -20°C for maximum 1 month. Don't not store and ship vials at room temperature.

Method:	IRAC No. 025	
Status:	Approved	
Species:	Pollen Beetle, *Meligethes spp*	
Species Stage:	Adults	
Product Class:	Organophosphates	
Comments:		

IRAC

Coleoptera WG – Methods update


Insecticide Resistance Action Committee
www.irac-online.org

IRAC Susceptibility Test Methods Series
Version: 3.3

Method No: 021

Details:

Method:	IRAC No. 021
Status:	Approved
Species:	Pollen Beetle (*Meligethes aeneus*)
Species Stage	Adults
Product Class:	Neonicotinoids

Comments:
The methodology "Adult-Vial-Test for neonicotinoids", using thiacloprid as reference, is based on the IRAC Method No. 011 for synthetic pyrethroids. It can be used for monitoring sensitivity of *Meligethes spp.* populations in oilseed rape to neonicotinoids. Since their introduction neonicotinoids are widely used in Europe for pollen beetle control. To support the resistance management approaches in oilseed rape it is obligatory to carry out a sensitivity monitoring.

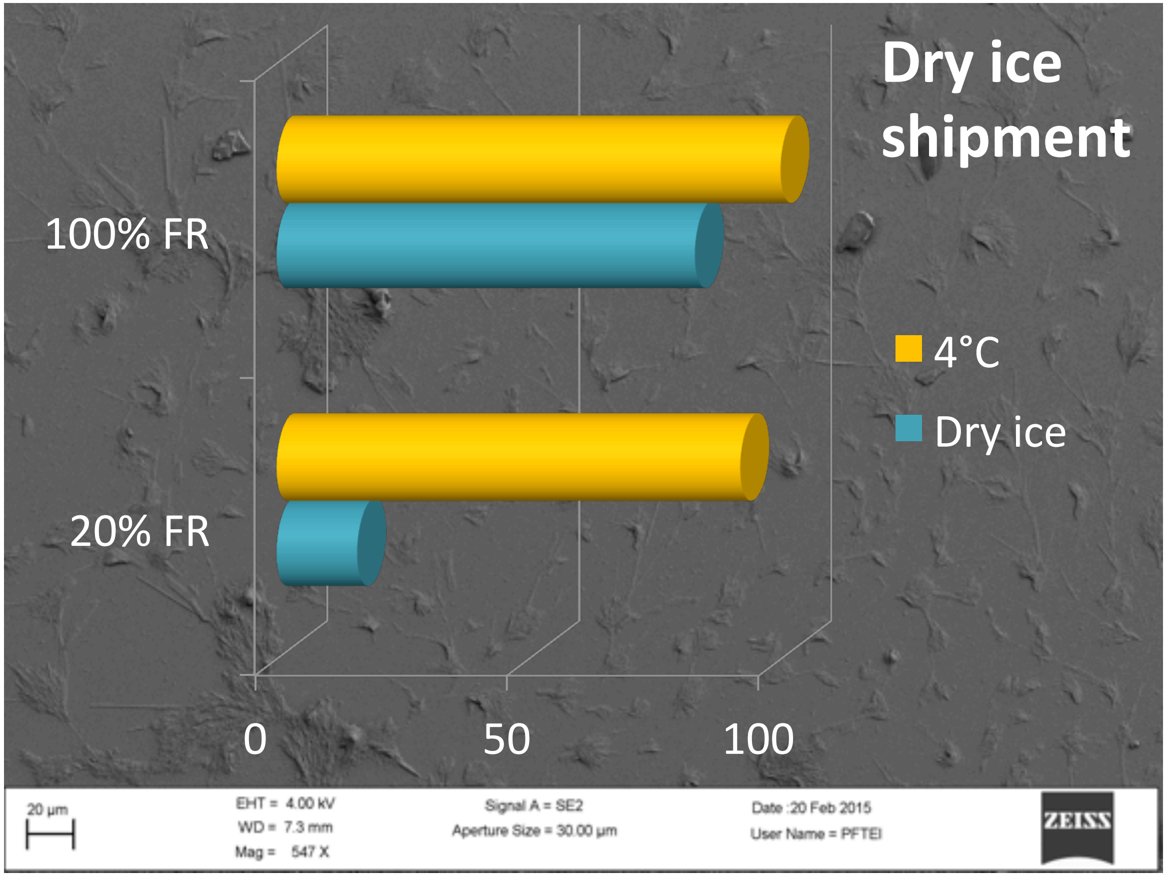
Description:

Materials:
Insect-proof containers, fine pointed brush, beakers for test liquids, syringes/pipettes for liquids or weighing balance for solids, acetone, syringes/pipettes for making dilutions, 20ml glass vials, vial roller (or hotdog roller), small funnel to transfer beetles to vials, binocular microscope or hand lens, paper towels, maximum/minimum thermometer.

Method:
(a) Collect approximately 200 adult beetles at different locations across the infested field. Store beetles in an aerated plastic container. Place some dry paper towel at the bottom of the container, and add some oil seed rape leaves plus two or three rape inflorescences as food source (Figure 1). The insects should not be subjected to excessive temperature, humidity or starvation stress after collection. Physically handling of the beetles should be reduced to a minimum.
(b) Use the attached recording sheet for sampling details and other information that maybe useful for tracking samples and interpreting susceptibility results later on.
(c) Ship the containers as quickly as possible to the test laboratory; transportation method should avoid excessive temperature, humidity or starvation stress.
(d) It is recommended that on arrival to the laboratory, the beetles be released into a ventilated holding cage (or equivalent) and left to recover overnight.
(e) The standard test neonicotinoid is thiacloprid (using as the commercially available formulation 'Biscaya®' (240g thiacloprid / litre in oil dispersion, preliminary trials revealed that technical material is not appropriate). Other neonicotinoids were not tested yet.
(f) The test containers are glass vials with an internal surface area of 20-80 cm^2. Newly purchased vials should be cleaned of potential residues from their manufacture by soaking overnight in soapy water, rinsing with acetone and air drying for at least 4 hours before use.

For further information please contact the IRAC International Coordinator:
Alan Porter: aporter@intraspin.com
www.irac-online.org

IRAC Method 021 v3.3 (updated)



IRAC

Coleoptera WG – New method

Insecticide Resistance Action Committee
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IRAC Susceptibility Test Methods Series

Method No: 031

Version: 1.0

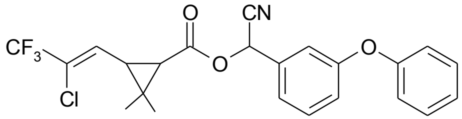
1) **Susceptible:** mortality at 0,015 µg/cm² =100%
2) **Decreased susceptibility:** mortality at 0,015 µg/cm² between 90 and 100%
3) **Resistance suspected:** mortality at 0,015 µg/cm² < 90%, or at 0,0375 µg/cm² < 100%

Details:

Method:	No: 031	 Photograph: Courtesy of Udo Heimback
Status:	Approved	
Species:	Rape stem weevil *(Ceutorhynchus napi)* Cabbage seedpod weevil *(Ceutorhynchus obstrictus)* Cabbage stem weevil *(Ceutorhynchus pallidactylus)* Cabbage stem flea beetle *(Psylliodes chrysocephala)* Flea beetles *(Phyllotreta spp.)* (For the pod midge *Dasyneura brassicae* a different approach should be used)	
Species Stage	Adults	
Product Class:	Synthetic pyrethroids (IRAC MoA 3A)	

Comments: The method was developed by Julius Kühn-Institut (JKI). It is currently being widely used in Germany for monitoring sensitivity of flea beetle and weevil species in oilseed rape to synthetic pyrethroids. This method is suitable for Resistance Monitoring and also for Susceptibility Baseline provided that additional rates/replicates are tested to obtain LD50 values.

Coleoptera WG – CSFB kdr monitoring

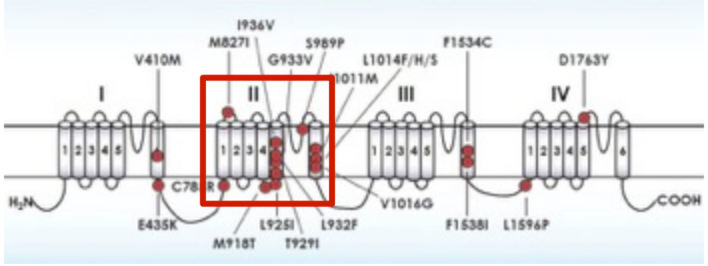


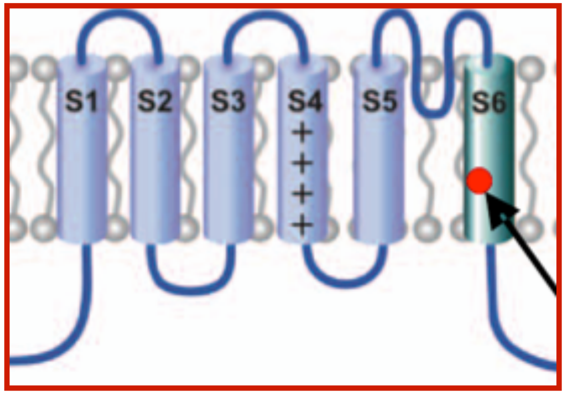
Transmembrane domain II

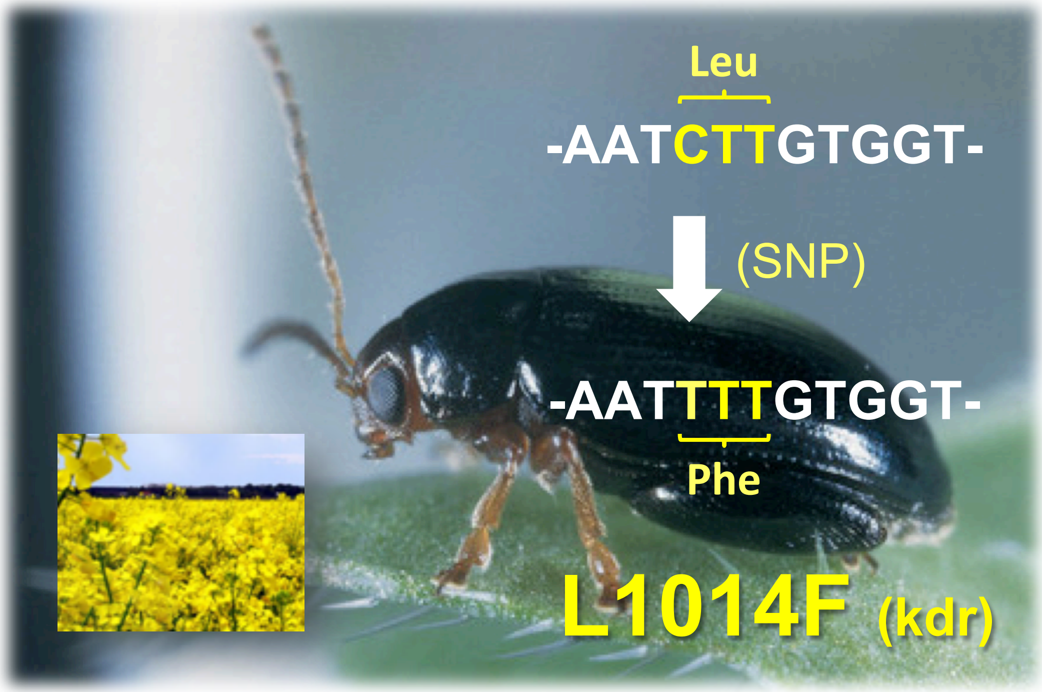
para-type vg sodium channel

Cabbage stem flea beetle (*Psylliodes* ssp.)

kdr mutations in the sodium channel







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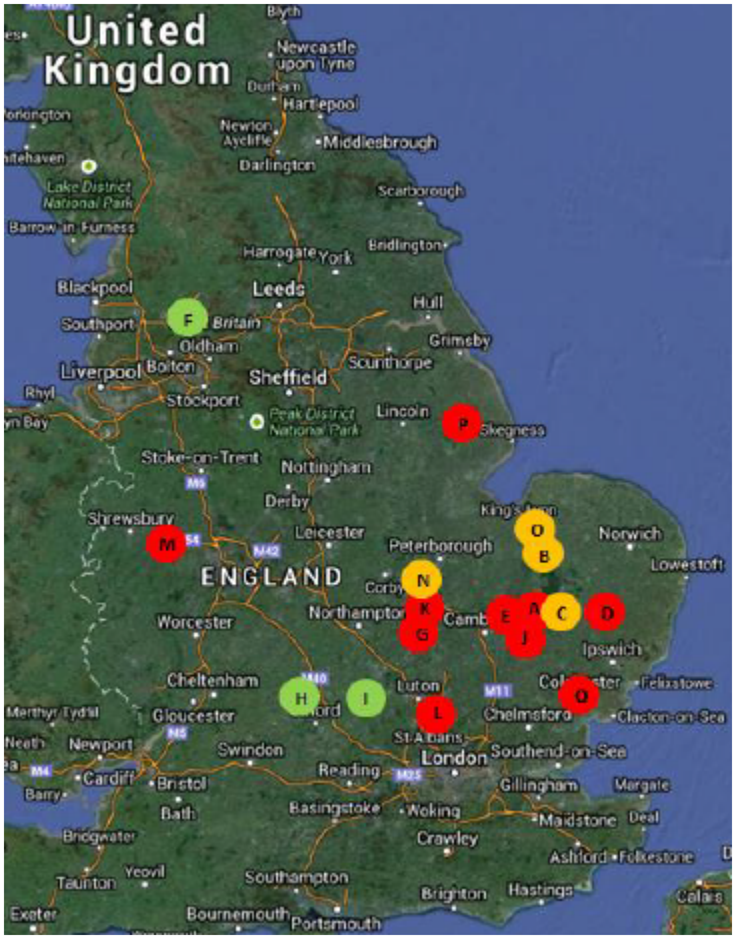
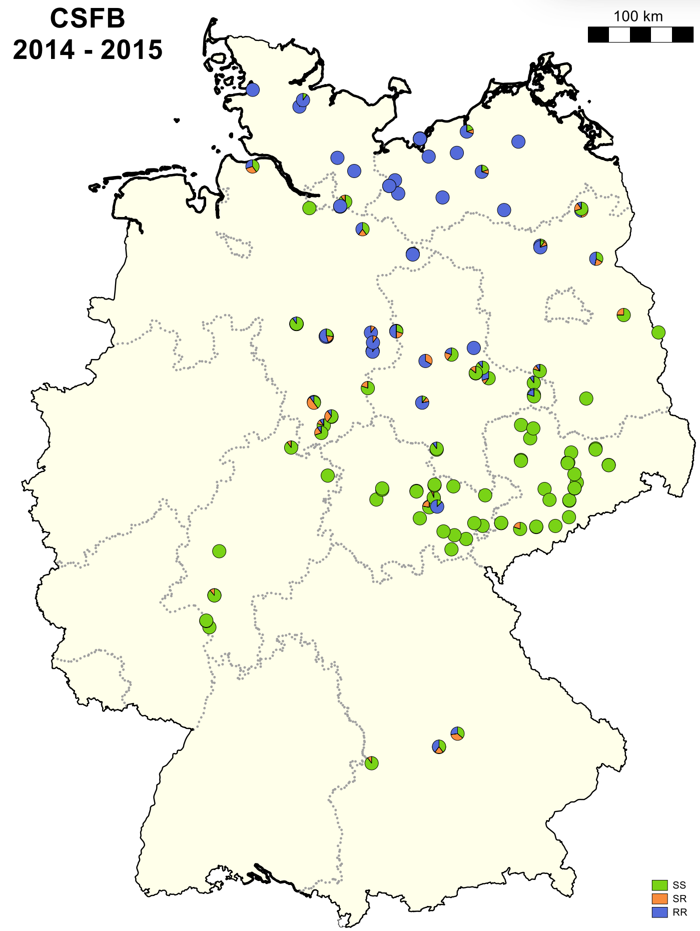
CSFB pyrethroid resistance



Source: Daum & Elias, April 2015



Source: Nauen *et al.*, November 2015

CSFB resistance alert – eConnection 37

IRAC eConnection

Insecticide Resistance Action Committee

About This Issue

This is a single topic IRAC eConnection to advise on the potential resistance situation developing with pyrethroid insecticides against the cabbage stem flea beetle in Europe. We provide some background on the reports of reduced performance of the pyrethroid insecticides, the implications, and propose some pest management guidelines to reduce the chance of further resistance developing.

Cabbage stem flea beetle (CSFB), *Psylliodes chrysocephala* - Resistance on the move

The cabbage stem flea beetle (*Psylliodes chrysocephala*) is an important European pest of winter oilseed rape, attacking plants from their emergence to the shooting stage. Pyrethroid insecticides have been heavily relied upon for the control of this pest for 30 years, with very few alternative modes of action available. However a second cornerstone and mode of action for its sustainable control included seed treatment applications by neonicotinoid insecticides, which were recently restricted by the EU by banning their use in flowering and bee-attractive crops like oilseed rape.

Cabbage stem flea beetle, *Psylliodes chrysocephala*
Photograph © Bayer CropScience

In recent years, there has been an increase in the number of reports of the reduced performance of pyrethroid insecticides against this pest in Germany, Denmark and the United Kingdom. The first confirmed case of reduced pyrethroid susceptibility in cabbage stem flea beetle was reported in northern Germany during 2008.[1] Subsequent studies have confirmed that the reduced susceptibility is associated with a *kdr* (L1014F) target site resistance mutation, which is also common in other pyrethroid resistant insect species.[2] Although the L1014F mutation has been demonstrated to only have a limited impact on the efficacy of pyrethroids in this species (10-20 fold reduction in activity), its association with the reduced performance of pyrethroids in the field suggests that under less than ideal conditions, the resistance could affect residual activity and result in a significant loss in beetle control.

In 2014 the Insecticide Resistance Action Committee (IRAC) started a collaborative program to monitoring the frequency and distribution of the L1014F *kdr* mutation in populations of cabbage stem flea beetles across Europe. In addition the survey also monitored for the presence and frequency of the M918T *super-kdr* mutation. The M918T mutation is commonly associated with high levels of pyrethroid resistance in other insects, but has not yet been detected in cabbage stem flea beetle.

The first results indicate a low frequency of the L1014F mutation in Eastern Europe (Czech Republic & Poland) where there have been no significant complaints of reduced performance of pyrethroids. However, in northern & eastern Germany, France and the United Kingdom the mutation is present in high frequencies. The regions of high mutation frequency also correspond with the areas of the UK and Germany where observations of reduced pyrethroid activity have been reported. The M918T *super-kdr* mutation was not found in any of the populations tested in Europe.

Due to the lack of any alternative modes of action in many European countries and the relatively low impact of the L1014F mutation as the only reported resistance mechanism yet on pyrethroid field efficacy against cabbage stem flea beetle, the use of pyrethroid insecticides remains the main option for the control of this pest. Recently neonicotinoid seed treatments provided an additional tool for resistance management purposes in terms of early season protection of young seedlings from flea beetle attack. Their recent ban is likely to have strong implications for oilseed rape production and without any doubt increases pyrethroid selection pressure and possibly facilitates the emergence of additional resistance mechanisms. To optimize pyrethroid activity and reduce the chances of further resistance development for the time being, the following insecticide use guidelines are recommended by IRAC.

Cabbage Stem Flea Beetle - Pest Management Guidelines

- In some cases the early sowing of oil seed rape allows the plants to sufficiently develop so that they are less susceptible to adult and larval damage. Higher seeding density may compensate for plant loss due to stem flea beetle attack.
- Where possible rotate insecticides with different mode of action (IRAC mode of action classification groups). In regions where only one mode of action is available, the use of insecticides should be strictly minimized to reduce the risk of resistance development.
- Always follow insecticide use guidelines, as outlined by the manufacturer. Always use the recommended label rates and water volumes (minimum 200L/ha).
- Only apply insecticides in accordance with regionally defined pest thresholds.
- Yellow water traps buried in the soil between plants can be used to detect the beginning of adult infestations in autumn. Larvae assessments can be conducted by dissecting leafstalks or stems and counting the number of larvae or galleries.
- The effectiveness of insecticides applied against adult beetles can be optimized by making applications late in the afternoon, as during this time adult beetles can often be found on the upper part of the plant and are therefore more vulnerable to contact insecticides.

Pyrethroid resistance monitoring should be continued in order to follow the spread of resistance and to detect new emerging resistance mechanisms likely to be facilitated by increased selection pressure.

References

1. Heimbach U, Müller A, Incidence of pyrethroid-resistant oilseed rape pests in Germany, Pest Management Science 69 (2013) 209–216.
2. Zimmer CT, Müller A, Heimbach U, Nauen R, Target-site resistance to pyrethroid insecticides in German populations of the cabbage stem flea beetle, *Psylliodes chrysocephala*, Pesticide Biochemistry and Physiology 108 (2014) 1-7.

Further Information

The eConnection is the newsletter of IRAC International.

Subscription: Free via the IRAC website.

Editor: Alan Porter, IRAC Coordinator.

IRAC website: www.irac-online.org

IRAC Executive Member Companies

CSFB resistance alert – eConnection 37

IRAC NEWSLETTER ISSUE 37 JULY 2015

IRAC

Insecticide Resistance Action Committee

eConnection

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IRAC NEWSLETTER ISSUE 37 JULY 2015

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Pyrethroid resistance monitoring should be continued in order to follow the spread of resistance and to detect new emerging resistance mechanisms likely to be facilitated by increased selection pressure.

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Insecticide Resistance Action Committee

DRAFT v3 31/03/16

Colorado Potato Beetle

(*Leptinotarsa decemlineata*)

Introduction

Leptinotarsa decemlineata is a common pest of potato, but also eggplant, tomato, pepper and tobacco. It is an important pest in North America, Europe and expanding its range in to various parts of Asia, most significantly in China and Iran .

The adults appear from hibernation in May, feed on young leaves, mate, and then start with oviposition. Each female lays eggs in clusters on the undersides of leaves. The larvae hatch 3-14 days later. There are 4 larval instars over a period of 2-4 weeks before the larvae drop to the soil to pupate. Pupation lasts a further 2-3 weeks, before the new adults emerge from the ground. There are usually 1-3 generations each year, with adults overwinter in the soil.

Treatment with insecticides has been the primary control option for growers either through tuber or foliar applied treatments. Timing of foliar insecticide applications are best targeted against small larvae for most effective control, with 1-2 foliar applications normally required per season.

Potato plants can withstand 20-30% foliage loss without impact on potato yields, so it is often not necessary to apply insectiocides unless one or more beetle per plant is observed.

Crop rotation and early/late planting can be used to reduce beetle populations, whilst covering the soil surface with straw-mulch has also been demonstrated as being an effective technique for reducing beetle pupation.

There are also a number of natural and biological control methods which can help to manage *L. decemlineata* (paricularly larvae), including pathogenic fungi (e.g. *Beauveria bassiana*), predatory bugs, carabid beetles and parasitic wasps.

Resistance Status

Insecticide resistance to modern insecticides has been recorded in the Colorado potato beetle since the early 1950's, when resistance to organchlorine insecticides was found in the USA and Europe.

During the 1970 to the mid-1990's carbamate, organophosphate (Group 1) and pyrethroid (Group 3) insecticides were widely used in both North America and Europe for potato beetle control. In some areas of the USA over-use resulted in resistance to all chemical insecticide options available. Resistance to carbamate, organophsphate and pyrethroid insecticides were also reported in Europe, albeit more sporadically than in North America. Although selection pressure was subsequently reduced, the use of group 1 and group 3A insecticides should only be considered with caution and knowledge of the local resistance situation. Resistance to Group 1 & 3 insecticides has been associated with a number of different resistance mechanisms, including enhanced metabolism and target site insensitivity. In the cases of enhanced metabolism there is some evidence to suggest cross-resistance amongst the chemical classes and therefore rotation amongst these MoA groups alone is not recommeded.

Resistance to the neonicotinoid insecticides (Group 4A) was first reported five years after registration in the USA. Subsequent reports of resistance have been made across several US states and Canada, however issues are much less prominent in Europe. Although the performance of Group 4A insecticides can not be assured in several regions in North America they may still provide a useful tool in pest management, especially as they can be used as either foliar treatments or systemic tuber treatments. It is recommended to monitor the performance of these products and consult with local crop advisors on their use.

There have been limited reports of resistance to other insecticides registered for the control of Colorado potato beetle, including avermectin, spinosad, nereistoxin's and diamides, however as yet these appear to be limited to localised occurences.

Table 1: Insecticide modes of action which are registered for the control of CPB and known resistance.
(Not all insecticides groups will be registered for use in all regions and crops. The likely absence of any insecticides belonging to a MoA group within a region is indicated by a grey box. Consult with local advisors to confirm product availability)

Primary Site of Action (MoA)	MoA Group	Insecticide Chemistry	*North America*	*Europe & Asia*
Acetylcholinesterase inhibitors	1A	Carbamates	XXX[1]	XXX
	1B	Organophosphates	XXX	XXX
GABA gated chloride channel blockers	2A	Cyclodiene organochlorines	XXX	XXX
	2B	Phenylpyrazoles (Fiproles)		
Sodium channel modulators	3A	Pyrethroids	XXX	XX
Nicotinic acetylcholine receptor competitive modulators	4A	Neonicotinoids	XX	(X)
Nicotinic acetylcholine receptor allosteric modulators	5	Spinosyns	(X)	
Glutamate-gated chloride channel allosteric modulators	6	Avermectins	(X)	
Microbial disruptors of insect midgut membranes	11A	*Bacillus thuringiensis*	(X)	
Nicotinic acetylcholine receptor channel blockers	14	Nereistoxin analogues		X
Inhibitors of chitin biosynthesis, type 0	15	Benzoylureas		
Moulting disrupter: Dipteran	17	Cyromazine		
Mitochondrial C-I electron transport inhibitor	21A	METI insecticide		
Voltage-dependent sodium channel blockers	22A	Indoxacarb		
Ryanodine receptor modulators	28	Diamides	(X)	
Compounds of unknown mode of action	UN	Azadirachtin		
		Cryolite		

[1]XXX = widespread reports of resistance, XX = resistance reported in several locations, X = isolated instances of resistance, (X) = rare cases of resistance, no entry = unknown. The information presented in this table is based on peer-reviewed published reports of field collected populations of *Leptinotarsa decemlineata* 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 may not exactly reflect the current status of insecticide resistance in all countries or locations.

Resistance Management

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 development. The following should be considered when designing a control programme for Colorado potato beetle:

- Plan ahead. Determine when in a typical season insecticide 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 occuring 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 overap with Colorado potato beetle, 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 arthropds and natural predators, especially during early season applications, where maintaining natural predators can reduce the need for later sprays.
- Consider planting the crop at different timings to avoid peak pest pressure, use straw-mulch to reduce beetle populations and consider the use of biological control agents.
- Always follow insecticide label instructions for application timings, volumes and concentrations.

Susceptibility Monitoring

The susceptibility of Colorado potato beetle and other leaf feeding coleoptera and lepidoptera can be conducted by using leaf dip assays, as described in the IRAC approved method No. 007.

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 Coleoptera WG, April 2016 Photograph credit to Ralf Nauen.

CropLife

OSR IRM trifold – under revision

IRAC

Oilseed Rape Pest Resistance Management

IRAC

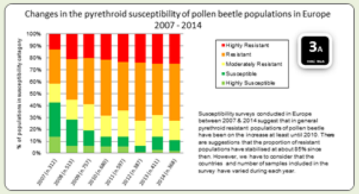
Insect pests of oilseed rape

Pollen Beetle
(*Meligethes aeneus*)

Pollen beetles are considered to be one of the most important pests of oilseed rape.

Although there are a number of species associated with the pollen or blossom beetle complex, but it is *Meligethes aeneus* that is considered the most critical pest. Adult beetles emerge from hibernation during the early spring before moving into oilseed rape fields. The adult beetles bite small holes into the developing buds into which the females lay their eggs. The damage caused by the adults and subsequently by the larvae which develop inside the buds can prevent flower and eventual pod formation. The damage to oil yields can be significant if beetle populations density is high. The beetles are found across the oilseed rape growing regions of Northern, Central and Eastern Europe.

Resistance to pyrethroids has been reported in this species since 1999. Initial reports suggest that pyrethroid resistance first occurred in North East France and over the following years has spread to other countries in Europe.



There is currently no evidence to suggest that pollen beetles have developed resistance to any of the other insecticide modes of action registered for the control of pollen beetle in Europe, however availability of these control options may differ between individual countries.

	IRAC MoA Classification
Organophosphates	Group 1
Pyrethroids	Group 3
Neonicotinoids	Group 4
Pymetrozine	Group 9
Indoxacarb	Group 22

Cabbage Stem Flea Beetle
(*Psylliodes chrysocephala*)

Flea beetles are an important pest of young oilseed rape seedlings.

Several species of flea beetles can be considered to be pests of oilseed rape, including the turnip flea beetle (*Phyllotreta atra*), and the striped flea beetle (*Phyllotreta striolata*), but it is the cabbage stem flea beetle (*Psylliodes chrysocephala*) that is the most widespread and important species. Adult beetles will attack young oilseed rape seedlings in autumn, feeding on the plant leaves. Larvae also emerge for eggs laid by the adults in the soil and then burrow into the stem of the young seedling. Cabbage stem flea beetles are most abundant in central and northern Europe, but they can also be found in other parts of Europe alongside other flea beetle species. The damage are caused by the adults and larvae

Pyrethroid resistance was first reported in populations of cabbage stem flea beetle in 2008. Although resistance is not considered to be as widespread or as impactful as with pollen beetle, resistant populations have been identified in the UK, France & Germany in 2014 and 2015.

In many countries there are no registered alternatives to pyrethroid insecticides. In some countries organophosphate or neonicotinoid insecticides (foliar) may be available as emergency registrations.

Stem & Seed Weevils
(*Ceuthorhynchus spp.*)

The majority of the stem and seed weevils are active from early spring through to the summer.

The main species of oilseed rape weevils include the cabbage stem weevil (*C.pallidactylus*) and the rape stem weevil (*C.napi*) which both emerge from hibernation in spring to lay eggs on the oilseed rape plant and the resultant larvae tunnel into the plant stem. Adult cabbage seed weevil (*C.obstrictus*) cause more significant damage to the seed pods either by direct feeding or creating entry points for pod midges. Pyrethroid resistance (kdr) of this species has been sown in France and Germany.

The rape winter stem weevil (*C.picitarsis*) perfers to target young rape plants during the winter. Eggs laid on the plant hatch during autumn and feed in the young plant stems. This species is most common in France, Germany and the UK.

Pyrethroid resistant individuals of all four species have been identified in field populations collected from various parts of Europe. Currently resistance does not appear to be widespread, but care should be taken when utilising pyrethroid insecticides.

Summer & Winter Aphids
(*Myzus persicae*) &
(*Brevicoryne brassicae*)

The green peach aphid (*Myzus persicae*) can attack young oilseed rape plants in the autumn. Although they do little damage by direct attack, they are the primary vector for Turnip Yellows Virus (TuYV). The green peach aphid has developed resistance to many of the insecticides used for its control. Resistance to pyrethroids, carbamates, organophosphates are widespread in Europe and care should be taken in their use.

The mealy cabbage aphid (*Brevicoryne brassicae*) can sometimes be found in spring and summer. Although direct damage is rare, large populations can damage seed development.

Brassica Pod Midge
(*Dasineura brassicae*)

Brassica pod midges lay their eggs preferably in the holes created by seed weevils.

The eggs quickly hatch into larvae, which feed inside the pod on the developing seeds. There are usually two or more generations per year. Attacked pods open before ripening and the seeds are lost.

There is no recorded evidence of pod midges developing resistance to insecticides.

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Pollen beetle: list of references

Pollen beetle: list of selected references

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Coleoptera WG objectives
(to be updated soon)

TEAM OBJECTIVES:

- To expand the remit of the team to include prioritised activties against a wider range of coleoptera pests.
- To provide researchers, validated methods for measuring the susceptibility of coleopteran pests.
- To provide summarised information to growers and influencers on available control options and strategies for controlling key coleoptera pests (posters, leaflets, etc).
- To co-ordinate oilseed rape coleoptera sensitivity monitoring in European oilseed rape crops, using validated methodologies.
- To provide oilseed rape pest sensitivity information to growers and regulators, so that informed decisions on oilseed rape pest control and resistance managment can be made.

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