Findings of insecticide monitoring in Nordic and Baltics

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Key findings

Pollen beetles:

- λ-cyhalothrin resistance is widely spread throughout the region. Efficacy of 75 ng/cm^2 λ-cyhalothrin was maintained in the Nordic countries, but decreased in the Baltic countries from 2016 to 2018
- τ-fluvalinate remains effective. However, susceptibility seems to decrease in recent years
- Thiacloprid remains effective. However, susceptibility in the Baltic countries seems to decrease in recent years
- Acetamiprid remains effective, based on data from Sweden and Denmark

Cabbage seed weevil:

- Full mortality of cabbage seed weevils was achieved with λ-cyhalothrin, τ-fluvalinate and thiacloprid at 100% field rate in all tested population samples (Swedish data) over a three-year period.

Introduction

This report aims to give a short and concise overview of the data obtained by members of the NorBaRAG insecticide subgroup from 2016-2018 and described the overall trends observed for resistance monitoring over a three-year period for pollen beetles. Furthermore, trials on resistance monitoring of the cabbage seed weevil, conducted in 2017 and 2018 are included.

In addition to this report, a poster of pollen beetle monitoring data for λ-cyhalothrin, τ-fluvalinate and thiacloprid from 2014-2018 was been created, to give an overview of the development of efficacy based on the two EPPO climatic zones represented by the Nordic and Baltic countries.

All members of NorBaRAG are encouraged to contribute to the collection of data for future reports by sending an overview of data to the insecticide subgroup chair. A range of actives were tested according to appropriate IRAC methods.

Method

A total of four active substances with two different modes of action were tested using standard IRAC susceptibility test methods. The tested actives were λ-cyhalothrin, τ-fluvalinate (synthetic pyrethroids), thiacloprid and acetamiprid (neonicotinoids).

The standard IRAC susceptibility test is performed as an Adult Vial Test (AVT), where the effect on insects by several dose rates are tested. Glass vials are coated with the relevant active by adding the dissolved active to the vials and letting the solvent evaporate under rotation of vials. Glass vials coated with acetone functions as control treatment.

Figure 1: Example of adult vial test

The target insects (normally 10 per vial) are placed in glass vials coated with the relevant insecticide active for 24 hours, after which number of affected and alive beetles are noted and %affected beetles is calculated. In some cases, the insects are moved to control vials for recovery. To ensure movement, pollen beetles should be exposed to light during the experiment.

Active	**Mode of action (IRAC)**	**IRAC Method used**	**Amount of active tested (ng/cm^2)**
λ-cyhalothrin	Pyrethroid (3A)	Method 011, Method 031	75
τ-fluvalinate	Pyrethroid (3A)	Method 011, Method 031	480
Thiacloprid	Neonicotinoid (4A)	Method 021	720
Acetamiprid	Neonicotinoid (4A)	Method 021	400

Methods 011 and Method 021 are developed for testing pollen beetles, while Method 031 was developed for testing a range of flea beetles and weevils. A specific IRAC method for testing the effect of neonicotinoids on weevils is not available. In that case, the IRAC method developed for pollen beetles was used for testing the cabbage seed weevil. For more information on specific IRAC methods, please see https://www.irac-online.org/methods/.

The monitoring results are divided into two parts, presenting data for pollen beetles and cabbage seed weevils separately. The monitoring data for each of the tested actives are discussed separately for each of the two insect species.

Brassicogethes aeneus

Brassicogethes aeneus (also known as *Meligethes aeneus*) is an important pest of oilseed rape particularly in Western Europe. The larvae are up to 3 mm long and white with brown sclerotised plates. Eggs are laid in the flower buds of the host-plant. The larvae develop within the flowers. Oviposition damage to the buds of oilseed rape can cause the flowers to drop off. Both adults and larvae feed on the pollen and nectar in the flowers.

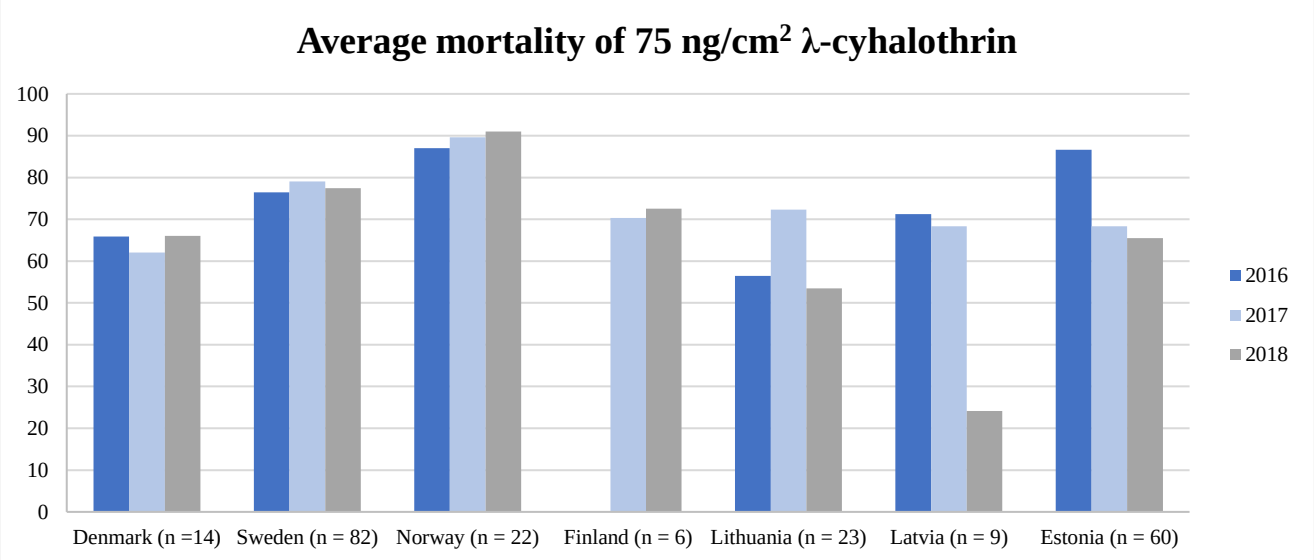
Resistance to pyrethroids has been reported in this species since 1999, especially against λ-cyhalothrin. Initial reports suggest that pyrethroid resistance first occurred in North East France and over the following years has spread to other countries in Europe. Investigations into the mechanism of resistance has primarily identified enhanced metabolism by P450 monooxygenases as the prime mechanism of resistance to pyrethroids. More recently, a target site mutation has been identified in some λ-cyhalothrin resistant populations from Denmark and Sweden[1].

λ-cyhalothrin

IRAC Method 011 tests the effect of synthetic pyrethroids, including λ-cyhalothrin, on pollen beetles in a laboratory setting. It is widely used for monitoring of sensitivity of *B. aeneus* throughout Europe. Beetles are placed in glass vials coated with λ-cyhalothrin for 24 hours, after which number of affected and alive beetles are noted and %affected beetles is calculated. Glass vials coated with acetone functions as control treatment.

The presented data represent the efficacy of 100% field rate (7.5 g/ha λ-cyhalothrin). Please note that 100% field rate tested in IRAC methods might not correspond to 100% field rate approved in the different countries.

Data was obtained from Latvia, Estonia, Lithuania, Finland, Denmark, Norway and Sweden. No data from 2016 in Finland was available. A total of 216 population samples were collected and tested in the lab against λ-cyhalothrin. Samples where the control mortality was above 20% were not included.



The average mortality of beetles exposed to 75 ng/cm^2 λ-cyhalothrin remained at a similar level in Denmark, Sweden, Norway and Finland over a three-year period. A similar level of susceptibility was also observed for Lithuanian data from 2016 and 2018. However, in 2017 a small spike of susceptibility was observed. For Latvia and Estonia, mortality by λ-cyhalothrin on pollen beetles seems to decrease over time, with a significant drop in Latvia in 2018. Most of the pollen beetle population samples were resistant to λ-cyhalothrin to various degree, indicating a possible issue with controlling pollen beetles in the field.

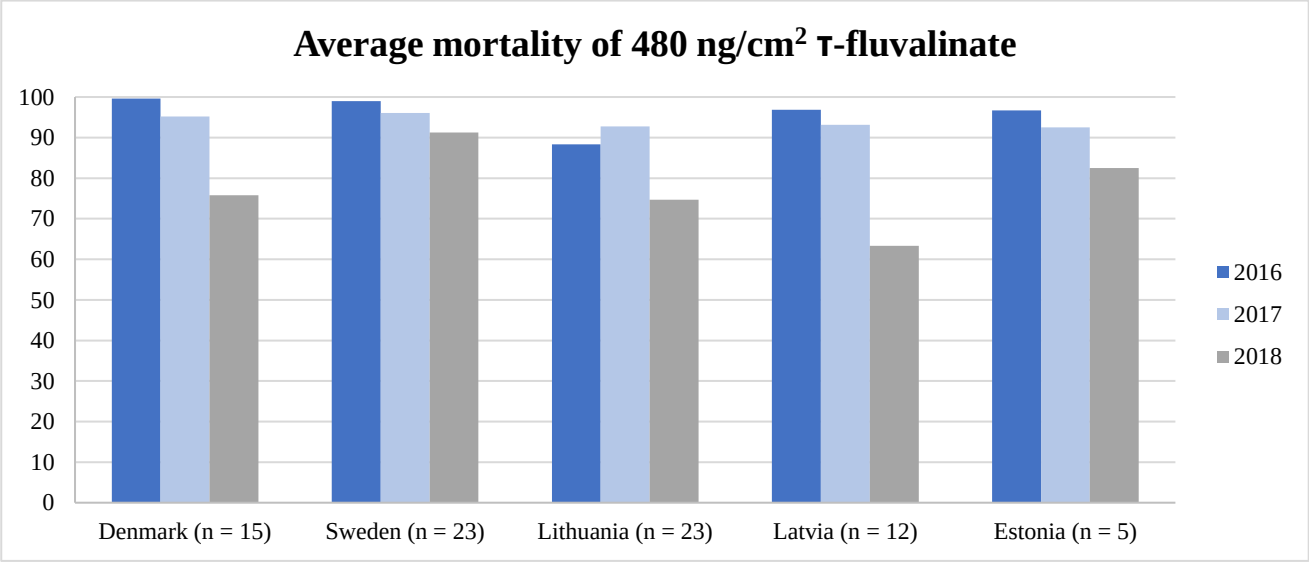
[1] Kaiser, C., Jensen, KM.V., Nauen, R. et al. J Pest Sci (2018) 91: 447. https://doi.org/10.1007/s10340-017-0856-x

τ-fluvalinate

IRAC Method 011 tests the effect of synthetic pyrethroids on pollen beetles in a laboratory setting. The standard of Method 011 is λ-cyhalothrin, however, τ-fluvalinate can also be tested with this method as long as differences in inherent potency is considered. Like for λ-cyhalothrin, beetles are placed in glass vials coated with τ-fluvalinate for 24 hours, after which number of affected and alive beetles are noted and %affected beetles is calculated. Glass vials coated with acetone functions as control treatment.

The presented data represent the efficacy of 100% field rate (48 g/ha τ-fluvalinate). Please note that 100% field rate tested in IRAC methods might not correspond to 100% field rate approved in the different countries.

Data was obtained from Latvia, Estonia, Lithuania, Denmark and Sweden. No data from Finland was available and only 2018 data exists for Norway. A total of 78 population samples were collected and tested in the lab against τ-fluvalinate. Samples where the control mortality was above 20% were not included.



The average mortality of beetles exposed to 480 ng/cm^2 τ-fluvalinate was above 88% in all countries in 2016 and 2017. However, the 2018 data suggests that susceptibility of pollen beetles against τ-fluvalinate is decreasing. This was the case for both the Nordic and the Baltic countries. The shift in susceptibility was most expressed in Denmark, Lithuania and Latvia.

Conclusion on pyrethroids

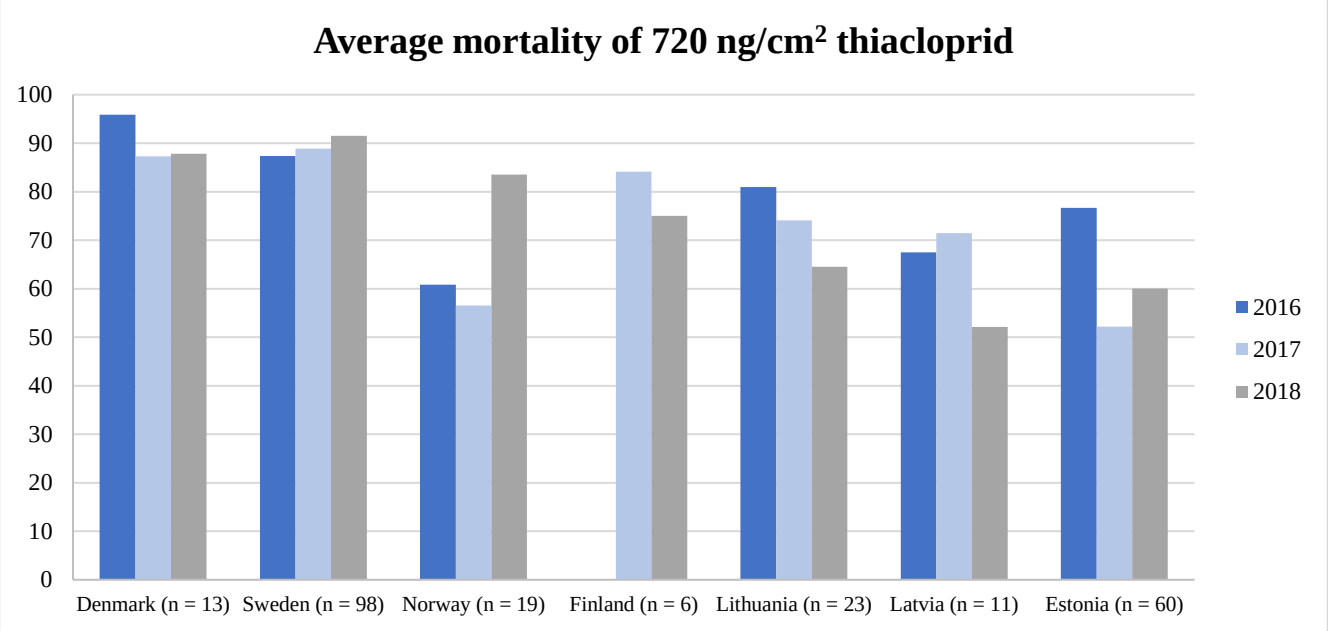
Both λ-cyhalothrin and τ-fluvalinate function as sodium channel modulators, stimulating repetitive nerve discharges, leading to death through paralysis. Results obtained in the laboratory setting using the adult vial test is not directly referable to field performance of the product but can give indications of possible control issues. Based on 2016-2018 trials, control issues for λ-cyhalothrin might already be present in the field as data show a large proportion of resistant population samples. The efficacy of 100% field rate of τ-fluvalinate was higher than that of λ-cyhalothrin, but for both actives, susceptibility seems to decrease over the three-year time frame.

Thiacloprid

Method 021 tests the effect of neonicotinoids on pollen beetles in a laboratory setting. The standard neonicotinoid used is thiacloprid. This method is widely used for thiacloprid monitoring purposes for *M. aeneus* throughout Europe. Beetles are placed in glass vials coated with thiacloprid for 24 hours, after which number of affected and alive beetles are noted and % of affected beetles is calculated.

The presented data represent the efficacy of 100% field rate (72 g/ha thiacloprid). Please note that 100% field rate tested in the IRAC method might not correspond to 100% field rate approved in the different countries.

Data was obtained from Latvia, Estonia, Lithuania, Finland, Denmark, Norway and Sweden. No data from 2016 in Finland was available. A total of 217 population samples were collected and tested in the lab against thiacloprid. Samples where the control mortality was above 20% were not included.



The average mortality of beetles exposed to 720 ng/cm^2 thiacloprid remained at a similar level in Denmark, and Sweden over a three-year period with efficacies above 87%. Data for Norway suggest an increase in susceptibility in 2018 compared to that of the previous two years. For Lithuania, Latvia and Estonia, mortality by thiacloprid on pollen beetles seems to decrease over time. A similar decrease of susceptibility was also observed for Finnish data from 2016 and 2017. Based on a baseline study[2] of the sensitivity of pollen beetles against thiacloprid, the expected mortality values when applying 720 ng/cm^2 was obtained in Denmark and Sweden, while susceptibility was lower for the remaining countries. The shift in susceptibility in recent years could indicate a possible issue with controlling pollen beetles in the field.

Acetamiprid

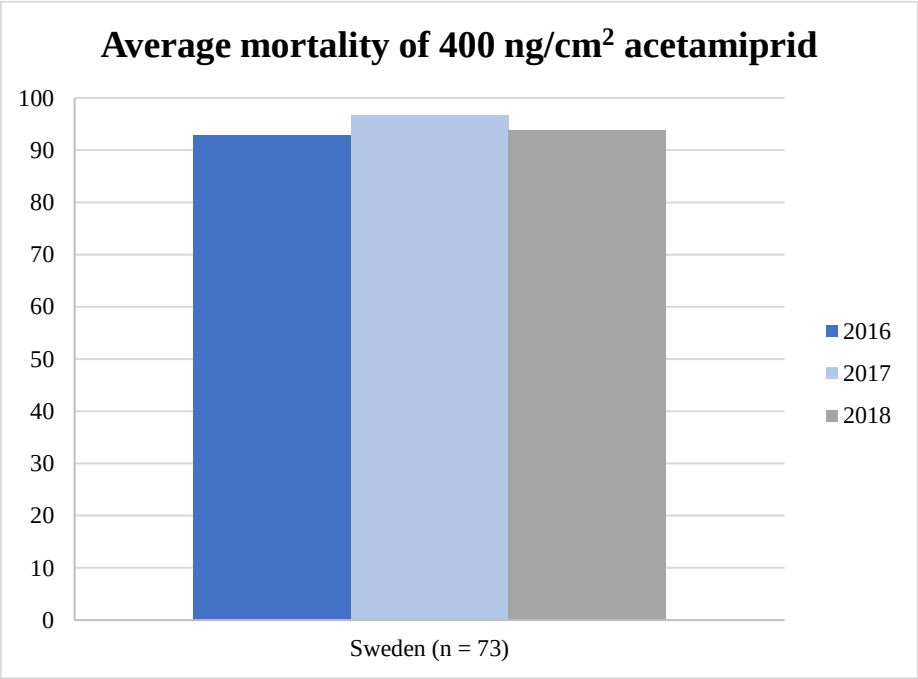
Method 021 tests the effect of neonicotinoids on pollen beetles in a laboratory setting. The standard neonicotinoid used is thiacloprid, however, acetamiprid can also be tested with this method as long as differences in inherent potency is considered. Both acetamiprid and thiacloprid belong to the group of chloropyridinyl neonicotinoids, so it is sensible to also use Method 021 for the monitoring of acetamiprid.

[2] Zimmer, C. T. and Nauen, R. (2011), Pyrethroid resistance and thiacloprid baseline susceptibility of European populations of Meligethes aeneus (Coleoptera: Nitidulidae) collected in winter oilseed rape. Pest. Manag. Sci., 67: 599-608. doi:10.1002/ps.2137

Like for thiacloprid, beetles are placed in glass vials coated with acetamiprid for 24 hours, after which number of affected and alive beetles are noted and %affected beetles is calculated. Glass vials coated with acetone functions as control treatment

The presented data represent the efficacy of 100% field rate (40 g/ha acetamiprid). Please note that 100% field rate tested in IRAC methods might not correspond to 100% field rate approved in the different countries.

Data was obtained from Sweden, where a total of 73 population samples were collected and tested in the lab against acetamiprid. Samples where the control mortality was above 20% were not included. Furthermore, two population samples were tested in 2017 in Denmark, both showing full mortality of pollen beetles at 400 ng/cm^2 acetamiprid.



The average mortality of beetles exposed to 400 ng/cm^2 acetamiprid was above 90% in all three years. This was also the case for the two Danish samples tested in 2017. The data suggest that currently there is no issues in control of pollen beetles, at least in Sweden and Denmark. More data is required if possible control issues of pollen beetles for the full NorBaRAG zone should be addressed.

Conclusion on neonicotinoids

Both thiacloprid and acetamiprid function as postsynaptic nicotinic acetyl choline receptor modulators, stimulating repetitive nerve discharges, leading to death through paralysis. Results obtained in the laboratory setting using the adult vial test is not directly referable to field performance of the product but can give indications of possible control issues. A total of 217 population samples from Scandinavia and the Baltics were collected and tested against thiacloprid. Based on 2016-2018 trials, control issues for thiacloprid might already be present in the field as data show a large proportion of populations with decreased efficacy of thiacloprid, especially in the Baltics. However, thiacloprid remains effective in controlling pollen beetles in most of the NorBaRAG countries. A total of 73 population samples from Sweden and two from Denmark were collected and tested against acetamiprid. Based on these data, there is no issues in acetamiprid control of pollen beetles currently, but more data is required to give the full overview of the NorBaRAG countries.

Ceutorhynchus obstrictus

C. obstrictus is native to Europe, where it is a major pest of oilseed rape. Like the pollen beetle, they emerge in early spring. Females lay their egg(s) in pods of oil seed rape and larva fed of the pods, possibly causing great harm. Despite that the main damage is caused by feeding larva, newly emerged adults can also cause damage to the pods by feeding before hibernation.

λ-cyhalothrin and τ-fluvalinate

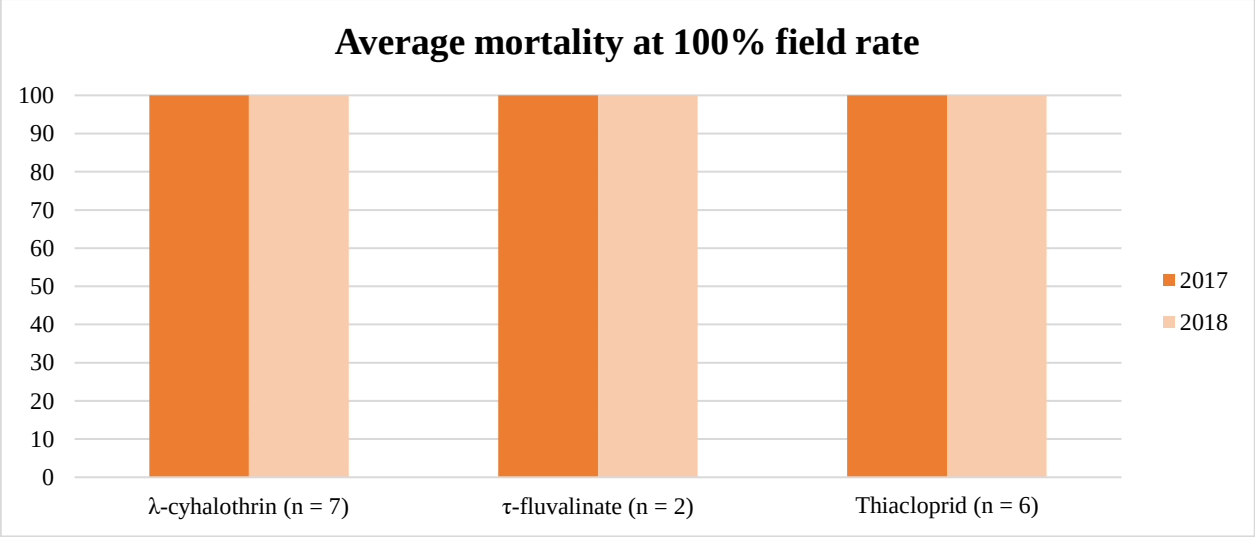
IRAC Method 031 has been developed to assess the effect of synthetic pyrethroids such as λ-cyhalothrin and τ-fluvalinate on flea beetles and weevils in a laboratory setting. Target species include *Ceutorhynchus* spp., *Phyllotreta* spp and *P. chrysocephala*. The method is widely used for monitoring of λ-cyhalothrin and τ-fluvalinate sensitivity throughout Europe. The standard of Method 031 is λ-cyhalothrin, however, τ-fluvalinate can also be tested with this method as long as differences in inherent potency is considered. Weevils are placed in glass vials coated with the relevant pyrethroid for 24 hours, after which number of affected and alive weevils are noted and % of affected weevils is calculated. Glass vials coated with acetone functions as control treatment.

Thiacloprid

As mentioned, no specific IRAC method for testing the effect of neonicotinoids on weevils is available currently. Therefore, the IRAC method developed for pollen beetles was used for testing the cabbage seed weevil. Like for IRAC method 021, weevils are placed in glass vials coated with thiacloprid for 24 hours, after which number of affected and alive weevils are noted and % of affected weevils is calculated. Glass vials coated with acetone functions as control treatment.

The presented data represent the efficacy of 100% field rate (75 ng/cm^2 λ-cyhalothrin, 480 ng/cm^2 τ-fluvalinate and 720 g/ha thiacloprid) for the three tested insecticides. Please note that 100% field rate tested in IRAC methods might not correspond to 100% field rate approved in the different countries.

Data was obtained from Sweden in 2017 and 2018. A total of 15 population samples were collected and tested in the lab against the three insecticides. Samples where the control mortality was above 20% were not included.



Full mortality of cabbage seed weevils was achieved with λ-cyhalothrin, τ-fluvalinate and thiacloprid at 100% field rate in all tested population samples. The data suggest that currently there is no issues in control of

cabbage seed weevils, at least in Sweden. More data is required if possible control issues of cabbage seed weevils for the full NorBaRAG zone should be addressed.

Overall conclusion

The susceptibility of pollen beetles and cabbage seed weevils over a three-year period against a range of insecticides was assessed. A total of four and three active substances with two different modes of action were tested using standard IRAC susceptibility test methods in pollen beetles and cabbage seed weevils, respectively.

A total of 584 population samples of pollen beetles were tested in 2016-2018 at 100% field rate. Results show that resistance against λ-cyhalothrin is widely spread throughout the region. Efficacy of 75 ng/cm^2 λ-cyhalothrin was maintained in the Nordic countries but decreased in the Baltic countries in recent years. For τ-fluvalinate, acceptable efficacy is maintained, however, susceptibility have decreased in recent years. Similarly, control with thiacloprid remains effective with a possible decrease of susceptibility in recent years in the Baltics. Acetamiprid was tested in Sweden and Denmark and showed average mortalities above 90%.

A total of 15 population samples of cabbage seed weevils from Sweden were tested in 2016-2018 against λ-cyhalothrin, τ-fluvalinate and thiacloprid. Full mortality of cabbage seed weevils was achieved with all three insecticides at 100% field rate.

Acknowledgements

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