Risk Assessment to Assess Potential Side Effect of Pesticides to Honeybees

An Industry Perspective

Christian Maus, Anne Alix, Diane Castle, Mike Coulson, John Cuffe, Gary Mitchell, Stella Simiyu-Wafukho, Helen Thompson & Steve Maund

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Introduction

- Safety to bees is one of the most crucial aspects of the environmental safety of pesticides
- This is substantiated by the particular importance of honeybees as pollinator of important agricultural crops, and as producer of honey and beeswax, as well as by the special trait of the honeybee which is a domestic animal on one hand, but at the same time an important element of agro-ecosystems on the other hand
- Risk assessment schemes and ecotoxicological study approaches have been developed to ensure bee safety of pesticides. These approaches need to be based on scientific principles
- Here, we outline a robust and easy-to-handle, but at the same time protective scheme that is based on the system which is currently being used in Europe (EPPO 170)
Fundamentals of Bee Testing and Risk Assessment

A science-based risk assessment should be:
- Tiered
- Hierarchical
- Risk-based rather than hazard-based

Test designs used for a science based risk assessment should be:
- Reproducible
- Validated
- Corresponding to the risk assessment
Fundamentals – Testing
Tiers and Hierarchy Levels

- A risk assessment scheme should be based on a system of different testing tiers
- These are made up by tests of different complexity and realism of design, which correspond to each other
  - **Lower-tier tests**: simple and easy-to-control setup, designed to detect intrinsic toxicity potential (frequently individual bees only)
  - **Higher-tier tests**: more complex and realistic setup, designed to evaluate risk potential under more realistic conditions (always whole colonies)
- Adverse effects seen in lower-tier tests can trigger higher-tier tests
- Results of higher-tier tests always override lower-tier test results
- Lower-tier tests may be omitted if higher-tier data are available
- Purpose: early filtering out those substances which have a toxicity potential to bees and focusing further evaluation efforts to those compounds which have a real toxicity potential
Fundamentals: Risk vs. Hazard

Risk = Exposure x Hazard

- **Exposure**: variable, depending on various factors, e.g. application rate and timing

- **Hazard**: invariable (intrinsic toxicity)

→ Toxicity does not equal risk. Therefore, a high intrinsic toxicity does not necessarily entail a high risk, and vice versa

→ Need for a risk-based Risk Assessment Approach that does not solely rely on intrinsic toxicity endpoints
Use of validated studies to generate reproducible results

- It is essential that tests used in a risk assessment generate reproducible results.
- It is relatively easy to develop a new test design, but by far more challenging do validate a design to make sure that it will generate reproducible results.
- Therefore, validation of test methods used (normally through ring-testing) is crucial. Application of non-validated may lead to erratic results.

Other key points

- **Safety** or **uncertainty factors** are in risk the assessment particularly useful in connection with **lower-tier studies**; on higher-tier data they are usually not applied, as these data reflect realistic conditions that ned no extrapolation.
- When evaluating higher-tier data, it is usually difficult to work with pre-defined universally valid acceptability criteria, due to complexity and variability of the system. **Therefore, expert judgment is always indispensable for the interpretation of higher-tier studies.**
Fundamentals: Summary

1. Tier: Laboratory
   - Realism of design
   - Complexity of design
   - Significance of results

2. Tier: Semi-Field

3. Tier: Field

Fundamentals:
- Lower-tier studies may trigger higher-tier studies
- Results of higher-tier studies override lower-tier results
- Possibility to omit lower-tier testing and do higher-tier testing instead
- Several study options in a toolbox approach
- Complemented by risk mitigation (avoiding exposure)
- Basis of current risk assessment systems in EU and US
Acute Laboratory Test (OECD 213/214)

- Relatively simple laboratory test to determine the intrinsic acute toxicity of substance or a product
- Separate tests to be conducted for oral and for contact toxicity
- Endpoint: LD50
- Design exactly prescribed by OECD Guidelines
- Required in Europe for each a.s. and for each product
Chronic Laboratory Test

- Laboratory study design in which bees are orally exposed to a test compound in spiked sugar solution
- Observation of mortality over 10 days, determination of NOEC
- Study design is occasionally applied, yet not validated nor established in a guideline
- Due to long exposure time, control mortality can be critical; conduction not trivial, but manageable
- Study can be helpful in particular as a lower-tier approach for the risk assessment for systemic compounds
- Design validation is envisaged
Bee Larval Laboratory Test

- Laboratory test for the determination of the intrinsic toxicity to bee brood
- Larvae are exposed in the laboratory under in vitro conditions
- Endpoints: LD50 or NOEC
- Entire larval development from early larval stage until adult hatch is covered
- In spite of the laboratory design, a complex and relatively difficult test the conduction of which can be challenging
- Acute design available, chronic design still in the development phase
- Results are covered - and overridden - by higher-tier testing
Bee Brood Feeding Test

- Test according to OOMEN et al. (1992) guideline; validation ongoing
- Bee hives are provided in-hive with 1 L sugar solution spiked with the test substance at the concentration of spray solution
- Placement of hives in a place with no alternative forage to ensure exposure
- Originally a specific test design to detect intrinsic larval toxicity
- However, can be easily modified to more realistic exposure conditions and be applied as a robust chronic life-cycle test for bee colonies
Semi-Field Test (Tunnel Test)

- Higher-tiered test design
- Is required when adverse effects have been seen in one of the previously discussed test approaches
- Conduction: Bee colonies are exposed to pesticide treatment according to agricultural practice in so-called tunnels made of insect-proof gauze
- Endpoints: mortality, flight activity, brood development, nectar and pollen foraging activity, colony strength, behavior, etc.
- Test guideline: EPPO 170, OECD 75
Field Test

- Highest tier test, very realistic test design
- To be conducted if adverse effects have been seen in a semi-field test
- Conduction: bee hives are set up in the field and exposed to crops that are treated under realistic agricultural conditions; isolation of test fields from each other and from other bee-attractive plants is of crucial importance
- Endpoints: mortality, flight activity, brood development, nectar and pollen foraging activity, colony strength, behavior, etc.
- Test guideline: EPPO 170 and OPPTS 850-3040
Risk Assessment Scheme

Soil-Systemic Applications (Seed Treatment, Drench, etc.)
- Exposure Possible
  - Acute Oral Toxicity Test (Laboratory)
    - TER Calculation
      - TER < 10
        - Chronic Oral Toxicity Test (Laboratory) (optional)
          - TER < 1
    - TER < 10
  - HQ Calculation
    - HQ > 50
      - Semi-Field Test
        - Adverse Effects
      - TER < 1
  - Adverse Effects

Foliar Applications
- Exposure Possible
  - Acute Oral Toxicity Test (Laboratory)
    - TER Calculation
      - TER < 10
      - Chronic Oral Toxicity Test (Laboratory) (optional)
        - TER < 1
    - TER < 10
  - HQ Calculation
    - HQ > 50
      - Semi-Field Test
        - Adverse Effects
      - TER < 1
  - Adverse Effects

Additional for IGRs / Larvicidal Products
- Exposure Possible
  - Larval Test (Laboratory) or Brood Feeding Test
    - Adverse Effects

Risk Mitigation Measures
- Adverse Effects
The Hazard Quotient (HQ) Approach - From Lower Tier to Higher Tier

The Hazard Quotient is an empirical Tier 1 risk indicator.

\[ HQ = \frac{\text{maximum application rate}}{LD_{50} \text{ (oral and contact)}} \times \frac{[\text{g a.i. / ha}]}{[\mu\text{g a.i. / bee}]} \]

- **<50**: Risk to honey bees can be considered to be negligible.
- **≥50**: Additional clarification is needed to better capture a potential risk, i.e. higher-tier studies or consideration of mitigation measures.
The HQ has been empirically validated by the evaluation of extensive data on bee toxicity of many compounds and their likelihood to be involved in incidences of bee intoxication in the field (ALDRIDGE & HART 1993).
Safety Measures and Risk Mitigation Options

If, as an outcome of the risk assessment, effects on honey bees by the application of a pesticide cannot be excluded, aspects of application practices may be considered for modification in order to mitigate a potentially predicted risk, for instance:

- Application rate
- Application timing (for example application in the evening, after daily bee flight)
- Avoiding of application during crop bloom
- Agronomic practice (e.g. removal of blooming weeds in the culture prior to application)

All these measures are aiming at reducing or preventing the exposure of bees and other pollinators to insecticides.
Some European countries have an official bee incident recording system (e.g. UK, Netherlands, and Germany). Statistics on pesticide-related bee incidents show a continuously decreasing trend over the last decades.

In most countries, absolute number of incidents is low (e.g. Germany ca. 50 incident per year vs. ca. 800,000 colonies; UK only ca. 5 incidents per year).

This clearly confirms the protectiveness of the test and risk assessment system.
Protectiveness of the Risk Assessment System – Evidence from Bee Monitoring

Example: The German Bee Monitoring

- Large-scale multi-stakeholder multifactorial monitoring project to analyze parameters affecting bee health and to investigate factors contributing to honeybee colony losses
- Project ongoing since 2004. More than 1200 bee hives from 120 apiaries distributed all over Germany are regularly assessed

Findings:

- No correlation between colony mortality and pesticide residues in hives;
- No correlation between colony mortality and exposure to pesticide-treated agricultural crops

- Similar projects have on smaller scale been conducted in many other European countries; in the vast majority of cases, no correlation between colony mortality and pesticide exposure been found
Conclusions

- Bee testing and risk assessment should be pragmatic and rely on scientific principles
- Risk assessment schemes should be risk- rather than hazard-based, tiered and hierarchical
- Testing methods should correspond to the risk assessment scheme and rely on validated methods
- For bee testing, a broad variety of internationally accepted, validated methods is available
- A risk assessment system which has proven to be robust, pragmatic, and protective in Europe is the EPPO 170 System.
- The well-proven EPPO System can be seen as a good paradigm for the development of bee risk assessment approaches beyond Europe
THANK YOU FOR YOUR ATTENTION!