Section 1 – Risk Assessment/Risk management

1.1.P Precision farming – consideration of reduced exposure in the pollinator risk assessment

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DOI 10.5073/jka.2020.465.039

Abstract

Observed declines in the distribution and abundance of various insect species have moved the topic of biodiversity and the protection of honey bees, an insect species of particular economic interest, into the focus of public attention. This also resulted in an increasing public pressure to reform the European agricultural policy and as part of this to minimise the amount of synthetic plant protection products used.

In this context, so-called ‘precision farming’ offers a considerable potential for a reduced application of plant protection products by using precision application techniques that allow to adjust applications to the actual scale of target distribution within a field. Is however currently not possible to exactly quantify the subsequent decrease of exposure of non-target organisms. Focusing on honey bees, the authors are therefore in a first step proposing a field study design to quantify the direct and indirect exposure of honey bees and their colonies in relation to the ratio of treated to untreated field area and the application pattern used. Furthermore, parameters of the bee risk assessment scheme are discussed that could be suitable to describe exposure reduction by precision application.

Keywords: precision farming, precision application, plant protection product, honey bees, exposure

Introduction

Recent publications on severe declines in the distribution and abundance of various insect species and the potential reasons for this trend (see e.g. DNR 2018, NABU 2018, Sánchez-Bayo & Wyckhuys 2019, Seibold et al. 2019) as well as citizens' initiatives on the protection of bees (two European Citizens Initiatives in 2019) have moved the topic of biodiversity into the focus of public attention. Consequently, European agricultural policy is under increasing public pressure to reorient the current agricultural practice in the European Union in general and in particular to minimise the amount of synthetic plant protection products applied and to reform the criteria for their authorisation and use (EU 2009a, FMFA 2013).

In this context, modern technological developments in the field of precision farming offer a considerable potential for a reduced use of plant protection products (e.g. Heege 2013) and thus for a decreased exposure of non-target organisms to plant protection products by adjusting applications to the actual scale of target (i.e. in-crop arthropods and weeds or fungi on crop plants) distribution within a field.

In the following, we exemplarily discuss the potential of precision application of plant protection products for the exposure reduction of adult honey bees, an economically and ecologically important insect group of particular public interest, and their colonies. In addition, a study design is proposed to further examine the relationship between the ratio of treated to untreated field area, application pattern and bee exposure.

Moreover, suggestions are made, how to include the resulting reduced exposure of honey bees into the honey bee risk assessment according to the ‘EFSA Guidance Document on the risk assessment of plant production products on bees’ (EFSA 2013) (hereafter called EFSA Bee GD). Parameters of the bee risk assessment scheme are discussed that could be suitable to describe risk mitigation by the precision application of plant protection products.

Examples for precision application equipment to reduce the area where plant protection products are applied

For the purpose of precision control of fungal diseases, insect pests and weeds, a wide range of application techniques for site/target-specific and small scale application are available or in the development stage. These application techniques may have further components to determine the spatial distribution of the target in real time. Such techniques are for example:

- Pulse-width modulation sprayers, allowing variable application rates across fields by quick flow rate changes and individual spray nozzle control (see Fig. 1a; see e.g. Butts *et al*. 2018)
- Direct injection spraying, allowing application of different plant protection products on sub-areas (*e.g*., Clarke 2018)
- Field sprayers or robots equipped with sensing devices and sprayer systems allowing real time, targeted spot applications on weeds (see Fig. 1b & c, 2; *e.g*., Scholz *et al*. 20014).

Fig. 1 Exemplary precision spraying systems – pulse width modulation (a), patch spraying of the SmartSprayer joint project (b), Bonirob (c)

Exposure routes of honey bees to plant protection products and the potential benefits of 'precision farming'

Within any agricultural landscape, there are several potential exposure routes for honey bee to plant protection products (Gradish *et al*. 2018). When considering the worst-case exposure situation of bees foraging in a flowering, bee attractive crop, the following main exposure routes to sprayed plant protection products or their residues, respectively, are relevant:

- Adult bees: contact exposure via spray deposits (i.e. overspray or spray drift) during foraging activity;
- Adult bees: oral exposure via pollen & nectar collected as food within the treated field (from crop and weed plants);
- Bee larvae: oral exposure via consumption of pollen and nectar collected by forager bees in the treated field and supplied as food to larvae

In contrast to overall spraying, the use of precision application techniques creates the possibility to reduce the share of treated area within a field. This reduction of treated in-field area will result in a declining number of (A) over-sprayed bees and (B) forage plants (crop plants and weeds growing in the field and close by) and subsequently in a decrease of the overall residue level in pollen and nectar collected in the field by the entire colony.

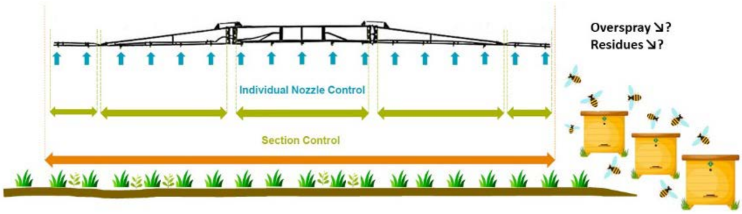

Fig. 2 Exposure of honey bees foraging within a field treated with precision application techniques

The authors would like to put forward the hypothesis that the decrease of exposure of an entire bee colony is proportional to the share of treated area within the field and that at a given ratio of treated to untreated field area, the reduction in exposure is independent from the application pattern.

Verification of the hypothesis on the correlation of application scheme and honey bee exposure

The following field study design is envisaged to verify the above given hypothesis. The scheme is based on EPPO (2010), EFSA Bee Guidance (2013) and current recommendations of the ICPPR WG on honey bee field testing:

- Use of several fields of a flowering and bee attractive crop (*e.g*., rape, mustard, buckwheat, phacelia);
- Fields of appropriate and uniform size (*e.g*., 2-3 ha with sparse alternative forage nearby);
- Honey bee hives located at the field border;
- Spray application of a non-toxic, hydrophilic (not bounding to wax) tracer;
- Use of a tracer to determine the proportion of bees topically contaminated via over-spray or spray drift (*e.g.,* via tracer colour by recording bees with digital monitoring devices);
- Determination of the amount of tracer as residue surrogate in pollen and nectar entering the hive by 'residue' analysis in these matrices obtained from returning honey bees (*i.e*., honey sac dissection, pollen loads);

The study set-up needs to include overall and partially sprayed fields; the latter with different application patterns, in sufficient replication (Fig. 3). For partially sprayed fields, ratios of 1 (treated): 1 (untreated) (Fig. 3b & c & d), 3 : 1 (Fig. 3e), *etc.* should be considered to investigate potential correlations of application scheme and exposure.

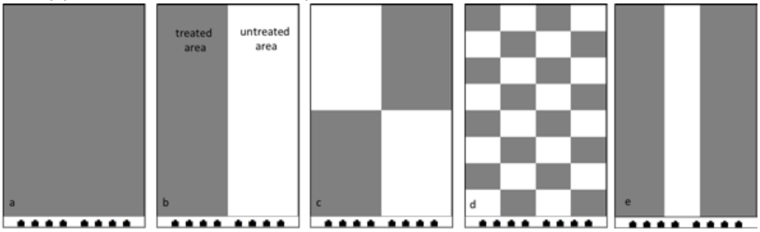

Fig. 3 Illustration of different application patterns to investigate contact exposure proportions of foraging bees and residue levels of pollen and nectar entering the hives ((a) total area treated, b) to d) ratio of treated vs. untreated area 1:1, in different application patterns, e) ratio treated vs. untreated area 3:1; ☗ honey bee hives located at the field border

Consideration of precision application in the honey bee risk assessment for plant protection products

The benefits of reduced exposure of honey bee colonies by precision application could be used in the honey bee risk assessment conducted for the placing of plant protection products on the market according to Regulation (EC) No 1107/2009 (EU 2009b).

The current risk assessment procedure described in the EFSA Bee Guidance Document (GD) assumes uniform exposure of foraging honey bees and uniform residues in pollen and nectar of crops and weeds growing within a treated field. In contrast, the use of precision application techniques would lead to non-uniform contact and oral exposure of forager bees in the treated field and reduced exposure of their colonies to residues in food matrices. Although, the EFSA Bee GD already envisages the consideration of spatial variation of exposure, details and guidance how to handle this aspect are not provided.

Thus, it would be necessary to adapt the current risk assessment approach to consider the exposure aspects of precision application. The following parameters could be suitable to describe reduced exposure in partially treated fields:

- The exposure factor, which is currently set to ’1’ (*i.e.*, 100% exposure) for adults and larvae;
- The mean default initial residue concentrations in pollen/nectar of the crop in the treated field (expressed as Residue Unit Dose (RUD)); and,
- The shortcut values for crops being attractive due to their pollen and/or nectar supply, depending among other parameters on the RUD.

However, results of field studies following the above outlined design need to be conducted first to get a realistic picture of the exposure of honey bees colonies in partly treated fields and to support the identification of suitable risk assessment parameters.

Acknowledgements

Many thanks to AMAZONE (Hasbergen-Gaste, Germany) providing figures on spraying systems and Jan-Dieter Ludwigs (Rifcon GmbH) for his comments on the manuscript.

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1.2.P Evaluation of honey bee larvae data: sensitivity to PPPs and impact analysis of EFSA Bee GD

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DOI 10.5073/jka.2020.465.040

Abstract

In addition to other assessments, the EFSA bee guidance document (2013) requires the risk assessment of plant protection products on honey bee larvae. At the time the EFSA GD was finalized, no data on honey bee larvae were available due to absence of suitable methods. That is why in 2013 the European Crop Protection Association (ECPA) perfomed an impact analysis of the new EFSA risk assessment, using extrapolated endpoints derived from acute oral honey bee endpoints. Today, a number of honey bee larvae toxicity studies (138 active substances or formulated products) have been conducted according to the newly developed testing methods for single exposure (OECD TG 237) repeated exposure studies until the end of the larval development (D7/D8) and repeated exposure testing (OECD GD 239) until adult hatch (D22). These experimental data have been used to determine the 'pass rates' for 215 worst case uses (72 fungicide spray and solid uses, 91 herbicide spray uses, incl. 8 PGR uses and in total 52 insecticide spray and solid uses, incl. 2 nematicide and 3 IGR uses) according to the EFSA Bee GD and to compare with the original ECPA impact analysis. As standardized test methods for non-*Apis* bees larvae were not available, risk assessment according to EFSA for bumblebees and solitary bees based on the honey bee endpoint as surrogate corrected by a safety factor of 10. Morevoer, the sensitivity of the NOEDs at D8 and D22 in repeated exposure (D 22) studies were analysed.

Overall, the toxicity of fungicides and herbicides to honey bee larvae (expressed as means and medians of NOED and LD_{50} values) was moderate to low, while insecticides as expected displayed stronger toxicity. Moreover, the endpoints for herbicides were on average a factor of 2 higher than fungicides which ranges within the normal biological variability (factor of 3). In addition, it is unclear, if the difference is related to a slightly higher toxicity or other factors like different physical chemical properties (e.g. lower solubility). For insecticides, toxicity was about 125 (based on medians) and 6 to 8 (based on means) times higher than herbicides. In the screening risk assessment according to EFSA Bee GD the majority of fungicide (83.3%) and herbicide (95.6%) uses passed the risk assessment for larvae; whereas, for all insecticide uses thr pass rate was about 29%. In the Tier 1 risk assessment, these pass rates slightly increased and were even higher in the 'treated crop' and 'weed in the field' scenarios for fungicide and herbicide uses, almost being 100%. Pass rates for insecticide uses did not improve very much and amounted to be about 42% for both scenarios. When basing the risk assessment of bumblebee and solitary bee larvae on 1/10th of the honey bee larval endpoint, the majority of active substances and their respective products will fail the screening (overall about 96%) and Tier 1 risk assessment (overall about 90%).