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Precision pesticide application as a tool to reduced exposure of crop visiting pollinators?

Johannes Lückmann, Sibylle Kaiser, Felix von Blanckenhagen, Michael Faupel
RIFCON GmbH, Goldbeckstrasse 13, 69493 Hirschberg, Germany, johannes.lueckmann@rifcon.de

Introduction

Recent publications on severe declines of insects moved the topic of biodiversity in agricultural landscapes into the focus of public attention. Consequently, European policy is under increasing public pressure to minimize the amount of synthetic pesticides applied and to reform the criteria for their authorization and use. In this context, modern technological developments in the field of precision farming offer a great potential for a reduced use of pesticides without compromising their efficacy to withstand pest pressures. For this purpose, a wide range of small-scale application techniques are available or in development. Adjusting applications to the actual scale of target distribution within a field (Fig. 1), precision farming techniques can lead to a decreased exposure of non-target organisms such as beneficial arthropods and bees to pesticides. However, it is unclear to what extent this is the case for different exposure pathways and how this can be taken into account in corresponding environmental risk assessments (RA).

Here, we exemplarily present precision application systems and their potential influence on the exposure of honey bees and their colonies. We depict parameters of the EFSA bee RA scheme [1], which are suitable to describe the risk mitigation. We present a study design to examine the relationship between the ratio of treated to untreated field area, application pattern and bee exposure.

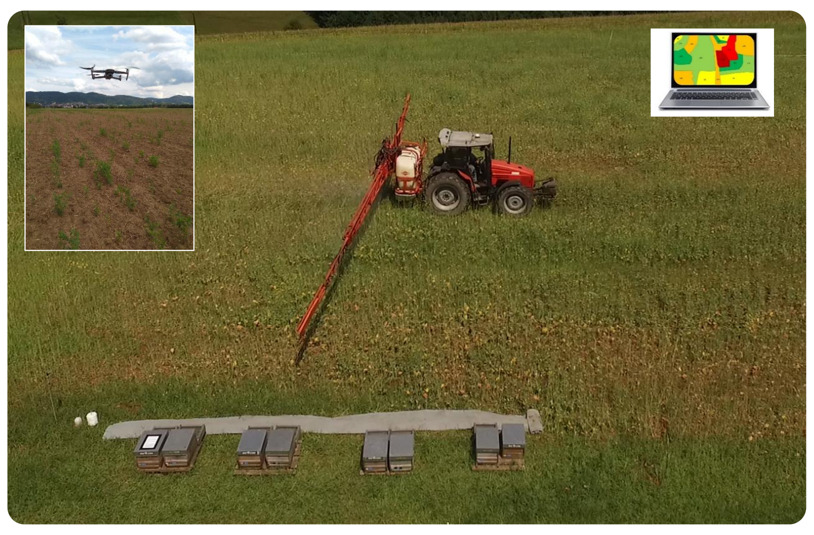

Figure 1: Example of precision application; weed-mapping via drones, data analysis followed by infestation orientated patchy herbicide application

Examples for precision application systems

Precision application systems that can reduce the area where the pesticides is applied:

- Pulse-width modulation sprayers, allowing variable application rates across fields by quick flow rate changes and individual spray nozzle control (see Fig. 2a);
- Direct injection spraying, allowing application of different pesticides on sub-areas;
- Field sprayers or robots equipped with sensing devices and sprayer systems allowing real time, targeted spot applications on weeds (see Fig. 2b - 2d, 4).

Figure 2: Exemplary patchy spraying systems - pulse width modulation (a), UX AmaSpot nozzle control (b), patch spraying of the SmartSprayer joint project (c), Bonirob (d)

Exposure routes of honey bees to pesticides and the potential benefits of 'precision pesticide application'

Main exposure routes for honey bees following spray application at flowering bee attractive crops are:

- Adult bees: contact exposure via spray deposits (i.e. overspray or spray drift); oral exposure via pollen & nectar collected as food within the treated field;
- Bee larvae: oral exposure via consumption of pollen and nectar collected by foragers.

In contrast to overall spraying, the use of precision application techniques reduces the share of treated area within a field. This reduction of treated in-field area will result in:

- a declining number of over-sprayed bees and forage plants;
- a decrease of the overall residue level in pollen and nectar collected by the entire honey bee colony.

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

Hypothesis: actual decrease of exposure of bees is depended on the treated area within the field; the reduction is independent from application pattern.

Proposed experimental field study design (see also [1] and [2]):

- Fields of a flowering & bee attractive crop, e.g. rape, mustard, *Phacelia*;
- Fields of appropriate size, e.g. ≥ 2 ha with sparse alternative forage nearby;
- Honey bee colonies located at the field border;
- Spray application of a non-toxic, hydrophilic colour tracer
  - determination of proportion of bees topically hit via overspray or spray drift;
  - determination of the amount of tracer as residue surrogate in pollen and nectar entering the colony by 'residue' analysis in these matrices obtained from returning bees (i.e. honey sac dissection, pollen loads)
- Study set-up needs to include overall and partially sprayed fields, the latter with different application patterns (Fig 3.).

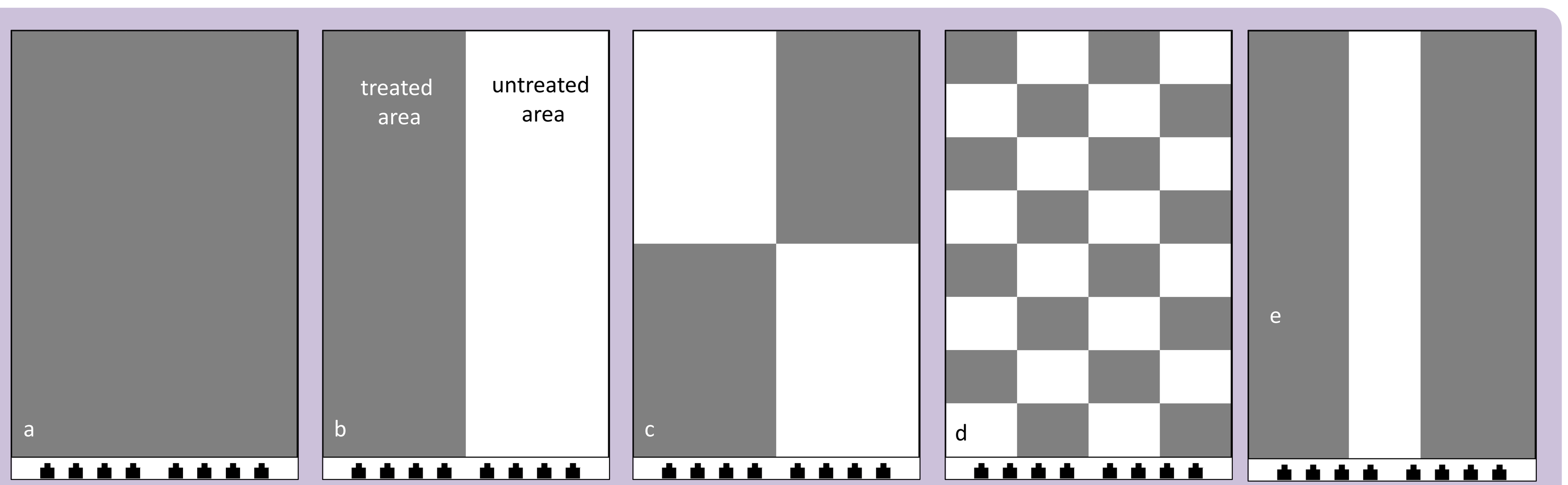

Figure 3: Illustration of different potential application patterns to investigate contact exposure proportions of foraging honey bees and residue levels of pollen and nectar entering the hives
a) total area treated
b) to d) ratio of treated vs. untreated area 1:1, in different application patterns
e)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

Consideration of precision application in the bee risk assessment for pesticides

Current RA procedure [1] assumes uniform exposure among foraging bees and uniform distribution of residues in pollen/nectar of crops and weeds growing within a treated field. However, a non-uniform exposure of foraging bees in the treated field and reduced exposure of their colonies and brood can be assumed following precision application techniques.

Parameters to refine 1st tier default values of the pollinator RA in flowering and bee attractive crops ('treated crop' scenario as worst case scenario) are (Fig. 4):

- exposure factor (Ef), currently set to '1' (i.e. 100% exposure) for adults and larvae;
- shortcut values (SV), provided by the SHVAL-tool [3] and based amongst others (e.g. food consumption, sugar content in nectar) on default initial residue concentrations in pollen/nectar of the crop in the treated field).

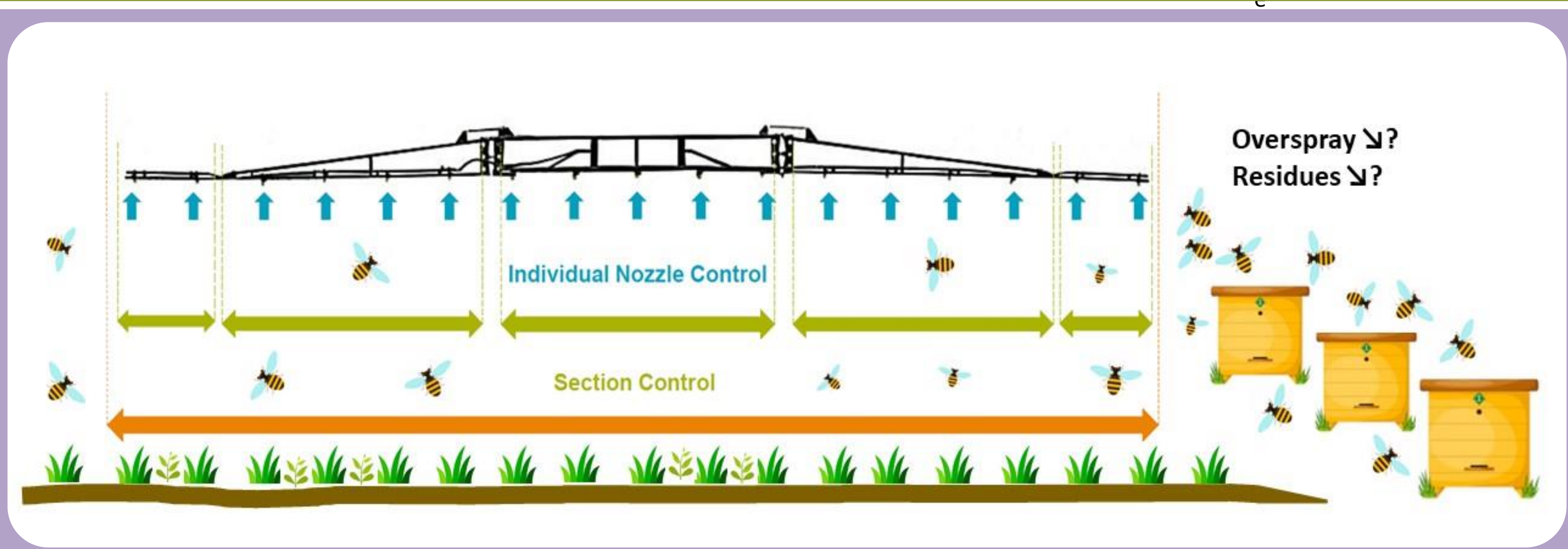

Figure 4: Exposure of honey bees foraging in a field treated with precision application techniques

Further needs and perspectives

1. Discussions with regulatory authorities and scientific experts are desired and needed.
2. Verify theoretical assumptions with field experiments.
3. Provide evidence that results can be repeated by conducting such studies at several sites, in several years and by considering different application patterns.
4. Establish regulatory agreement for consideration a reduced proportion of treated area per field in the risk assessment for bees.
5. Set-up a clear procedure based on the risk assessment to e.g. define a maximum proportion of treated area at a given application rate on the product label.

[1] EFSA (2013): EFSA Guidance Document on the risk assessment of plant production products on bees (*Apis mellifera*, *Bombus* spp. and solitary bees) (published on July 04, 2013, updated on 04 July 2014). EFSA Journal 11(7): 3295.
[2] EPPO [2010]: PP 1/170 (4): Side-effects on honeybees. EPPO Bulletin 40: 313-319.
[3] EFSA (2014): User Manual: A small application developed in R for the estimation of the residue intake rate for certain bee species under given conditions: the SHVAL tool. – EFSA supporting publication, EN-623: 10 p.