

A PROBABILISTIC MODEL FOR ESTIMATING THE EXPOSURE AND EFFECTS AFTER SPRAY APPLICATIONS IN REAL LANDSCAPES

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Abstract

In current risk assessments for plant protection products applied via spray application, default drift-values are used which are based on a large number of field trials conducted by Ganzelmeier et al.[1] and Rautmann et al. [2]. These values, which represent the 90th percentiles of the spray drift measured adjacent to fields, provide a robust estimate of the spray drift in first tier risk assessments. However, since the data from these field trials provide quite a large database, they can also be used for a probabilistic approach. Therefore, we developed a probabilistic model, which makes it possible to estimate spray drift and related effects in any given landscape and under a specific agricultural practice. We apply the model for the risk assessment of non-target arthropods in orchards regarding a hypothetical insecticide.

Introduction

Default drift-values from Ganzelmeier et al. [1] or Rautmann et al [2] used in first tier risk assessments, which represent the 90th percentiles of the spray drift measured adjacent to fields, provide a robust estimate of the spray drift. However, since the database from which these values were derived is quite large and covers many field trials, a more accurate estimation of spray drift and its variability can be obtained with a probabilistic approach. Here we present such an approach, which is based on a few rather simple assumptions and which can be implemented into a spatially explicit landscape model or a geographic information system (GIS). Exemplarily, the model is applied for estimating the exposure and effects in a real landscape after application of a hypothetical insecticide in orchards. It is assumed that the risk for a given non-target arthropod species is addressed. Results are compared to a standard tier I risk assessment.

Materials and Methods

A spatially explicit, grid based landscape model was developed, which represents fields or orchard, off-crop areas, or other habitats. Each cell of the grid contains information about the habitat type. Spray drift is estimated for each cell by a probabilistic model which is based on data from 30 field trials from Ganzelmeier et al. [1] and Rautmann et al. [2]. In the model, a randomly selected field trial from Ganzelmeier et al. [1] and Rautmann et al. [1] is first selected for each field or orchard in the landscape. From this field trial the spray drift data is used in the form of distributions for simulating spray drift on the downwind side of a field (figure 1). The amount of drifted residues, based on a given application rate, is simulated for each cell of the landscape under some worst case assumptions (application on all fields at the same time, no interception, for distances not covered in Ganzelmeier et al. [1] or Rautmann et al. [2] drift values of the next closer distance for which data are available are used). After estimating the exposure in each cell of the landscape with the probabilistic model, the amount of effect is calculated based on the dose-response curve of a given compound and species. A dose response for a hypothetical insecticide (application rate: 100 g a.s./ha) and given non-target arthropod species is assumed (ER_{50} : 10 g a.i./ha, slope: 1.0). Simulations were performed in a landscape from a fruit growing region in Southern Germany, considering 8 random wind directions (figure 2).

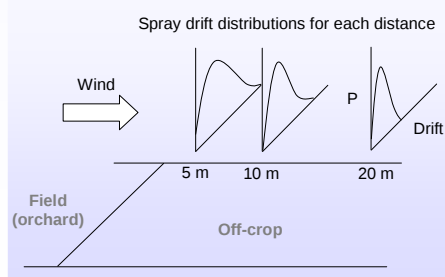


Figure 1. Schematic illustration of spray drift distributions used in the model. For each distance a spray drift distribution is calculated based on the field trials of Ganzelmeier et al. [1] and Rautmann et al. [2].



Figure 2. Landscape used for the spray drift model. Green: Orchards, grey: settlement and road, olive: off-crop habitats.

Results and Discussion

First tier risk assessment

A standard first tier risk assessment was first conducted based on the ER_{50} and the default drift values (90th percentiles) from Rautmann et al. [2]. TER passed the trigger value of 5 only when using 90% drift reducing measures ($TER = 6.4$, 3 m distance from field).

Risk assessment with the probabilistic spray drift model

Since the 1st tier risk assessment showed that 90% drift reducing measures would be needed to pass the trigger, 90% drift reducing measures were also considered for simulations with the probabilistic model, in order to make a direct comparison possible. When assuming 90% drift reducing measures, PEC never reached the ER_{50} of 10 g a.i./ha (see also figure 3). The median exposure amounted to 0.08 g a.i./ha (90th percentile: 0.49 g a.i./ha). Assuming a pragmatic NOEC of 1/5 of the ER_{50} (i.e. $NOEC = 2.5$ g a.i./ha) effects were expected in 0.2% of all cases. However, effects were lower than 5% in 99.9% of all cases (median effect in a cell: 0.0 %, 90th percentile: 0.09%, see figure 4). In the entire off-crop area an average (median) effect of 0.07% was expected (maximum over all simulations: 0.14%).

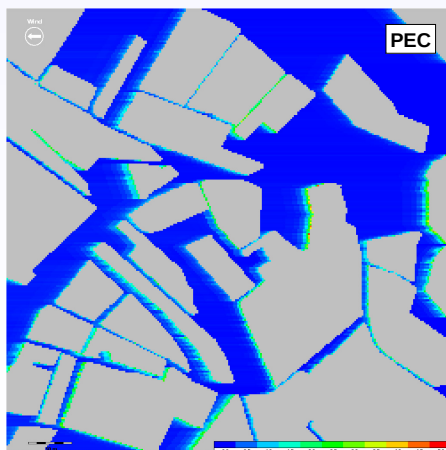


Figure 3. PEC (g a.i./ha) in non-target off-crop after application in all orchards. Results are shown for a single simulation only (100 simulations were performed in total).

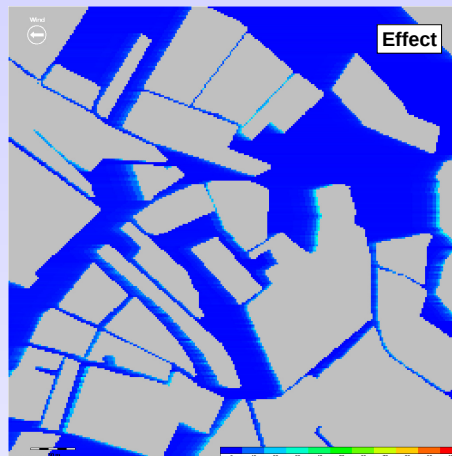


Figure 4. Amount of effect (in percent) expected after application in all orchards. Results are shown for a single simulation only (100 simulations were performed in total).

Conclusions

A probabilistic model for the estimation of spray drift in off-crop habitats was developed. The model, which is based on a few simple assumptions (to each simulated field data from a random field trial from Ganzelmeier et al. [1] and Rautmann et al. [2] is applied, all fields in the landscape are sprayed at the same time, etc.), showed how the exposure (PEC) in non-target off-crop areas and the effect on the non-target fauna can be estimated, based on a dose-response curve.

The spray drift model, which was applied in a grid-based landscape model, makes it possible to simulate spray drift in real agricultural areas.

Assuming a hypothetical insecticide, a comparison with conventional first tier risk assessment showed what a safety factor of $TER = 5$ actually means in biological relevant terms: While the TER just passed the trigger ($TER = 6.4$ assuming 90% drift reducing measures) the actual effect on the non-target species was 0.00% (median over off-crop landscape cells, 90th percentile: 0.09%). This shows that the use of a threshold of $TER = 5$ provided a considerable safety factor.

Results demonstrate not only how spray drift can be calculated probabilistically, but also how the susceptibility of certain habitat structures can be identified. For further refinement, interception could be included in the model. Long-term effects may be analysed with regard to recolonization or population development.

For further details see:

Wang, M. and Rautmann, D. 2008. A simple probabilistic estimation of spray drift – Factors determining spray drift and development of a model. Submitted to Environ. Toxicol. Chem.

References

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