Multi-dimensional exposure modelling in soil for inhomogeneous water flow and pesticide application

Klaus Hammel, Bayer CropScience AG
Tom Schröder, BASF SE

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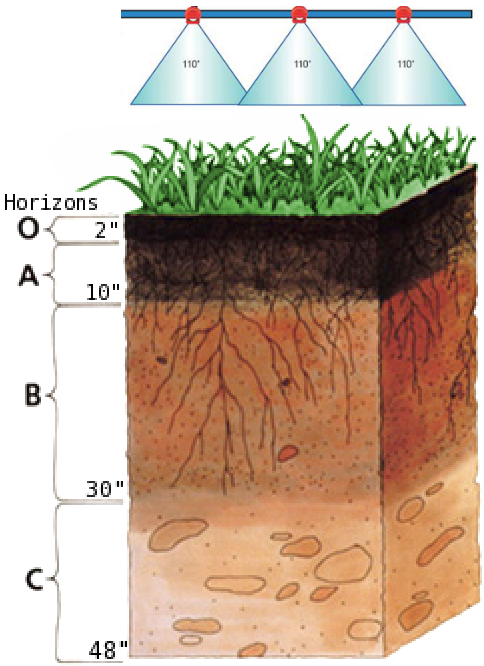
Introduction

Pesticide exposure and leaching in soil is most often described by 1-D modelling



- **Water flow effectively in vertical direction, lateral water flow**
  - **only at small scale**
  - **not relevant for macroscopic processes**

- **Pesticide application is horizontally homogeneous**

Appropriate for many situations with surface spray application and level soil surface

Introduction

However situations may exist where a multidimensional representation improves the assessment

Ridged soil systems

- **variable transport distance to reference depth**
- **potentially redistribution of rainfall by surface run-off → concentration of precipitation in furrow**
- **inhomogeneous pesticide loading due to redistribution or localised application**
- **differences in local soil properties due to presence of plants or other external factors**

Aim of study

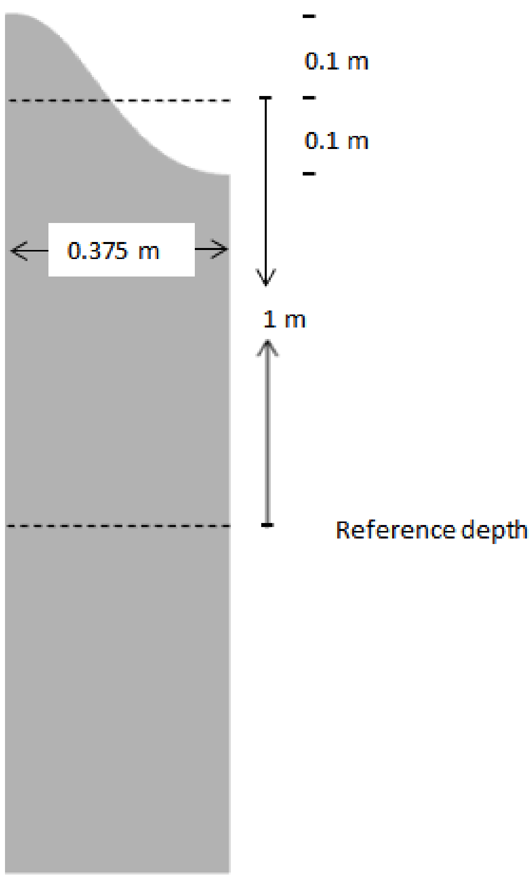
Explore transport and leaching behaviour of a pesticide in ridged soil systems by 2-D modelling for different application modes:

(i) surface application with redistribution

(ii) “in-row” application (within ridge)

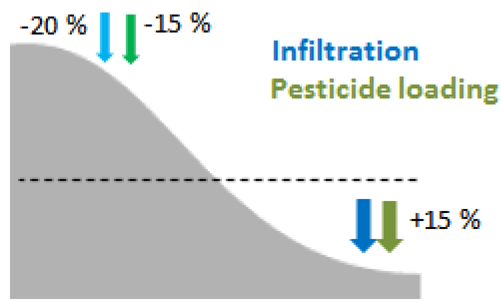
Methods

Simulation domain

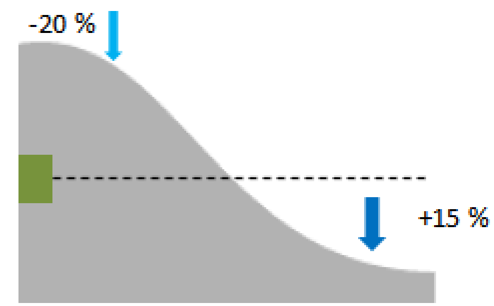


Infiltration distribution* and pesticide application

surface application with redistribution*



in-row application



* taken from Leistra and Boesten (2010): Pesticide Leaching from Agricultural Fields with Ridges and Furrows. Water Air Soil Pollution 213: 341-352

Methods

Simulation model

- HYDRUS 2D/3D

Soil parameters and weather data

- FOCUS Hamburg groundwater scenario

Pesticide properties*

- DT50=21.8 days, Koc=27.6 L/kg
- dependance of degradation on soil moisture and temperature as defined in FOCUSgw report

Application

- 155 g/ha at begin of simulation period

Simulation period

- 10/05/1907 to 31/12/1911 (4.5 years) to allow complete breakthrough at reference depth (1 m)

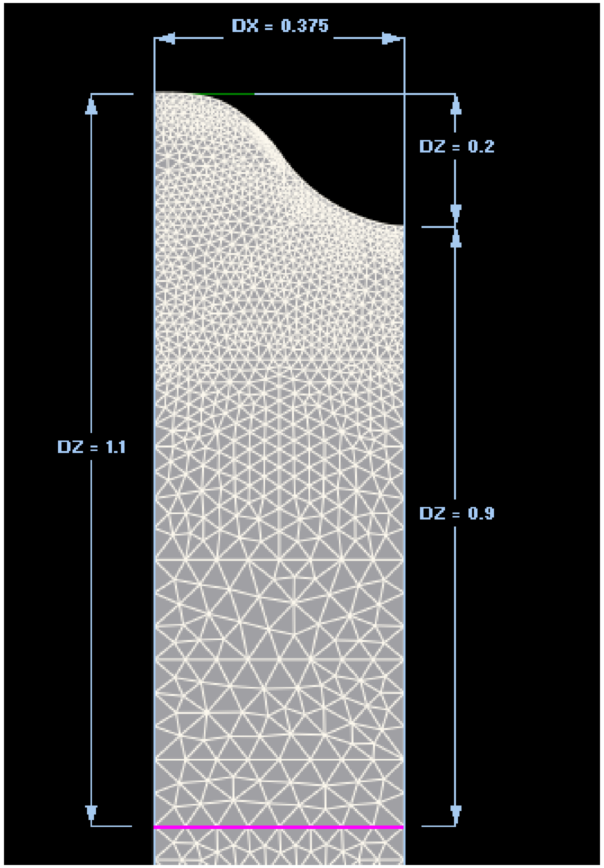
Lower boundary condition

- free drainage

Plant

- none for simplicity

Finite element discretisation with mesh refinements (distances in m)



* refering to pesticide carbofuran taken from Leistra and Boesten (2010)

Results

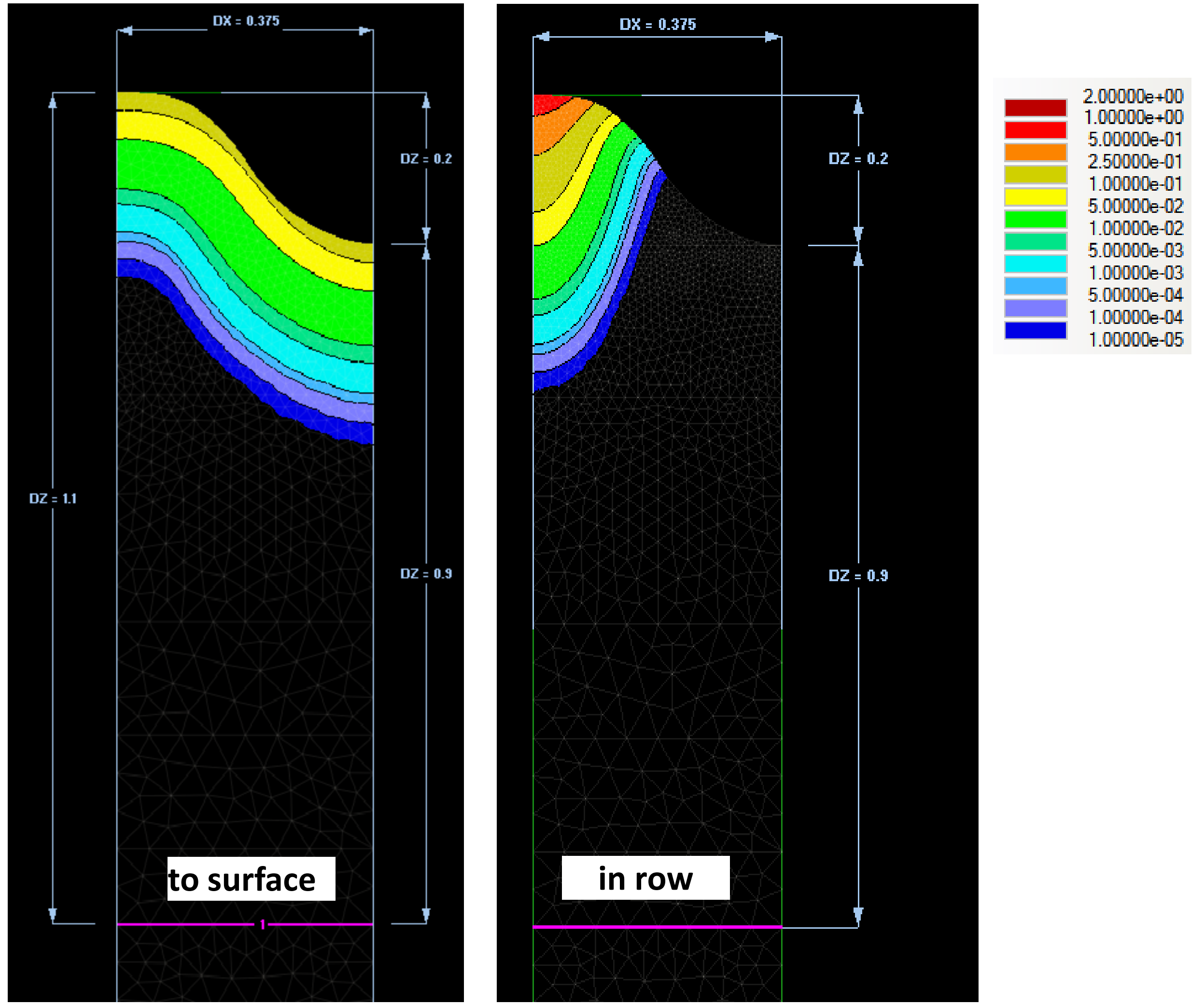
Liquid concentration (mg/L) distribution 6 weeks after application (June)

Surface application:

- **leading edge of solute plume located below the furrow**

In-row application:

- **leading edge of solute plume below the ridge**
- **partially upward movement of pesticide (due to evaporation)**



Results

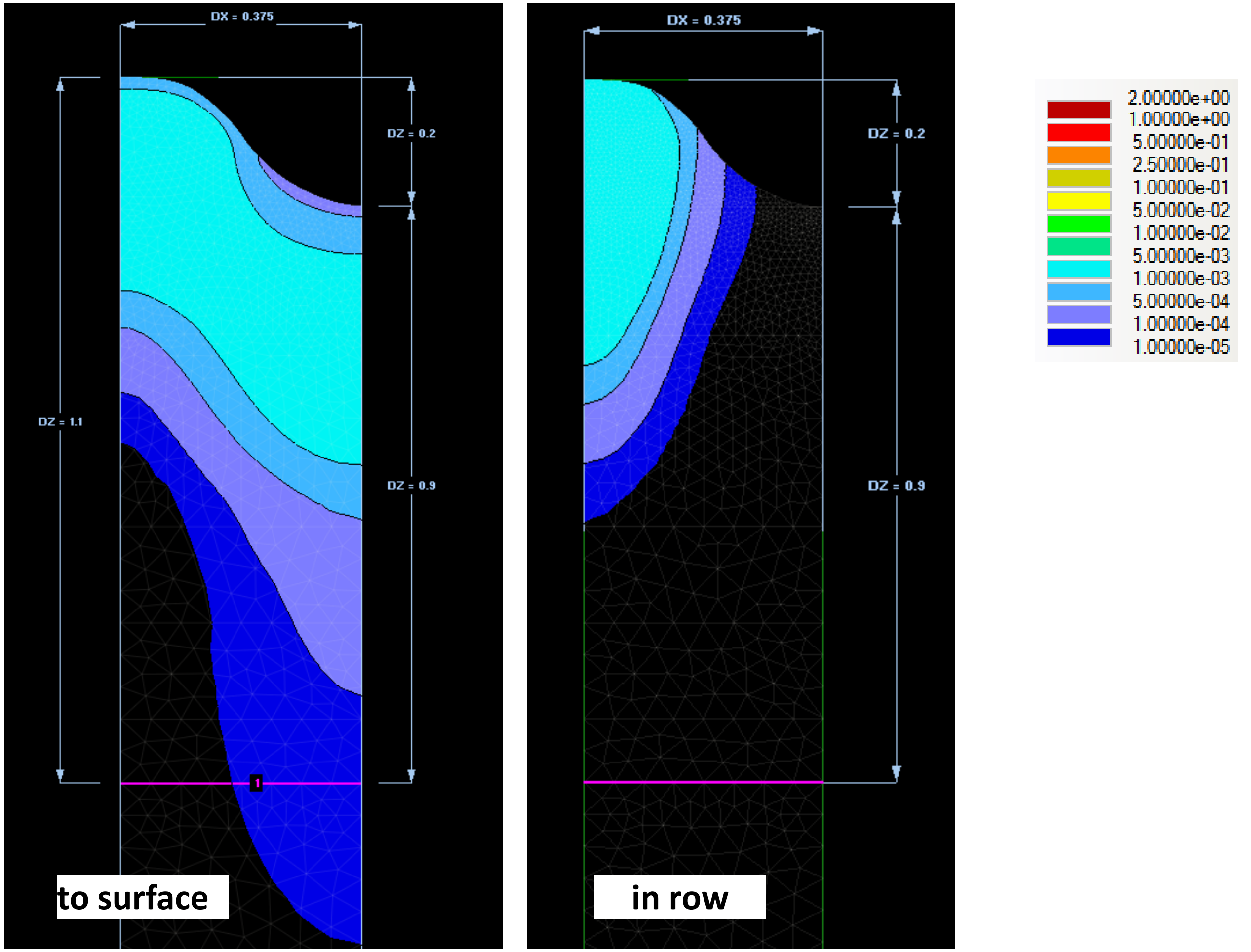
Liquid concentration (mg/L) distribution <u>8 months</u> after application (January)

<u>Surface application:</u>

- **leading edge of solute plume still located below the furrow**
- **Breakthrough at reference depth observed**

<u>In-row application:</u>

- **leading edge of solute plume still below the ridge**
- **Breakthrough starts approximately 1 year later**



Results

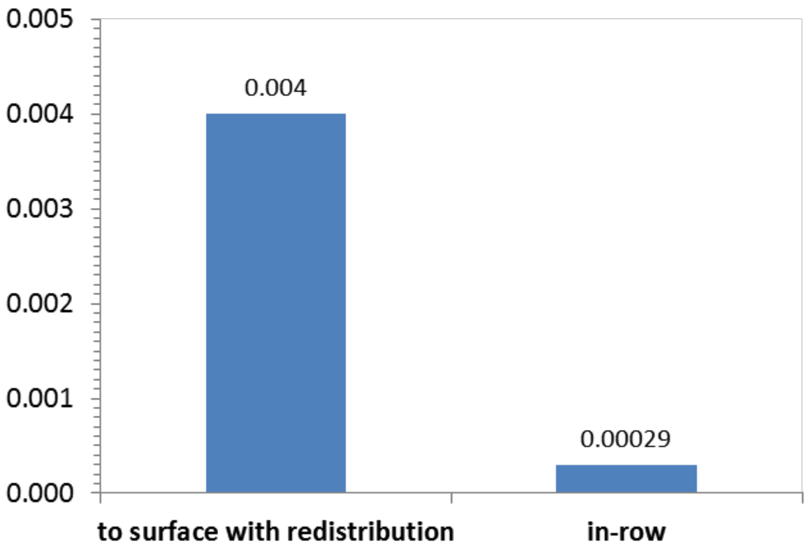
As the concentration distributions already suggested, the mass leached is very different :

- **Much less mass leached for in-row application**
- **Differences larger than one order of magnitude**

→ **Mainly caused by the reduced infiltration of water in combination with lower mass load on the ridge**

→ **In addition, the travel distance is longer from the ridge to the reference depth than from the furrow**

Ratio mass leached/mass applied



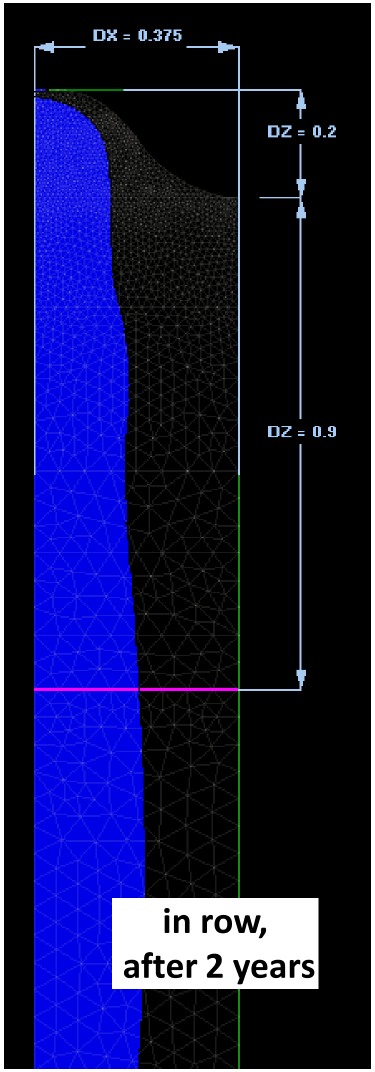
Application mode

Discussion

The results show that for an average travel distance of 1 m there is

- some lateral mixing
- but a fair amount of inhomogeneity is still present

➢ Such a case can be better described by multidimensional simulations



Conclusions

- 2-D simulations with the model HYDRUS were found feasible and capable to assess the characteristics of transport and leaching in ridged soil systems

- A case study has demonstrated that inhomogeneities of infiltration and pesticide loading at the soil surface may impact the transport and leaching behaviour over typical travel depths relevant for pesticides

- For the ridged systems considered leaching was strongly impacted by the mode of application

➢ The variety of interactions between application, redistribution, infiltration and pesticide properties requires more investigations to better characterise pesticide leaching in ridged systems.

➢ Further more basic research into the effects of local water and pesticide uptake by the (potato) crop is recommended.

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Thank you!

Wien, EMW 2014

Klaus Hammel, Bayer CropScience AG
Tom Schröder, BASF SE

The Chemical Company