Modelling the Path to Better Soil-Applied Pesticides

SWEEENEY P.¹, TRAVIS K.¹, WHALLEY R.², WHITMORE A.², DAILEY G.², WU L.² VAN BEINUM W.³, BROWN C.⁴

² Rothamsted Research, ³ FERA UK, ⁴ University of York

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Current Regulatory Models: Evolving Legislation

Current regulatory models are 1-dimensional and model plant growth and processes in a relatively simple way:

- Simple root distribution
- Plant growth proceeds in a fixed fashion independent of environmental conditions
- Fit-for-purpose in most cases

Recent opinion has highlighted the inability of current models to represent specific cropping systems:

- Ridge and Furrow systems
- Drip Irrigation

Opinion has also separated different application regimes:
Granules and seed treatments

These each have a spatial component and require different model frameworks if they are to be modelled
Overview of Crop/Soil Modelling

There are good models of plants

There are good models of soil water/pesticide movement

There are few good models of both that also have a spatial element
TSB Project “modelling the Path to Better Soil Applied Pesticides”

Syngenta

Funding via R+D external collaborations budget

Rothamsted Research

University of York

Syngenta 600K

TSB 600k of money

Co-Funding
What we have done: soil/fate model

• Taken a sophisticated finite element pesticide fate model that is capable of modelling several different geometries

• Richard’s equation for soil water movement

• That models pesticide fate
  • Soil/moisture dependence
  • Sorption
    • Freundlich
    • Time dependent
    • Non-equilibrium

Photo taken from HYDRUS documentation
What we have done: plant model

- Linked it with a plant model (SPACSYS) for wheat and maize.
- Retained the crop development part of the model but took out the nutrient plant growth.
- Turned the root growth model from 3-D to 2-D using a root density function from DAISY model.
- Included the Trapp model of plant uptake and redistribution.

SPACSYS: Wu et al Ecological modelling (2007)
DAISY: Abrahamsen and Hansen Environmental modelling (2000)
Testing Plant Module: Root Density

Plant growth is now dependent upon environmental conditions and varies year to year

**Mean root density (cm$^{-2}$)**

![Graph showing mean root density variations over time.](image)

**MeanZ - normalised**

![Graph showing MeanZ normalised variations over time.](image)
Results: Growing Season Winter wheat

- Shortest growing season: 292 days
- Longest growing season: 309 days
- Median growing season: 300.5 days

- Focus growing season: 292 days
  - (estimated by the period of time over which roots exist)
Comparison against Measured data: LAI and Dry Matter
Maize Model: development over 2 years (UK conditions)

Green LAI (-)

Cob Growth

Development index (-)

Harvest because of lower temperature

Root length distribution
Crop Parameterisation Needs to be Site Specific

LAI vs. days. Okehampton W Wheat

Root DM vs. days. Okehampton W Wheat

LAI vs. days. Seville W Wheat

Root DM vs. days. Seville W Wheat
Benchmarking against Known models: Substance D

Pressure Head

Water Content

Concentration

Temperature
Problems to look at: release from seed treatment under dry and wet conditions
Zone of Control: Wet Scenario

45% of points in 16cmx100cm block have concentration above 0.1 pg/L
Zone of control: Dry Scenario
Comparison of Wet and Dry Scenarios

- Little effect of release rate on movement in soil
  - Why? Process of movement of chemical through soil takes much longer than release from seed

- Zone of control larger with wet scenario than dry
  - Why? Greater water movement washes more chemical through the soil profile before it can degrade

Note that situation may be different if there are plants present and if a different threshold is specified.
Project Summary

● We have produced a new, spatially explicit model of pesticide movement in soil
  - Uses best available science of pesticide fate and solute movement
  - Plant growth model dependent upon environmental conditions

● The model can reproduce FOCUS results when parameterised similarly

● This approach shows promise as a framework to model
  - Crop/soil combinations having a spatial element
  - Considerable work will need to be done to match crop growth parameters to scenarios