Predicting the impact of temporary crop covers on pesticide exposure using a modelling-based scenario approach

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Cambridge Environmental Assessments

Temporary crop covers

Background - PS2246

- Previous project (PS2246; 2011) looked at how temporary crop covers are used in the UK.

- Key finding: increased risk of GW and SW exposure for **root and tuber** crops when covers are used, based on qualitative predictions.

- Approx. 10,000 ha root and tuber crops are grown in the UK using **plastic, fleece and straw covers**. This allows almost year-round production in UK.

EFSA protected crops guidance

- Project **PS2252** completed Jan-Sep 2013, alongside EFSA consultation on protected crops guidance.

- EFSA guidance on emissions from protected crops does not cover mulching and direct crop covers:

  "Mulching and direct crop cover are considered to have little impact on emissions of PPP to environmental receptors, so that environmental risk assessment (ERA) for open fields can be applied."

UK crop cover uses

- Plastic and fleece covers often applied to root and tuber crops in strips.
  - Risk of increased runoff and drainage from the wheelings/furrows?
  - Had not anticipated modelling separate environments within a field, but too much uncertainty in results if not accounted for.

Outline of project PS2252

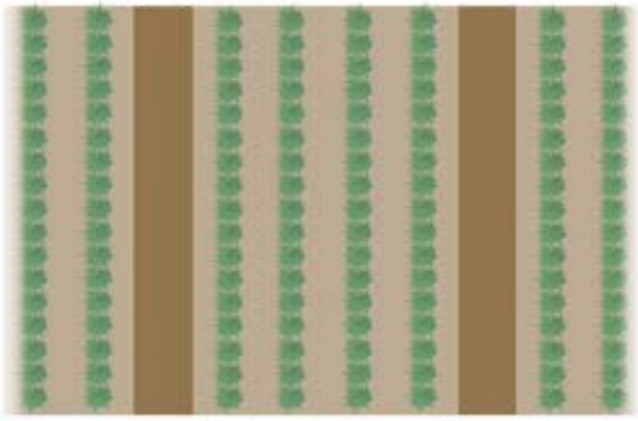
- Built GW and SW modelling scenarios for covered root and tuber crops in the UK:
  - Runoff (PRZM – based on R1 scenario)
  - Drainage (MACRO – based on D3 and D4 scenarios)
  - Leaching (PEARL – based on Châteaudun scenario)
- Calculated PECs with crop covers present:
  - Perforated plastic (carrots)
  - Fleece (potatoes)
  - Straw mulch (with and without plastic underneath; carrots)
- Compared to PECs from control scenarios (appropriate for UK conditions) with no covers.

Modelling scenarios

- How the crop calendar and application timing is shifted by the cover.
  - e.g. fleece/plastic brings forward crop growth, straw allows over-wintering.
- Microclimate underneath the cover: temperature, rainfall, evapotranspiration.
  - Based on literature search for each cover type.
- Irrigation schedules for covered crops
  - Especially important since irrigation is often applied over the top of plastic covers.

Field micro-environments

- Separate scenarios for ridges/furrows for potatoes (both control scenario and fleece cover scenario).
    - Based on methodology of Leistra & Boesten (2010)
- Separate scenarios for rows/wheelings for plastic-covered carrots.
- Simulate field micro-environments separately, weight/combine model outputs.



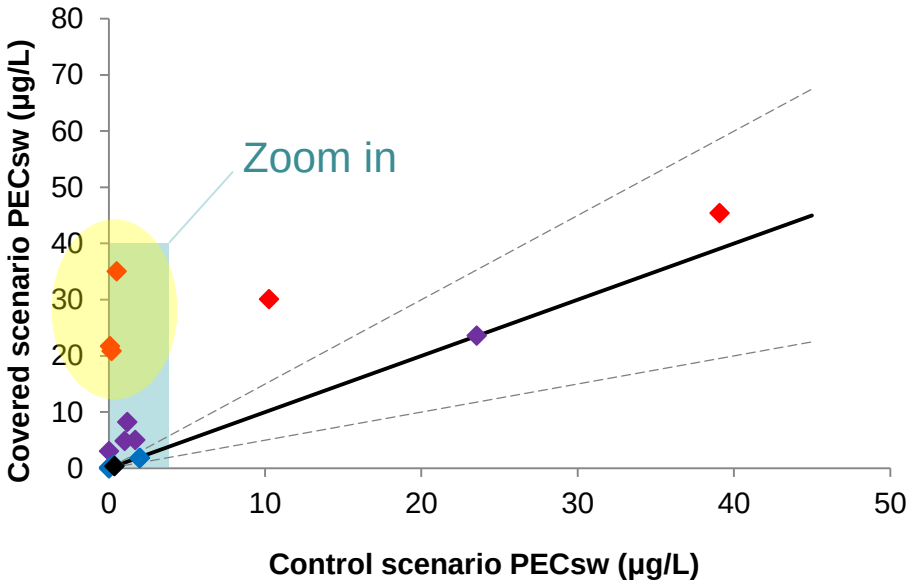
Example:

Carrots grown in plastic-covered beds of four rows, 210 cm wide.

Wheelings are approx. 40 cm wide.

Key results: drainage (1)

- Early-season applications to fleece-covered potatoes: predicted increase in drainage for mobile compounds, even with short DT_{50} values.



Low K_{oc} (≤ 15 L/kg)
Moderate K_{oc} (60-100 L/kg)
High K_{oc} (≥ 500 L/kg)
Metabolite (K_{oc} = 580 L/kg)
1:1
Difference of ± 50%
DT_{50} ≤ 6 days

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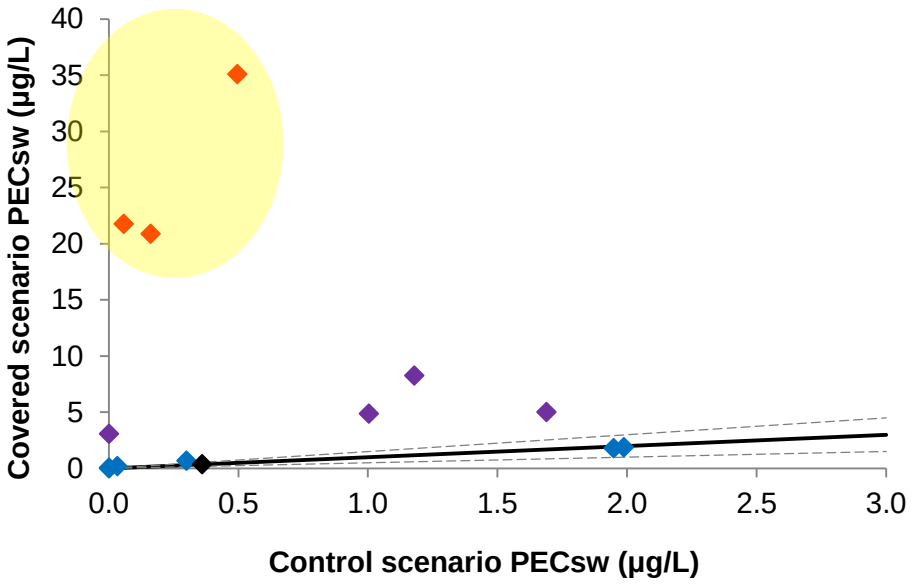
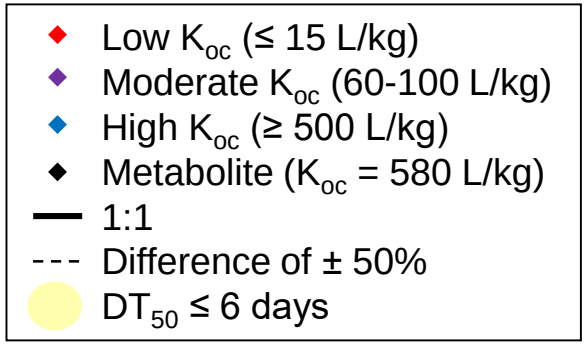




Key results: drainage (2)

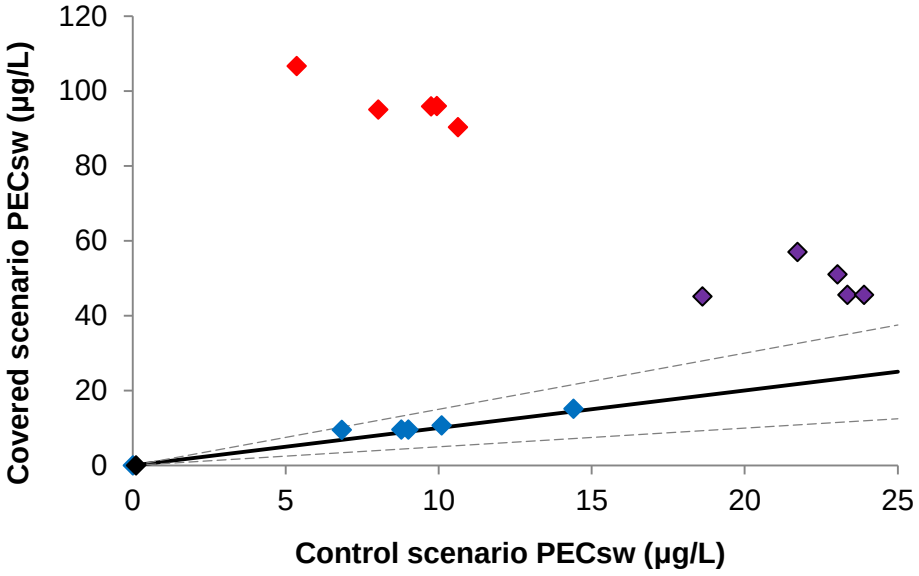
- Rapid drainage from furrows: maximum PEC_{SW} approx. 1 month after application.

- Pesticide flux from the field dominated by furrows (~99.98%), with uncovered furrows 65-75% of total.

- Ridges and furrows were also simulated separately in control, so increase is due to fleece cover.
    - Brings forward applications (early March vs. April)
    - Extra rainfall received by uncovered furrows

Key results: runoff (1)

- Early-season applications to plastic-covered carrots: predicted increase in runoff for compounds, especially with low K_{oc} values.



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Moderate K_{oc} (60-100 L/kg)
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Metabolite (K_{oc} = 580 L/kg)
1:1
Difference of ± 50%

Key results: runoff (2)

- PEC_{SW} for applications to covered carrots driven by exposure *via* the wheelings:
  - Runoff volume 4 × greater from wheelings than rows
  - Runoff flux 15-20 × greater from wheelings than rows
- N.B. control scenario did not have separate simulations for crop rows and wheelings.
- Separate simulations of micro-environments may not allow an accurate description of processes across the field as a whole.

Key results: runoff (3)

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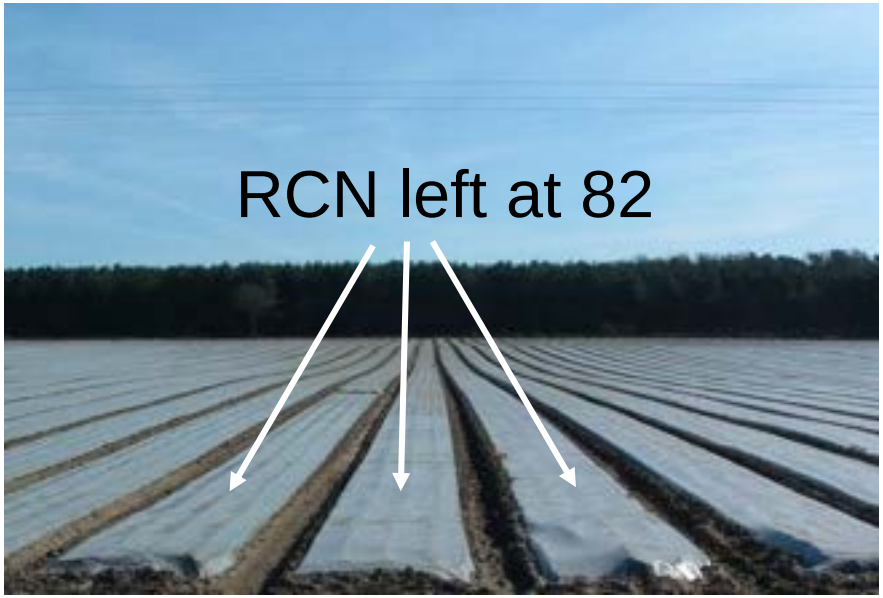
Control scenario

Runoff curve number = 82 across whole field

Plastic cover scenario



RCN set to 91

No literature RCN values available for fields with strips of plastic/fleece; field measurements desirable.

Key results: leaching

- Increase in leaching predicted across early-season applications.

Crop	Cover type	GW-A (µg/L)		GW-D (µg/L)	
		Control	Cover	Control	Cover
Carrots	Perforated plastic	2.59	4.49	0.093	0.597
	Straw	2.59	6.29	0.093	0.346
	Straw & polythene	2.59	3.91	0.093	0.141
Potatoes	Fleece	5.54	6.97	0.333	1.20

For clarity, only a subset of test compounds is presented.

Risk matrix

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Application timing	Exposure route	Cover type			
		Perforated plastic	Fleece	Straw	Straw and plastic
Early-season	Drainage	Slightly increased risk possible	Significantly increased risk possible	No sig. change	No sig. change
	Runoff	Significantly increased risk possible	No sig. change	No sig. change	No sig. change
	Leaching	Increased risk possible	Increased risk possible	Increased risk possible	Increased risk possible
Late-season	Drainage	No sig. change	No sig. change	Increased risk possible	Increased risk possible
	Runoff	No sig. change	Decreased risk possible	Increased risk possible	Increased risk possible
	Leaching	Decreased risk possible	Decreased risk possible	Increased risk possible	Decreased risk possible

Conclusions

- PEARL, PRZM and MACRO modelling scenarios developed for root and tuber crops grown using plastic, fleece and straw covers.

- Potential for increased drainage and runoff for early-season applications where crop covers are applied in strips (e.g. fleece, plastic)
  - Most exposure occurs *via* furrows / wheelings

- Leaching may also increase for early-season applications (all crop covers).

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Questions?