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Station de recherche Agroscope Reckenholz-Tänikon ART

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Two pesticide application strategies in tomato and their risk for workers

Frank Hayer, Thierry Boulard
Caroline Raeppel, Gérard Gaillard

10.01.2011

INRA

UNIVERSITÉ DE STRASBOURG

Outline

- Introduction
- Method
  - Data needed
  - Model calculations
  - Input data
- Results
  - Operator -, worker risk
- Conclusion

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Introduction

- Greenhouse production has several advantages
  - Complete control of crop nutrition needs
  - High productivity per m^2
  - Higher water efficiency
  - Plant health management is also favored by protected cultivation
- But in a closed system, pesticide transfer is quite different from that in field cropping conditions which has two important consequences
  - The transfer of pesticides to the environment is limited, but
  - the exposure of pesticide operators and re-entry workers might be increased

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Introduction

- Aim of this study is to perform a risk assessment for pesticide operators and re-entry workers based on a case study including one application patter applied in a greenhouse and a tunnel

- The study:
  - is part of a comparison of tomato production in greenhouses and tunnels in south and north France using Life Cycle Assessment
  - was conducted in a collaboration of Unité de Recherches Intégrées en Horticulture (URIH) of INRA Sophia-Antipolis and the LCA Group of Agroscope ART
  - The collaboration was financed by the European Network for the durable exploitation of crop protection strategies (ENDURE)

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Risk for operators and re-entry worker

- **Acute indicators**
  - **acute derived P**esticide **Oc**cupational and **E**nvironmental **R**isk Indicator **(POCER) and described in a H**armonised environmental **I**ndicators for pesticide **R**isk **(HAIR) project report**
- **Indicators proposed in the report**
  - **operators**
  - **re-entry workers or greenhouse workers with inhalation**
  - **bystanders**
- **Acute risk indicators are based on**
  - **estimation of potential exposure under different scenarios**
  - **division of potential exposure by AOEL**

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Data needed: Operator risk

- **Exposure**
  - Dermal, inhalation and oral exposure during mixing/loading and application (L_i, L_{Hand}, L_{Body}) as mg a. s. * kg a. s.$^{-1}$
  - Personal protective equipment coefficients for gloves (PPE_{Hand}), overall (PPE_{Body}) and protective mask (PPE_{inhal})
  - Inhalation and dermal absorption factors in % (Ab_i, Ab_{dermal})
  - Application rate as kg*ha^{-1} (AR)
  - $Area_{treated}$ as ha * d^{-1}
  - Body weight in kg (BW)
- **Toxicity**
  - AOEL from a short term toxicity study mg a. s. * kg a. s.$^{-1}$

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Data needed: Re-entry worker risk

- **Exposure**
  - **Application rate as** — **$kg*ha^{-1}$** — **(AR)**
  - **Leaf area index** — **$m^2leaf*(m^2soil)^{-1}$** — **(LAI)**
  - **Dislodgeable foliar residue in** — **$\mu g * (cm^2)^{-1}$** — **(DFR)**
  - **Transfer factor** — **$cm^2*person^{-1}*h^{-1}$** — **(TF)**
  - **Duration of re-entry in** — **h** — **(T)**
  - **Personal protective equipment coefficients** — **(P)**
  - **Task specific factor** — **(TSF)**
- **Toxicity**
  - **AOEL**

Calculations HAIR: Operator risk

- **Internal Exposure**
  - $IE_{operator} = (IE_{mix/load} + IE_{application}) * AR * Area_{treated} * BW^{-1}$
  - $IE_{mix/load} = (L_{l\ mix} * PPE_{l} * Ab_{l}) + (L_{hand\ mix} * PPE_{hand} * Ab_{DE\ Concentrate})$
  - $IE_{application} = (L_{l\ appl} * PPE_{l} * Ab_{l}) + (L_{hand\ appl} * PPE_{hand} * Ab_{DE\ spray\ dilution}) + (L_{body\ appl} * PPE_{body} * Ab_{DE\ spray\ dilution})$
- **Risk indicator**
  - $Ri_{operator,\ acute} = IE_{operator,\ acute} * AOEL^{-1}$

Calculation Hair: Re-entry worker risk

- **Exposure**
  - $IE_{re\text{-}entry\ worker} = ((Dermal * AB_{dermal}) + (Inhalation * AB_i)) * BW^{-1}$
  - $Dermal = 0.01 * AR * TF * T * P * LAI^{-1}$
  - $Inhalation = AR * TSF * T$
- **Risk indicator**
  - $Ri_{re\text{-}entry\ worker,\ acute} = IE_{re\text{-}entry\ worker,\ acute} * AOEL^{-1}$

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Scenarios

- **Scenario 1**
  - Operator with PPE, Re-entry worker without PPE
  - Re-entry time 8h after application
- **Scenario 2**
  - Operator with PPE, Re-entry worker without PPE
  - Re-entry time dependent from a.i.
- **Scenario 3**
  - Operator and re-entry worker with PPE
  - Re-entry time dependent from a.i.

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Input data: Assumptions

- **Body weight (operator and re-entry worker)**

  70 kg

- **Area treated by operator**

  1 ha*d^{-1}

- **Personal protectiv equipment operator**

  PPE_{hand}, PPE_{body} during mixing and application

  $PPE_{inhalation}$ during application

  Coefficient for PPE = 0.1

- **Personal protectiv equipment re-entry worker**

  Scenario 1 & 2: No PPE

  Scenario 3: PPE_{hand}, PPE_{body}

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Re-entry delay scenario 2 & 3

	Re-entry delay		AOEL		Re-entry delay		AOEL
	Greenhouse	Tunnel			Greenhouse	Tunnel	
	h	h	mg a.s.*kg bw^{-1}*d^{-1}		h	h	mg a.s.*kg bw^{-1}*d^{-1}
Acetamiprid		8	0.124	Pymetrozin	8		0.03
Carbendazim	8		0.02	Pyrimethanil	8		0.12
Cyromazine	8		0.06	Glyphosat	24		0.2
Diethofencarb	8		0.3	Copper Sulfate		24	0.072
Fenbutatin-oxid	8		0.1	Hexaconazole	24		0.025
Fenhexamid	8		0.3	Methomyl		24	0.0025
Hexythiazox	8		0.01	Pyriproxyfen	24		0.04
Indoxacarb	8		0.004	Abamectin	48		0.0025
Iprodion	8		0.3	Bupirimate	48		0.05
Myclobutanil		8	0.16	Chlorthalonil	48		0.009
Propamocarb		8	0.29				

Input Data: Operator risk

Formulation	Activ substance	Variable	Ab_i	$Ab_{De\ Conce}$	$Ab_{De\ dilution}$	$L_{i\ mix}$	$L_{hand\ mix}$	$L_{body\ mix}$	$L_{i\ appl}$	$L_{hand\ appl}$	$L_{body\ appl}$
		Description	Absorption coefficient			Exposure (mixing)			Exposure (application)		
			Inhal	Dermal		Inhal	Dermal		Inhal	Dermal	
				Concentrate	Delution		Hand	Body		Hand	Body
		Unit	%			mg a.s./kg a.s.			mg a.s./kg a.s.		
Liquid	Carbendazim	Jonk	100%	0.1%	0.1%	0.02	159.00	38.33	0.16	265.00	857.00
	Chlorthalonil	Orzin		0.3%	0.02%						
	Abamectin	Vertimec		1.0%	1.0%						
	Pyrimethanil	Scala		1.0%	20.0%						
	Glyphosat	Roundup		3.0%	3.0%						
	Bupirimate	Nimrod		10.0%	10.0%						
	Diethofencarb	Jonk		10.0%	10.0%						
	Fenbutatin-oxid	Torque S		10.0%	10.0%						
	Hexaconazole	Anvil		10.0%	10.0%						
	Pyriproxyfen	Admiral		30.0%	30.0%						
	Propamocarbe	Previcur N		100.0%	100.0%						
WG	Indoxacarb	Steward 30		0.3%	0.2%	0.03	5.83	1.47			
	Pymetrozin	Plénum		6.0%	6.0%						
	Fenhexamid	Lazulie		20.0%	20.0%						
WP	Iprodion	Rovral		1.0%	1.0%	0.94	12.96	N/A			
	Hexythiazox	Nissorun		2.0%	2.0%						
	Copper-sulfate			10.0%	10.0%						
	Cyromazine	Trigard		10.0%	10.0%						
	Methomyl	Lannate		10.0%	10.0%						
	Acetamiprid	Supreme		30.0%	30.0%						
	Myclobutanil	Nova 40 W		50.0%	50.0%						

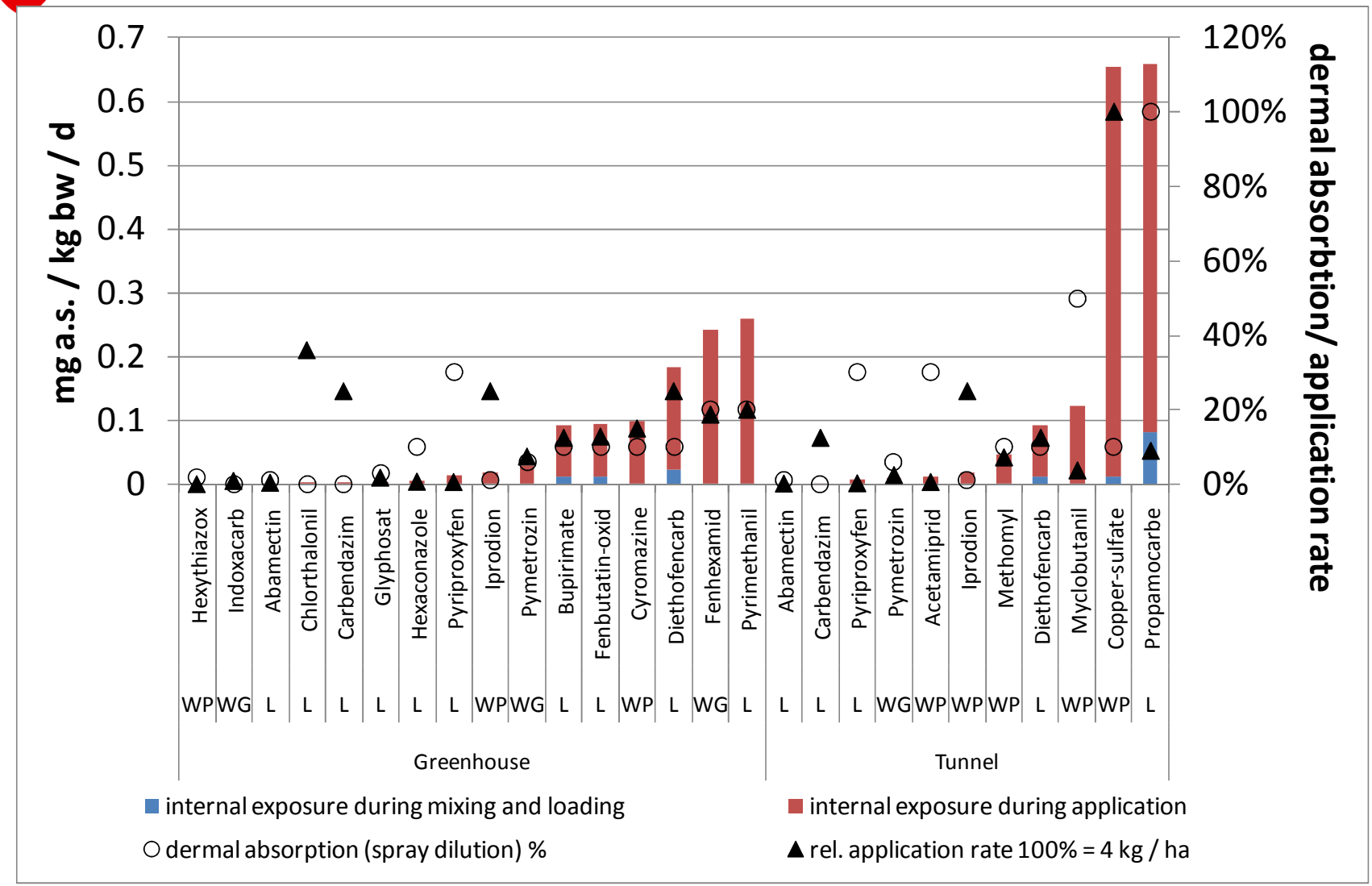
Input data: re-entry worker risk I

	Variable	Application Rate	DFR	LAI	TF	T
	Description			Leaf area Index	Transfer Factor	duration of re-entry
	Unit	kg a.s. * ha^{-1}	µg*cm^2	m^2*m^2	cm^2 * person * h^{-1}	h
Greenhouse	Hexythiazox	0.003	0.008	3	5000	8
	Abamectin	0.018	0.058			
	Pyriproxyfen	0.025	0.078			
	Hexaconazole	0.030	0.097			
	Indoxacarb	0.038	0.119			
	Glyphosat	0.072	0.221			
	Fenhexamid	0.750	0.313			
	Pymetrozin	0.300	0.933			
	Bupirimate	0.500	1.618			
	Fenbutatin-oxid	0.513	1.698			
	Cyromazine	0.600	1.986			
	Pyrimethanil	0.800	2.454			
	Diethofencarb	1.000	3.004			
	Iprodion	1.000	3.198			
	Carbendazim	1.000	3.236			
	Chlorthalonil	1.440	4.604			

Input data: re-entry worker risk II

	Variable	Application Rate	DFR	LAI	TF	T
	Description			Leaf area Index	Transfer Factor	Duration of re-entry
	Unit	kg a.s. * ha^{-1}	µg*cm^2	m^2*m^2	cm^2 * person * h^{-1}	h
Tunnel	Abamectin	0.009	0.029	3	5000	8
	Pyriproxyfen	0.013	0.039			
	Acetamiprid	0.025	0.075			
	Pymetrozin	0.100	0.311			
	Myclobutanil	0.150	0.491			
	Methomyl	0.290	0.638			
	Propamocarbe	0.360	1.183			
	Diethofencarb	0.500	1.502			
	Carbendazim	0.500	1.618			
	Iprodion	1.000	3.198			
	Copper-sulfate	4.000	13.333			

Exposure Operator



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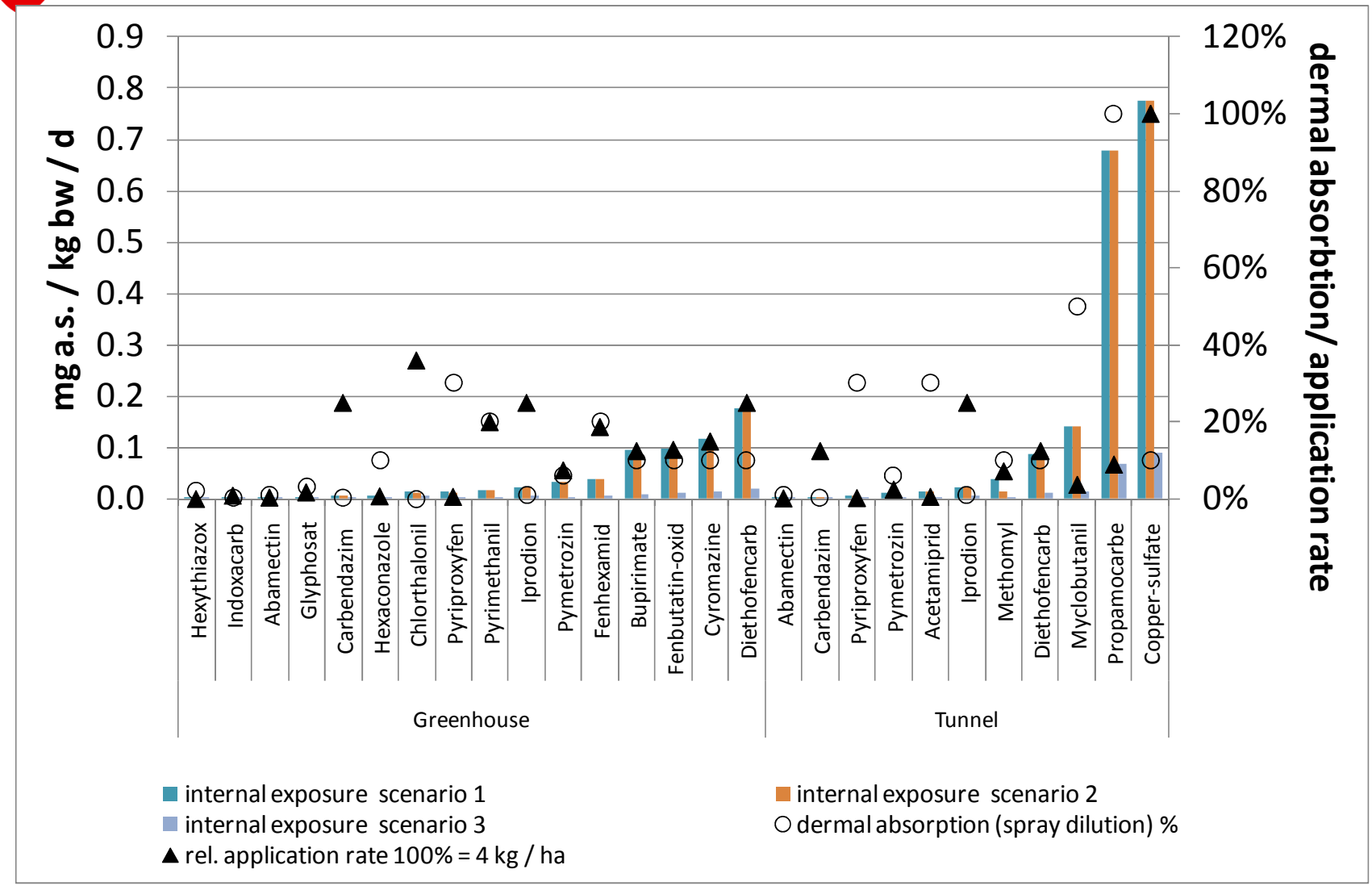
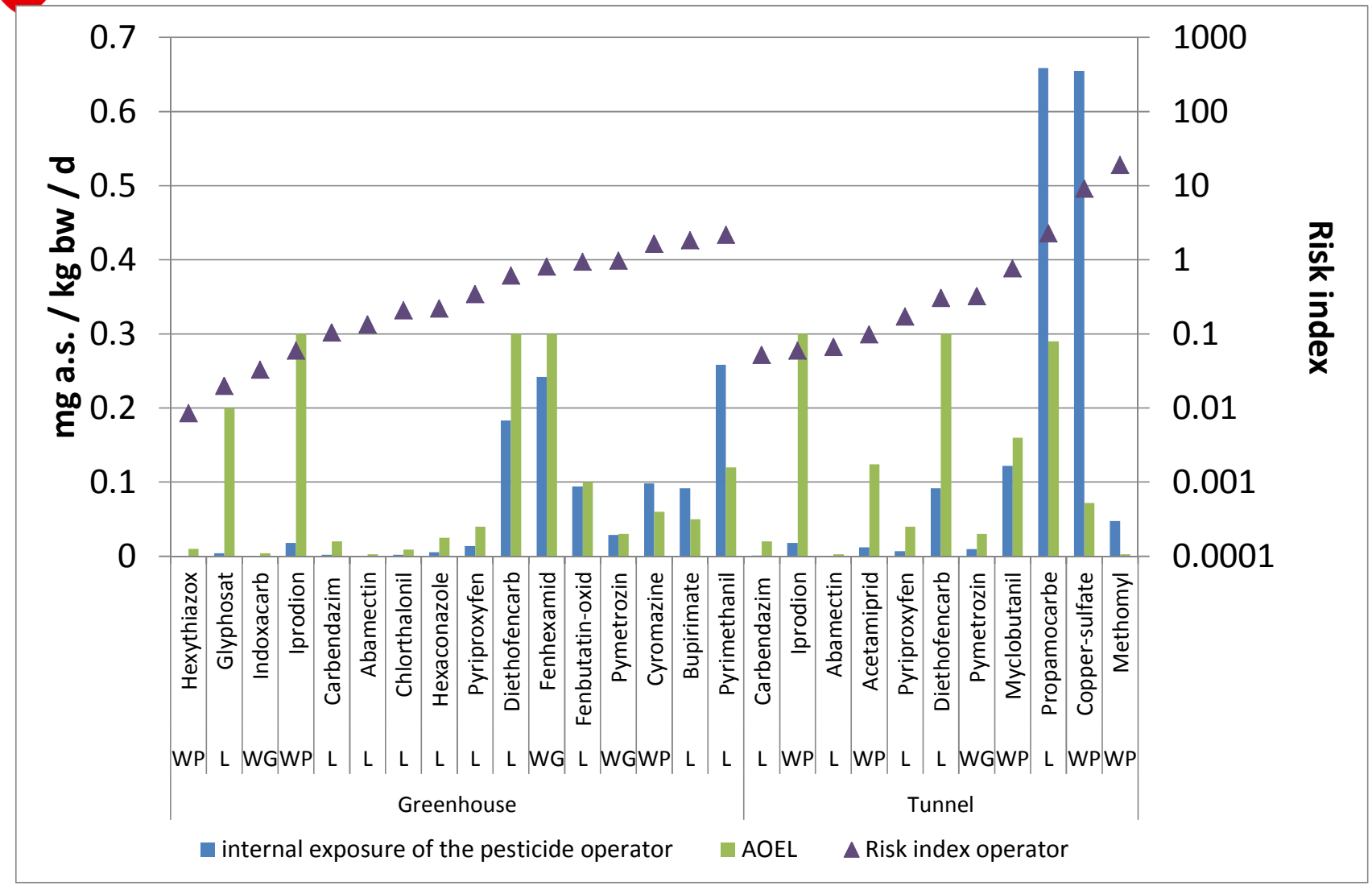
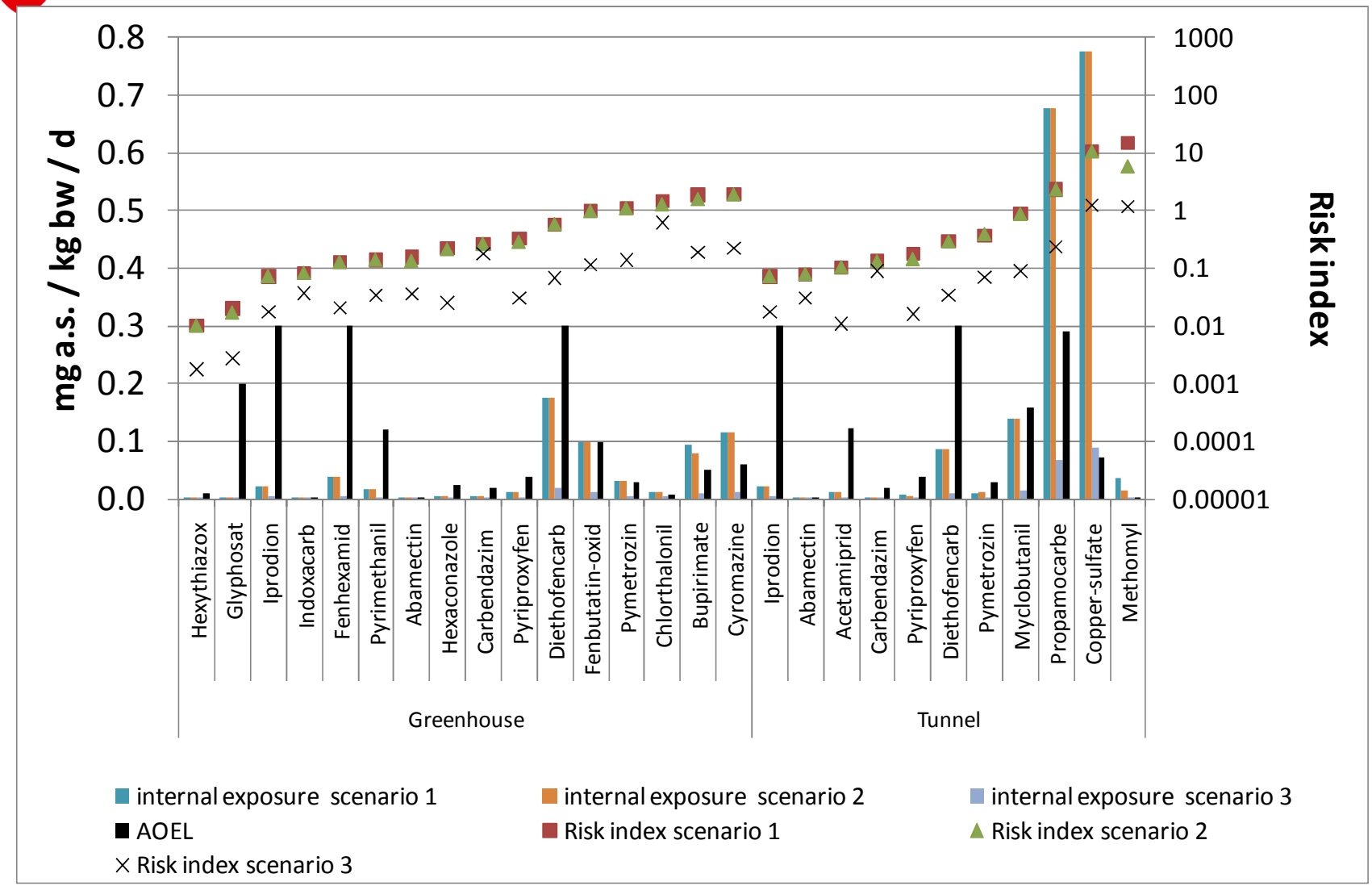
Exposure re-entry worker



Risk index operator



Risk index re-entry worker



Conclusions

- **Under considered assumptions**
- **6 out of 21 a.i. with a risk index for operators higher than 1**
- **7 a.i with a risk index > 1 for re-entry workers**
- **with PPE equipment the exposure of re-entry workers is much lower than the AOEL with exception for Methomyl**

risk index > 1	
operator	**re-entry worker**
Methomyl	
Copper-sulfate	
Propamocarbe	
Cyromazine	
Bupirimate	
	Chlorthalonil
	Pymetrozin
Pyrimethanil	

Conclusions

- Hair risk indicator
  - uncertainties in transfer and absorption coefficients
  - Around 30% of the active ingredients applied cause risk indices above 1 for operators and/or re-entry workers
  - risk for re-entry workers could be decreased with PPE

- Limitations
  - Data availability
    - Absorption coefficients
    - Exposure estimations (for GH few values available)
    - AOEL
    - Degradation rates on plant

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