Economic and environmental evaluation of IPM strategies in wheat- and maize-based rotations

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Objectives and strategies

- assess the environmental and economic sustainability of two IPM levels against CON scenarios in wheat and maize based systems

- CON: most common rotation and standard practices

- IPM1 (ADV): more diversified rotation, integration of cultural, chemical, mechanical practices, use of monitoring and forecast systems for decisions

- IPM2 (INN): more complex rotations (e.g. cover crops), use of all tools that highly reduce dependence on pesticides (i.e. non-chemical methods preferred, although more expensive and/or less effective)

Cost-benefit analysis (CBA)

Gross margin

- Gross margin = Financial yield – variable costs

- Financial yield
  - Yield
    - Derived from the experiments
  - Price
    - Average price (Eurostat) or regional prices
    - No extra price for IPM-strategies

Cost Benefit Analysis

Total variable costs

- Inputs
  - Seeds, pesticides, herbicides, fertilisers
- Application costs
  - Contract work prices
    - Including cost for labour, machinery and fuel
    - Regional contractor prices

SYNOPS environmental risk assessment

- Comparison of pesticide use strategies under field based environmental conditions
- Based on application scenarios of on-station experiments

Exposure

soil

surface water

field margins

Toxicity

earthworm

daphnia, algae, fish, lemna, chironomus

bee, other arthropods

active ingredient database

a.i.1 LC50 ;NOEC

a.i.2 LC50 ;NOEC

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$$\text{Risk (ETR)} = \frac{\text{calculated Exposure}}{\text{Toxicity}}$$

model application within PURE

RESULTS

Four risik categories for		acute risk	chronic risk	groundwater	
very low risk		ETR<0.01	ETR<0.1		
low risk		0.01<ETR<0.	0.1<ETR<1	ETR<1	no risk
medium risk		0.1<ETR<1	1<ETR<10	1<ETR<10	medium risk
high risk		ETR >1	ETR >10	ETR >10	high risk

Overall sustainability

- DEXiPM (*Pelzer et al. 2012*)
  - Multi-criteria decision-aid model, based on DEXi software
  - Evaluates sustainainability of systems
    - Economic
    - Environmental
    - Social
  - Adjusted ex-post version using quantitative results from CBA and SYNOPS

Wheat based experiments

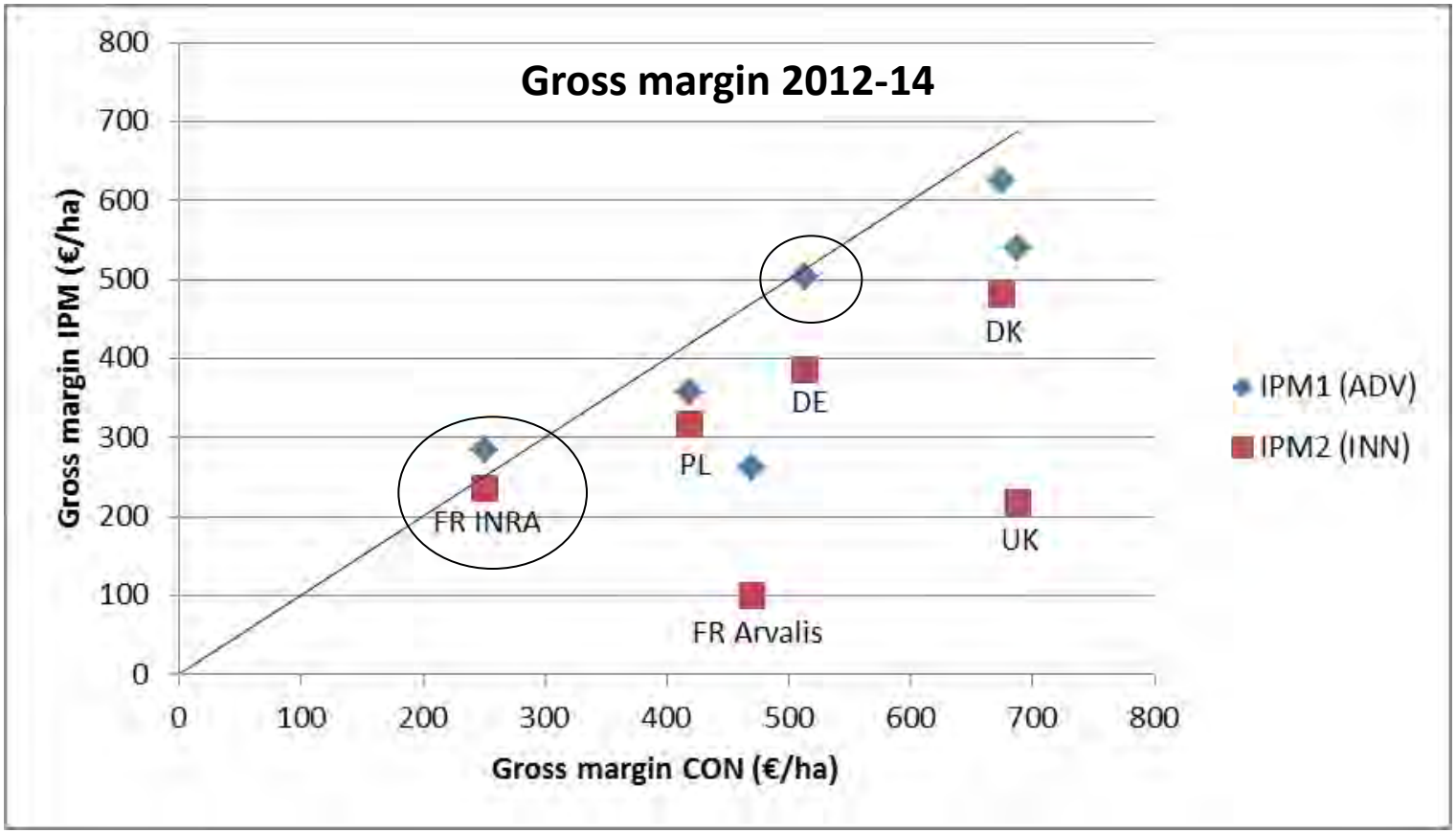
Sites	CON	IPM1 (ADV)	IPM2 (INN)
Balruddery (UK)	WW-WW-WSOR	SB-WW-WSOR	Pea-WW-WSOR
Flakkebjerg (DK)	WSOR-WW-WW	WSOR-WW-SB	WSOR-WW-SO
Winna Gora (PL)	WSOR-WW-WW	WSOR-WW-SB	WSOR-WW+cc-SB
Dahnsdorf (DE)	M-WW-WB	M+us-WW-WB	M+us-WW-WB+cc
Boigneville (FR)	Spea-WSOR-DW-SB-WW	WB-SL-DW-SB-WW	ALF-ALF-WW-SL-WFB-WW
Grignon (FR)	WSOR-WW-SPea-WW	WFB-WW-WSOR-WW-SB	SFB-WW-HE-TR-M-WW

- **All crops present every year (2012 to 2014)**

ALF: alfalfa; CC: cover crop; DW: durum wheat; HE: hemp; M: maize; PEA: pea; SB: spring barley; SF: sunflower; SFB: spring faba bean; SL: spring linseed; SO: spring oat; SPEA: spring pea; TR: triticale; WB: winter barley; WFB: winter faba bean; WOSR: winter oilseed rape; WW: winter wheat; US: under-sowing *Festuca* spp.

Wheat based systems

CBA – Gross margin at rotation level



- Overall, small reduction of IPM1(ADV) gross margin compared to CON
- Considerable reduction of IPM2 (INN) compared to IPM1 and CON

Wheat based systems

Environmental risks, mean value in rotation

Site	Systems	Acute risk		Chronic risk	
		Aquatic	Terrestrial	Aquatic	Terrestrial
Balruddery (UK)	CON	HIGH	MEDIUM	HIGH	MEDIUM
	IPM1 (ADV)	HIGH	MEDIUM	HIGH	MEDIUM
	IPM2 (INN)	HIGH	MEDIUM	MEDIUM	MEDIUM
Dahnsdorf (DE)	CON	MEDIUM	VERY LOW	LOW	VERY LOW
	IPM1 (ADV)	LOW	VERY LOW	LOW	VERY LOW
	IPM2 (INN)	MEDIUM	VERY LOW	MEDIUM	VERY LOW
Grignon (FR)	CON	MEDIUM	LOW	MEDIUM	MEDIUM
	IPM1 (ADV)	MEDIUM	LOW	MEDIUM	LOW
	IPM2 (INN)	VERY LOW	VERY LOW	VERY LOW	VERY LOW

- scenarios assumed 1m distance to water courses (5m in Germany) and neglected product related distance provisions

Four risk categories of SYNOPS	acute risk	chronic risk
very low risk	ETR<0.01	ETR<0.1
low risk	0.01<ETR<0.1	0.1<ETR<1
medium risk	0.1<ETR<1	1<ETR<10
high risk	ETR >1	ETR >10

Wheat based systems

DEXiPM results

Country	System	Sustainability			
		Economic	Environmental	Social	***Overall***
Balruddery (UK)	CON	M	L	H	***M***
	IPM1	M	M	H	***M***
	IPM2	L	M	M	***M***
Dahnsdorf (DE)	CON	H	L	H	***M***
	IPM1	H	M	M	***M***
	IPM2	M	H	M	***M***
Grignon (FR)	CON	VH	M	M	***H***
	IPM1	H	H	M	***H***
	IPM2	H	VH	M	***H***

Conclusions (wheat-based systems)

- Economic assessment
  - Compared to optimised CON both IPM1 and IPM2 have lower gross margins
    - lower yields not compensated by lower costs and/or
    - IPM premium prices
- Environmental risk assessment
  - Shows across regions reduced risk potentials of both IPM1 and IPM2 compared to CON
    - essential is pesticide selection rather than dose rate
- Overall sustainability
  - Remained the same to CON for IPM systems

Maize-based systems
Gross margin at rotation level

Site	Cropping systems and level of crop protection		
	CON	**IPM1 (ADV)**	**IPM2 (INN)**
IT	Maize-maize-winter wheat-maize (2nd cycle)	Maize-winter wheat-soybean-maize(2nd cycle)	Maize-winter wheat-CC-soybean-CC-maize (2nd cycle)
HU	Maize-maize-winter wheat-maize (2nd cycle)	Maize-winter wheat-peas-maize(2nd cycle)	Maize-winter wheat-CC-peas-CC-maize(2nd cycle)

➢**Crops in the rotation not present every year**

Site	Financial yield (€/ha)		Total variable costs (€/ha)		Gross Margin (€/ha)	
	ADV	INN	ADV	INN	ADV	INN
Legnaro (IT)	-121	-224	-341	-269	**220**	**45**
Debrecen (HU)	-375	-389	113	122	**-489**	**-511**

Maize based experiments

Environmental risks, mean value in rotation

Site	Systems	Acute risk		Chronic risk	
		Aquatic	Terrestrial	Aquatic	Terrestrial
Legnaro (IT)	CON	HIGH	VERY LOW	HIGH	LOW
	IPM1 (ADV)	MEDIUM	LOW	MEDIUM	LOW
	IPM2 (INN)	LOW	VERY LOW	VERY LOW	VERY LOW
Debrecen (HU)	CON	HIGH	VERY LOW	HIGH	VERY LOW
	IPM1 (ADV)	MEDIUM	VERY LOW	HIGH	VERY LOW
	IPM2 (INN)	MEDIUM	VERY LOW	MEDIUM	VERY LOW

- scenarios assumed 1m distance to water courses and neglected product related distance provisions

Four risk categories of SYNOPS	acute risk	chronic risk
very low risk	ETR<0.01	ETR<0.1
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medium risk	0.1<ETR<1	1<ETR<10
high risk	ETR >1	ETR >10

Maize based experiments

DEXiPM results

Site	System	Sustainability			
		Economic	Environmental	Social	***Overall***
Italy	CON	M	VL	H	***M***
	IPM1	H	M	H	***H***
	IPM2	H	H	H	***VH***
Hungary	CON	M	L	H	***M***
	IPM1	L	L	VH	***M***
	IPM2	L	H	VH	***M***

Conclusions (maize-based systems)

- Tested IPM-systems
  - Overall sustainability improved or the same
    - Economic sustainability decreased in HU due to lower gross margin substituting maize in the sequence, and to a lesser extent lower yields
    - Environmental sustainability improved
  - Rotation effects more visible after repeated rotation cycles

Overall conclusions

- Overall IPM seems to be applicable even though for arable crops (low value)
- Tools tested provided sufficient pest or weed control
- IPM greatly reduced wheat and maize reliance in pesticides
- Pests and weeds can be managed with an advanced IPM level using tools that are already available
- Capacity building and willingness of farmers and/or contractors important to use tools in the proper way and have sustainable results

Thank you for your attention!

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