A network of long term experimental sites to include quantitative modelling of pesticides losses in the multi-criteria assessment of innovating cropping systems in France

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INTRODUCTION

The French "Ecophyto plan 2018" aims at halving the use of pesticides and biocidal products over ten years. In such a context, agronomical research has been challenged to design new cropping systems that ensure a safe food supply and reduce drastically the dependence on pesticides. Designing innovative and sustainable cropping systems with low-pesticide inputs implies also to assess both their environmental and economical performances by quantifying different environmental and production components (Debaeke et al., 2009; Deytieux et al., 2012, Colnenne-David et al., 2013).

OBJECTIVE

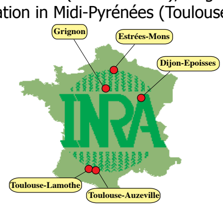
The objective of the project is to assess the performances of new cropping systems in several pedoclimatic conditions and for major crop productions. Among the environmental impacts it is necessary to quantify the reduction of pesticide fluxes out of agricultural fields induced by these new cropping systems. Such an assessment can be achieved by long-term field experiments coupled by model simulations.

A NETWORK OF SEVERAL LONG TERM EXPERIMENTAL FIELD SITES

DESIGNING AND TESTING NEW CROPPING SYSTEMS

- ✓ Based on Integrated Pest Management (IPM) and Ecological Intensification principles in order to meet a reduction of at least 50% of Treatment Frequency Index (TFI = ΣT ADT / HDT, with ADT the pesticide applied dose and HDT the registered dose) and avoid their use if possible
- ✓ Adapted to the French regional specificities : cereals, oilseed crops and legumes in Burgundy (Dijon) and Ile de France (Grignon) regions, sugar beet in Picardie (Estrées-Mons), irrigated maize monoculture or durum wheat – sunflower rainfed rotation in Midi-Pyrénées (Toulouse)

- Climate and soil variability
- Crop and cropping system diversity (17 in total)



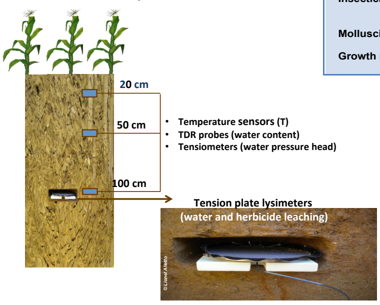
- Testing technical innovations to reduce pesticide use :
  - Mechanical weeding, false seed bed technique
  - Sowing date and sowing density, resistant cultivars
  - Diversification and extension of crop rotations
  - Cover-cropping, intercropping and tillage

MONITORING PESTICIDE LEACHING

- ✓ Knowledge of the field site history in terms of former pesticide applications
- ✓ Multi-residue analysis in leachate samples
- ✓ Few products monitored at the different sites according to their use (e.g. glyphosate, AMPA)
- ✓ Focus on specific compounds : S-metolachlor (Maize-Toulouse-Lamothe)

FIELD INSTRUMENTATION

- ✓ Temperature and water content are monitored at 20, 50 and 100 cm depth. Soil tension is measured at Toulouse-Lamothe
- ✓ Water flow measurements and quantification of pesticide leaching were carried out with tension plate lysimeters installed at 50 or 100 cm depth



THE EXPERIMENTAL SITES

	Dijon-Epoisses	Grignon	Toulouse-Auzeville	Toulouse-Lamothe	Estrées-Mons
Sarting date	2000	2008	2010	2010	2012
Objectives	Reduce pesticide use	Reduce pesticide use or fuel consumption or greenhouse gaz emission	Reduce fertilizer and pesticide use	Reduce irrigation, and pesticide use	Reduce pesticide use
Soil type **FAO classification**	Clayey soil Calcic Cambisol	Loamy soil Calcic Cambisol	Loamy clay soil Gleyic Luvisol	Loamy clay soil Gleyic Luvisol	Loamy clay soil Haplic luvisol
Plot surface (ha)	2	0.4	0.3	0.08	0.6
Reference system	oilseed rape winter wheat winter barley	field bean winter wheat oilseed rape winter wheat mustard spring barley	durum wheat sunflower	irrigated maize	NT*: oilseed rape- winter wheat-winter barley CT*: winter wheat-sugar beet - winter wheat - oilseed rape
Innovative systems	3	4	6	5	4
Repetitions	2	3	3	2	2
Management options	diversified crop rotations mechanical weeding competitive and resistant cultivars delayed sowing high sowing densities false seed bed technique soil tillage	extended crop rotations mechanical weeding competitive and resistant cultivars mixing cultivars diversified sowing dates reducing N fertilization reduce yield objectives	diversified crop rotations mechanical weeding competitive and resistant cultivars mixing species catch crops with high density	diversified crop rotations mechanical weeding catch crops with high density mulching and no-tillage competitive and resistant cultivars strip-tillage and permanent cover crop	diversified crop rotations mechanical weeding competitive and resistant cultivars mixing species delayed sowing false-seed bed technique cover crop soil tillage
Pesticide losses measurement (repetitions/plots)	Wick Lysimeters (2)	Tension plate lysimeters (2)	Tension plate lysimeters (2)	Tension plate lysimeters (2)	Not instrumented
Molecules applied **Herbicides**	Glyphosate Isoproturon Pendimethalin Imazamox Cloquintocet-mexyl Pinoxaden, Fluroxypyr Napropamide Florasulam Metazachlor Quinmerac	Glyphosate Isoproturon Pendimethalin Imazamox Cloquintocet-mexyl Pinoxaden, Tribenuron-methyl Thifensulfuron-methyl Mesosulfuron-methyl Iodosulfuron-methyl Clomazone Clopyralid Fluroxypyr 2,4-MCPA, 2,4-D Aclonifen	Glyphosate S-Metolachlor Pendimethalin Imazamox Cloquintocet-mexyl Dimethenamide Tribenuron-methyl Thifensulfuron-methyl Mesosulfuron-methyl Iodosulfuron-methyl Flurochloridone Clodinafop-propargyl	Glyphosate S-Metolachlor Isoproturon Mesotrione Florasulam Cloquintocet-mexyl Iodosulfuron Quizalofop-p-ethyl Sulcotrione Bentazone	Glyphosate Isoproturon Mesotrione Diflufenican Cloquintocet-mexyl Metsulfuron-methyl Amidosulfuron Clopyralid Diclofop-methyl Fenoxaprop-p-ethyl Fluroxypyr Bromoxynil 2,4-MCPA Pyroxsulam, Florasulam Triclopyr, Pyraflufen-ethyl
Fungicides	Boscalid Epoxiconazole Cyproconazole Prothioconazole Azoxystrobin Pyraclostrobin	Boscalid	Metconazole Difenoconazole Fenpropimorphe Azoxystrobin	Epoxiconazole	Boscalid Epoxiconazole Prothioconazole Tebuconazole Prochloraz, Fluxapyroxad Pyraclostrobin Trifloxystrobin
Insecticides	λ-Cyhalothrin	Cypermethrin	λ-Cyhalothrin Cypermethrin Tau-fluvalinate	λ-Cyhalothrin	
Molluscicides		Mercaptodimethur	Metaldehyde	Metaldehyde	
Growth regulators	Prohexadione-Ca Mepiquat-Chloride			Thiamethoxam	Trinexapac-ethyl

MODELING

- ✓ Comparing various models and approaches: i) PRZM 3.12 (Carsel et al., 1998), ii) PEARL 4.4.4 (Leistra et al., 2001), iii) MACRO 5.2 (Larsbo & Jarvis, 2003)
- ✓ Assessing their abilities to simulate pesticide fate and transfer in complex crop rotations and pluriannual scenarii
- ✓ Targeting uncertainties and their sources

PESTICIDE FATE AND TRANSFER MODELING AS ONE PART OF GLOBAL ASSESSMENT

- ✓ The outputs of the pesticide fate models will be included in the multicriteria analysis, among other criteria such as :
  (i)other environmental impacts (energy uses, greenhouse gas emissions, nitrogen fluxes, crop diversity, soil quality)
  (ii)crop quality and yield
  (iii)economic performance
- ✓ The final objectives are to define which cropping systems will be suitable to optimize the sustainability of the arable crop production in each regional and pedoclimatic context in the case of a strong reduction of pesticide use

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See also in this conference !! : Posters N°A22 and B48 concerning results from Toulouse-Lamothe experimental site and platform presentation by L. Alletto.