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

Benoit P.1, Alletto L.2, Gavaland A.3, Giulano S.2, Farcy P.4, Darras S.5, Ubertosi M.6, Pernel J.7, Montagnier C.8, Vericel G.9, Mamy L.10, Pot V.1, Bedos C.1, Colnenne-David C.11, Doré T.11, Justes E.9, Munier-Jolain N.12

1 INRA-AgroParisTech, UMR Environnement et Grandes Cultures, Thiverval-Grignon
2 Université de Toulouse - Ecole d’Ingénieurs de Purpan, UMR AGIR, Toulouse
3 INRA, Unité Expérimentale ‘Grandes Cultures’ de Toulouse-Auzeville
4 INRA, Unité Expérimentale de Dijon-Epoisses
5 INRA, Unité Expérimentale ‘Grandes Cultures Innovation Environnement-Picardie’, Estrées-Mons
6 AgroSup Dijon, UMR AgroEcologie, Dijon
7 Agro-Transfert Ressources et Territoires (AGT-RT), Mons-en-Chaussée
8 INRA, INRA, Unité Expérimentale ‘Grandes Cultures’, Versailles-Grignon
9 INRA, UMR AGIR, Toulouse
10 INRA, UR PESSAC, Versailles
11 INRA-AgroParisTech, UMR Agronomie, Thiverval-Grignon
12 INRA, UMR AgroEcologie, Dijon

Corresponding author: benoit@grignon.inra.fr

Introduction

The French Ecophyto plan 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). 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. This is currently done in research projects such as SystemEcoP4 and EcoPest.

Long term field experiments to test cropping systems and measure pesticide losses

Several prototypes of cropping systems have been designed on the basis of Integrated Pest Management (IPM) and Ecological Intensification principles in order to meet a reduction of 50% to 100% of TFI.1 The design of each cropping systems has been adapted to the French regional specificities among a network of experimental sites: cereals, oilseed crops and legumes in Burgundy and Ile de France regions, sugar beet in Picardie, irrigated maize monoculture or durum wheat – sunflower rainfed rotation in Midi-Pyrénées. Concerning the environmental assessment of these different cropping systems, we plan to measure and model pesticides vertical transfer and total losses over pluri-annual time periods. The sites have been equipped by wick lysimeters or tension plate lysimeters to measure pesticide leaching2. On certain sites, losses by volatilization to the atmosphere will also be quantified.

1 TFI: Treatment Frequency Index = ΣT ADT / HDT, with ADT the applied dose of the pesticide and HDT the homologated dose of the pesticide.
2 See communication of L. Alletto et al. Comparison of the environmental performances of four maize monocropping systems: a three years monitoring of pesticides leaching.
Table 1: Main characteristics of the sites and cropping systems

<table>
<thead>
<tr>
<th></th>
<th>Dijon-Époisses</th>
<th>Grignon</th>
<th>Toulouse-Auzeville</th>
<th>Toulouse-Lamothe</th>
<th>Estrees-Mons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>Reduce pesticide use</td>
<td>Reduce pesticide use or fuel consumption or greenhouse gas emission</td>
<td>Reduce fertilizer and pesticide use</td>
<td>Reduce irrigation, and pesticide use</td>
<td>Reduce pesticide use</td>
</tr>
<tr>
<td>Soil type</td>
<td>Clayey soil</td>
<td>Loamy soil</td>
<td>Loamy clay soil</td>
<td>Loamy clay soil</td>
<td>Loamy clay soil</td>
</tr>
<tr>
<td>FAO classification</td>
<td>Calcic Cambisol</td>
<td>Calcic Cambisol</td>
<td>Gleyic Luvisol</td>
<td>Gleyic Luvisol</td>
<td>Haplic clay soil</td>
</tr>
<tr>
<td>Plot surface (ha)</td>
<td>2</td>
<td>0.4</td>
<td>0.3</td>
<td>0.08</td>
<td>0.6</td>
</tr>
<tr>
<td>Reference system</td>
<td>oilseed rape winter wheat</td>
<td>field bean winter wheat oilseed rape winter wheat mustard spring barley</td>
<td>durum wheat sunflower</td>
<td>irrigated maize</td>
<td>NT*: oilseed rape, winter wheat, winter barley</td>
</tr>
<tr>
<td>Innovative systems</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Repetitions</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Management options</td>
<td>diversified crop rotations mechanical weeding competitive and resistant cultivars delayed sowing strong sowing densities false-seed bed technique soil tillage</td>
<td>extended crop rotations mechanical weeding competitive and resistant cultivars mixing cultivars diversified sowing dates reducing N fertilization reduce yield objectives</td>
<td>diversified crop rotations mechanical weeding competitive and resistant cultivars mixing species catch crops with high density</td>
<td>diversified crop rotations mechanical weeding catch crops with high density mulching and no-tillage competitive and resistant cultivars strip-tillage and permanent cover crop</td>
<td>diversified crop rotations mechanical weeding competitive and resistant cultivars mixing species delayed sowing false-seed bed technique cover crop soil tillage</td>
</tr>
<tr>
<td>Pesticide losses measurement (repetitions/plots)</td>
<td>Wick Lysimeters (2)</td>
<td>Tension plate lysimeters (2)</td>
<td>Tension plate lysimeters (2)</td>
<td>Tension plate lysimeters (2)</td>
<td>Not instrumented</td>
</tr>
</tbody>
</table>

* NT: no tillage – CT: conventional tillage

Assessment of pesticide fate model performances

Different pesticide fate models are currently tested for their ability to simulate short-term and mid-term scenarios in such contexts\(^3\). Outputs of the models will be included in the multicriteria analysis, among other criteria such as (i) environmental characteristics (energy uses, greenhouse gas emissions, nitrogen fluxes, crop diversity, soil quality), (ii) crop quality and yield, and (iii) economic balance. 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.

References


This work is financially supported by the EcoPhyto Plan-violet Expe (System ECOP4 project), the Pesticides – Ecophyto 2018 Research Program (ECOPEST project) and the ANR Systerra Programm (MICMAC design project - ANR-09-stra-06).

\(^3\) See communication of J. Marin-Benito et al. Comparison of three pesticide fate models for S-metolachlor leaching under field conditions in different maize cropping systems.