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Does soil compaction modify the fate and effect of isoproturon?

Laure Mamy*, Pauline Vrignaud, Nathalie Cheviron, François Perreau, Mehdi Belkacem, Agathe Brault, Sébastien Breuil, Ghislaine Delarue, Jean-Pierre Pétraud, Isabelle Touton, Christian Mougin, Véronique Chaplain

INRA - UR 251 PESSAC, Route de Saint Cyr 78026 Versailles, France
** laure.mamy@versailles.inra.fr*

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Introduction

Soil is essentially a non-renewable resource which performs many functions and delivers services vital to human activities and ecosystems survival[1].
However the capacity of soil to keep on fully performing its broad variety of crucial functions is damaged by several threats, and among them chemical contamination by pesticides and compaction.
How these two threats could interact is unknown: compaction may modify the fate of pesticides therefore their effects on the biological functioning of soil.

Objectives

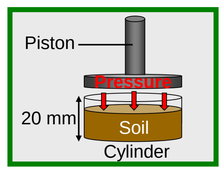
To study the effect of soil compaction on:

(1) The degradation of one herbicide, isoproturon

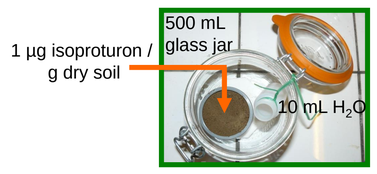
(2) The ecotoxicological impact of this herbicide measured through two enzyme activities involved in C (β-glucosidase) and N (urease) cycles in soil.

Materials & Methods

Undisturbed soil cylinders were sampled in the 2-4 cm layer of La Cage experimental site (INRA, Versailles), under intensive agriculture practices.
Soil: Loam, 1.69% organic matter, pH_{H_2O} = 7.3



Soil samples were prepared at three levels of compaction (bulk density, ρ, in g cm^{-3}):
- No: ρ = 1.33 ± 0.16
- Moderate (100 kPa): ρ = 1.45 ± 0.02
- High (800 kPa): ρ = 1.57 ± 0.13



Samples were then incubated at 18 ± 1°C in darkness for 63 days.
Each jar contained a vial with 10 mL of water to maintain a constant relative humidity.

At 0-2-7-14-28-63 days:

- **Degradation of isoproturon (IPU)**
  Soil extraction with CH_3OH → HPLC/UV for IPU and its main metabolites in soil: monodesmethyl-IPU and didesmethyl-IPU.

- **β-glucosidase and urease activities**
  Addition of substrates to soil samples → Quantitative determination of the reaction product with spectrophotometer.

Results & Discussion

Degradation of isoproturon as a function of soil compaction

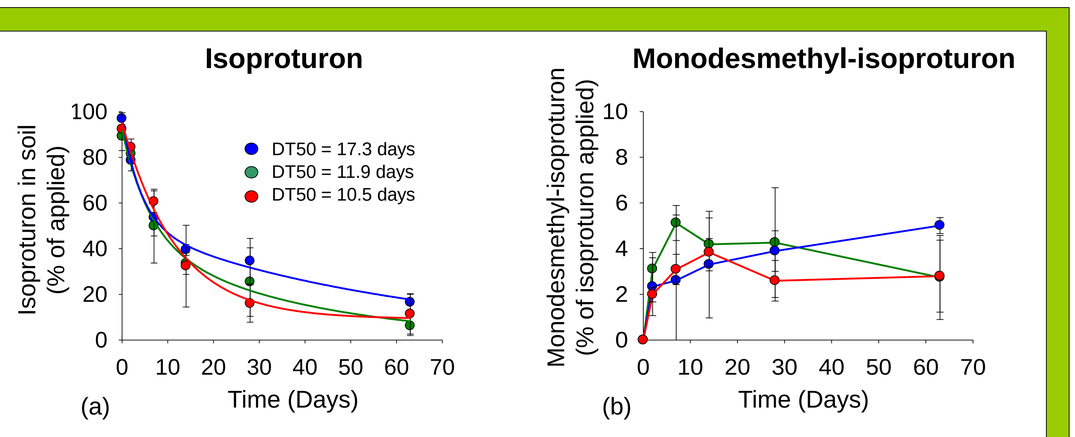


Figure 1. Degradation kinetics of isoproturon (a) and formation kinetics of monodesmethyl-isoproturon (b) as a function of soil compaction: (●) No compaction, (●) Moderate compaction, (●) High compaction. For isoproturon, lines are adjustments with first-order kinetics.
From Mamy et al., 2010[2].

- Compaction did not modify significantly the degradation of isoproturon ($P > 0.05$, Kruskal-Wallis test) (Mamy et al., 2010[2]).
  ➡ Compaction is known not to affect microbial communities[3] probably because it reduces porosity, favoring small and habitable pores accessible to bacteria and fungi[4].
- Degradation was slightly faster in the highly compacted soil probably because it had the highest degree of saturation[2].
- Only one main metabolite, monodesmethyl-isoproturon, was detected independently of the conditions of compaction. The formation kinetics are not significantly different ($P > 0.05$, Kruskal-Wallis test)[2].

Effect of isoproturon as a function of soil compaction

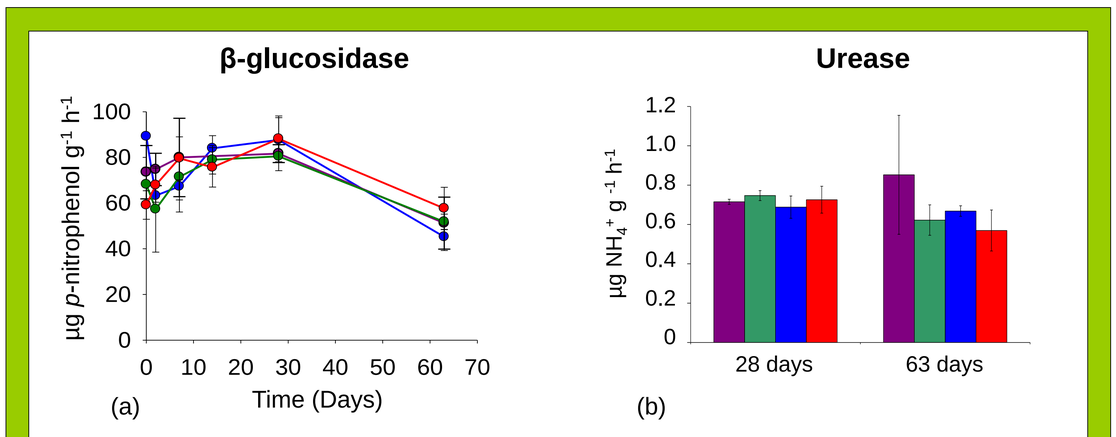


Figure 2. β-glucosidase (a) and urease* (b) activities as a function of soil compaction:
(●) No compaction, (●) Moderate compaction, (●) High compaction;
(●) Control (Isoproturon-free not compacted soil).
From Mamy et al., 2010[2].

- There was no significant effect of isoproturon on both enzymes activities compared to the control ($P > 0.05$, Mann-Whitney test)[2].
  ➡ The lack of effect can be due to the adaptation of microorganisms following the previous applications of the herbicide in the field.
- Compaction did not modify the effect of isoproturon on β-glucosidase and urease activities (in the long term) ($P > 0.05$, Kruskal-Wallis test)[2].
  ➡ This is in agreement with studies showing that compaction is of little consequence on the microbial communities[3].

* An experimental problem led to the loss of the samples from 0 to 14 days.

Conclusion

The results suggest that under soils compacted zones (due to traffic, tillage or short rotations), the persistence of pesticides should not increase and their effect should not be modified.
However, further studies should be performed measuring additional biological indicators, studying the relationship between compaction and the degree of soil saturation, and studying the overall balance of the fate of pesticides (mineralization, extractability and formation of non-extractable residues).

Acknowledgements

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References : [1] Directive 2006/0086/EC. [2] Mamy L, Vrignaud P, Cheviron N, Perreau F, Belkacem M, Brault A, Breuil S, Delarue G, Pétraud JP, Touton I, Mougin C, Chaplain V, 2010 (online). Environ. Chem. Lett. [3] Gregory AS, Watts CW, Whalley WR, Kuan HL, Griffiths BS, Hallett PD, Whitmore AP, 2007. Eur. J. Soil. Sci., 58:1221-1232. [4] Shestak CJ & Busse MD, 2005. Soil Sci. Soc. Am. J. 69:236-246.