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MODELLING AND EXPERIMENTAL FATE OF GLYPHOSATE COMPARED TO THAT OF HERBICIDES REPLACED WITH THE INTRODUCTION OF GLYPHOSATE-RESISTANT OILSEED RAPE

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INTRODUCTION

Crops resistant to glyphosate may mitigate the increased contamination of the environment by herbicides, since their weeding requires smaller amounts of herbicides and fewer active ingredients.
However, there are few published data comparing the fate of glyphosate with that of substitute herbicides under similar soil and climatic conditions.

OBJECTIVES

1. To evaluate and to compare the fate in soil in field conditions of glyphosate, as used on glyphosate-resistant (GR) oilseed rape, with that of trifluralin and metazachlor used for weed control on the same crop, albeit non resistant.
2. To compare field results with predictions of PRZM parameterized with laboratory data.

MATERIALS AND METHODS

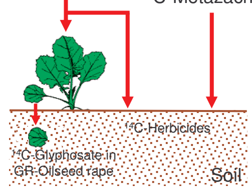
LABORATORY → **MODELLING** ↔ **FIELD**

Incubation & Batch

^{14}C-Glyphosate

^{14}C-Trifluralin

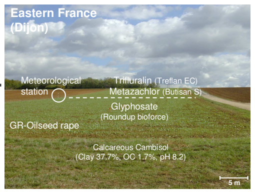
^{14}C-Metazachlor



Climate, Soil, Crops & Management input data

PRZM
Pesticide Root Zone Model[c]
v. 3.21

Glyphosate: Method of characteristics algorithm (MOC) & Dispersion
➨Calibration of thickness of the compartments in the soil horizon.
Trifluralin & Metazachlor: No MOC, no calibration.



Formulations of glyphosate (foliar applied), trifluralin (8 cm soil incorporated) & metazachlor (soil applied).

Degradation & Sorption
$T_{1/2}$ – Q10 – Kd

Simulated Dissipation & Distribution in soil profile

Field Dissipation & Distribution in soil profile

Table 1. Laboratory degradation half-lives ($T_{1/2}$) and rates (k), Q10 factors, adsorption coefficients (Kd) of herbicides and AMPA (Aminomethylphosphonic acid, main glyphosate metabolite)[a]

Herbicide / *Metabolite*	$T_{1/2}$ (d)	$k = \ln 2 / T_{1/2}$ (d^{-1})*	Q10	Kd ($L\ kg^{-1}$)**
Glyphosate	0.8 (Soil) / 16.3 (Oilseed rape)	0.142 / 0.042	2.3	42.8 to 56.2
AMPA	34.0 (Soil) / 115.5 (Oilseed rape)	0.020 / 0.006	-	32.0 to 42.0
Trifluralin	24.2	0.018	2.1	20.7 to 47.8
Metazachlor	2.7	0.216	1.7	0.37 to 1.06

* For modelling, k were multiplied by 0.5 for 30-60 cm depth and 0.3 for 60-90 cm depth[b], and it was assumed that 20% of glyphosate was intercepted by crops, 80% directly reached the soil.
** Kd per soil layer (0-10 cm – 10-20 cm – 20-30 cm – 30-60 cm – 60-90 cm).

$$\text{Model Efficiency ME} = 1 - [\Sigma(O_i-P_i)^2 / \Sigma(O_i-\bar{O})^2]$$

Where Oi and Pi are observed and predicted values of sample i respectively, and $\bar{O}$ is the mean observed values. ME = 1 indicates a perfect fit.

[a] Mamy, L. & Barriuso, E., 2005. Chemosphere, 61, 844-855 - Mamy, L., Barriuso, E. & Gabrielle, B., 2005. Pest Management Science, 61, 905-916 - Mamy, L. 2004. PhD Thesis, INA PG, Paris, France. [b] FOCUS, 2000. Report of the FOCUS Groundwater Scenarios Workgroup, EC, Doc. Ref. Sanco/312/2000 rev.2. [c] Carsel, R.F., Imhoff, J.C., Hummel, P.R., Cheplick, J.M. and Donigian, A.S.Jr, 1998. USEPA.

RESULTS

DISSIPATION OF HERBICIDES IN SOIL SURFACE

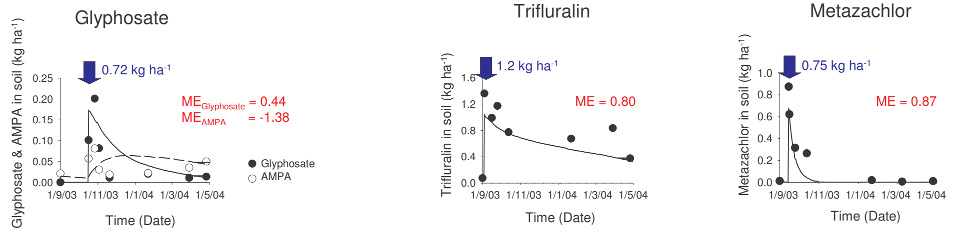


Figure 1. Observed (circles) and simulated (lines) dissipation kinetics of glyphosate, trifluralin and metazachlor in soil surface (0-5 cm). ME is model efficiency.

VERTICAL DISTRIBUTION OF HERBICIDES IN SOIL PROFILE

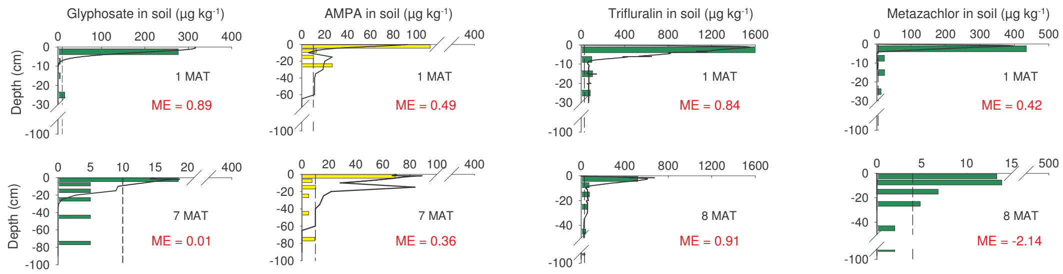


Figure 2. Observed (bars) and simulated (lines) distribution of glyphosate, AMPA, trifluralin and metazachlor in soil profile 1 and 7 or 8 months after treatment (MAT). Dotted lines are limits of quantification (LOQ): when < LOQ, amounts were considered = LOQ / 2.

- Field persistence increased as follows (DT50): metazachlor (11.6 d) < glyphosate (26.5 d) < trifluralin (203.8 d), differing from laboratory where glyphosate was the least persistent. AMPA was steadily more persistent than glyphosate.
- PRZM provided acceptable predictions of glyphosate and AMPA distribution in soil profile, however dissipation of glyphosate in soil surface was underestimated and formation of AMPA was poorly predicted.
The model gave accurate simulations of trifluralin and metazachlor dissipation. Prediction of distribution in soil profile was good for trifluralin, but was underestimated for metazachlor probably because PRZM ignores preferential flows.

CONCLUSION

Substitution of both trifluralin and metazachlor by low doses of glyphosate might contribute to decrease environmental contamination by herbicides, although the likely build-up of its metabolite AMPA in soils might raise some concern.
In general, data from laboratory allowed an acceptable parameterization of PRZM. This model might be used to evaluate and to compare others weed control strategies for herbicide-resistant as well as non-resistant crops.

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