Fate of realistic maize herbicides mixtures and impacts on soil microbial communities

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Pesticide Behaviour in Soils, Water and Air
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Herbicides in environment

- Possible transfer of herbicides molecules after spraying on cultures

- Important literature on the impact of herbicides sprayed alone at exaggerated or realistic doses

  Lo, 2010; Puglisi, 2012 (review)

IMPACT on ecological processes and biochemical cycles
Lack of knowledge on the effects of pesticides mixtures
Study case: replacement of Atrazine

MIXTURE of pesticides!
< 3 kg/ha/yr
Experimentation design

Herbicides used alone or in mixture (2 or 3 molecules)
Microcosms study (5 replicates/condition/date of sampling)
Following an application schedule (sequential pollution)
Experimentation design

Experimental conditions:
- Limagne “clay-rich” soil
- Sieved at 4mm
- Humidity at 50% of WHC
- Room temperature at 20°C ± 2°C
- Day/Night cycle (14h/10h)
Experimentation design

- Herbicides & metabolites concentrations (HPLC)
- Total microbial community
  - Specific communities (involved in nitrogen cycle and phototrophic organisms)
- Abundance / Diversity / Activities
Results

Fate of herbicides
Fate of herbicides

S-metolachlor contained in the commercial formulation Dual Gold Safeneur

Percentage of herbicide initial input remaining vs. Day of treatment.
Fate of herbicides

S-metolachlor contained in the commercial formulation Dual Gold Safeneur

Percentage of herbicide initial input remaining vs. Day of treatment
Fate of herbicides

S-metolachlor contained in the commercial formulation Dual Gold Safeneur

Percentage of herbicide initial input remaining vs Day of treatment

- DG
- DG (DG/C)
- DG (DG/M)
Fate of herbicides

S-metolachlor contained in the commercial formulation Dual Gold Safeneur

Percentage of herbicide initial input remaining

Day of treatment
Fate of herbicides

- Different S-metolachlor dissipation kinetics between mixtures
- Presence at day 120 at around 20 to 40% of the initial input

Total dissipation of mesotrione after 91 days whatever the considered treatment

Production of degradation products

- Slow dissipation of nicosulfuron
- At day 120, more than 60% of the initial input remains
Results

Nitrogen cycle

\[
\text{NH}_4^+ \rightarrow \text{NO}_2^- \rightarrow \text{NO}_3^- \rightarrow \text{NO}
\]

nitrification  denitrification
Ammonium (NH$_4^+$)

Day of treatment

N-NH$_4^+$ (µg g$^{-1}$ dry soil)
Ammonium (NH$_4^+$)

![Graph showing N-NH$_4^+$ (µg.g$^{-1}$ soil$_{dw}$) over the day of treatment.](image)
Nitrates (NO$_3^-$)

Day of treatment

- 56
- 91
- 120

Co, DG, C, M, DGC, DGM, CM, DGCM

a, ab, bc, c

Bars represent N-NO$_3^-$ (µg g$^{-1}$ of soil dw)
Abundance of nitrifying communities

NH₄⁺ → amoA → NO₂⁻
Archeal (AOA) / Bacterial (AOB)

Differences at days 22 and 28 only

AOA

Archeal amoA gene (copies, ng⁻¹, DNA tot.)

AOB

Bacterial amoA gene (copies, ng⁻¹, DNA tot.)
Impact of herbicides mixtures on the nitrogen cycle

Analyses in terms of activities are needed, in order to confirm hypothesis 1 results.

The increase of ammonium quantities can also be linked to the action of herbicides mixtures on sensitive communities (hypothesis 2).
Results

Phototrophic communities
Phototrophic communities

Shifts in soil surface colonization by phototrophic communities

Analyses of diversity and pigments abundance
Phototrophic communities

HPLC analysis of pigments content

Retention time (min.)

Peak intensity (AU)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

fucoxanthin

chlorophyll a
Phototrophic communities

Shifts in soil surface colonization by phototrophic communities

Day 56

Day 91

Day 120

Pigment (µg.g⁻¹ soil dw)

Co  DG  C  M  DGC  DGM  CM  DGCM

0  2  4  6  8  10  12  14  16

Co  DG  C  M  DGC  DGM  CM  DGCM

0  2  4  6  8  10  12  14  16

Co  DG  C  M  DGC  DGM  CM  DGCM

0  2  4  6  8  10  12  14  16

Fucoxanthin

Chlorophyll a

Day 56

Day 91

Day 120
Phototrophic communities

Cloning-sequencing

Day 91

T
DG
C
M
DGCM

Xanthophyceae
Diatom
Chlorophyceae
Conclusion

- Herbicides mixtures, at the recommended field rate, change the molecules dissipation rate and temporally impair the microbial communities.

\[ \text{NO}_2^- \quad \text{NO}_3^- \quad \text{NH}_4^+ \quad \text{NO} \]

Nitrification

AOA abundance

Sensitive communities (phototrophic...)

Resistant communities (degrading)

Mixture of 2 or 3 herbicides

Pool of O.M.
Perspectives of this work
Analyses currently running in order to confirm the results

Use another type of soil and analyse the behaviour and the impact of the herbicides mixtures with these new parameters

Limagne soil (clay dominant)

Versailles soil (silt dominant)
Thank you for your attention

Isolation of pesticide-degrading bacteria by Most Probable Number (MPN) method using tetrazolium salts; Magalie Stauffert; Clermont Université; France

Isolation and characterization of edaphic herbicide-degrading fungal strains after exposure to a mixture of herbicides; Magalie Stauffert; Clermont Université; France

Biodegradation of sulcotrione herbicide in a Vertic dark soil: impact of pesticide/soil/bacteria interactions; Edith Dumas; Clermont Université; France

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Poster session A, today, 5 p.m. to 6:30 p.m.