

S-metolachlor and Benoxacor volatilization from soil with and without crop residues

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CONTEXT and OBJECTIVES : Transfer to the atmosphere through volatilization may represent a major dissipation pathway for pesticides applied to soils or crops. These losses may be modified by soil surface conditions or in the presence of crop residues on the soil surface. Although volatilization is often mentioned in the literature to explain differences in pesticide persistence due to tillage operations, this phenomenon, especially its intensity and its occurrence, remains poorly understood. We conducted two experiments to measure volatilization fluxes for 3 days after an application of S-metolachlor together with benoxacor. The first experiment was based on the use of two wind-tunnels to compare the effect of the presence of crop residues on the soil on volatilization losses and the second one was carried out at the field scale from bare soil (so without crop residues) to quantify the losses under real conditions.

MATERIAL and METHODS:

In both experiments, application took place in Spring 2012 with the commercial solution (Calibra, SYNGENTA Agro SAS, liquid) with a concentration of 400, 20 and 40 g S-metolachlor, benoxacor and mesotrione per liter, respectively.

S-metolachlor and benoxacor volatilization fluxes were measured for 3 days after application following 2 methods:

- Wind tunnel systems (Figure 1): one on bare soil without crop residue (conventional maize monoculture reference plot T-MM1) and one on soil partially covered by crop residues (conservation tillage maize monoculture plot T-MM3).

The volatilization fluxes were estimated by a mass balance calculation:

$$F = Q (C_o - C_i) / S$$

where C_i and C_o ($ng\ m^{-3}$) are the pesticide concentrations at the tunnel inlet and outlet respectively, Q ($m^3\ s^{-1}$), the air flow rate through the wind-tunnel and S (m^2) the soil area covered by the tunnel.

- Field scale (Figures 2 and 3) : the volatilization fluxes were calculated with an atmospheric dispersion model (FIDES 2D) in an inverse mode.

Pesticide concentrations were measured 1) in the spraying solution, 2) on filters deposited on soil surface during application to estimate the application dose, 3) in the air by trapping pesticide on an adsorbent (Tenax), 4) in 0-2cm soil surface at the end of the experiment and 5) in crop residues when they were present. Analysis were done by TD/GC/MS or UHPC/MS/MS depending on the sample types.

Meteorological conditions as well as soil humidity were monitored during the experiments at an hourly time scale.

	Unit	S-metolachlor	Benoxacor
Cas number	-	87392-12-9	98730-04-2
Molecular	g mol ⁻¹	283.8	260.1
Mass			
Vapor	Pa	3.7E-03 (25°C)	5.9E-04 (20°C)
pressure			
Water	mg L ⁻¹	480 (25°C)	20(20°C)
solubility			
Henry's	Pa m ³ mol ⁻¹	2.2E-03 (25°C)	7.7E-03 (20°C)
constant			
K_{oc} Soil	m ³ kg ⁻¹	0.206	0.042-0.177
K_{oc} Crop	m ³ kg ⁻¹	0.062-0.118	No information
residue			

Table 1: Physico-chemical properties of both active ingredients



Figure 1: Wind-tunnels on bare soil (T-MM1) & on soil partially covered by crop residues (T-MM3)



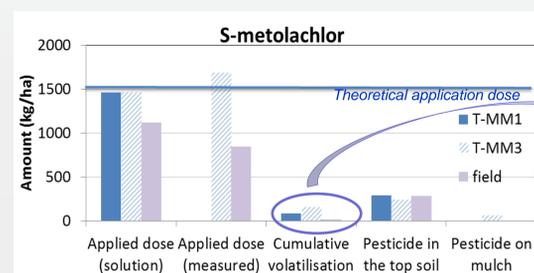
Figure 2: Application on the field (bare soil, 32 ha)



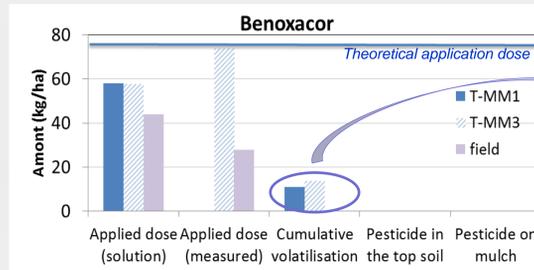
Figure 3: Overview of the field

RESULTS -

Amount of pesticides found in each compartment



S-metolachlor	T-MM1 (bare soil)	T-MM3 (crop residue)	Field
% cumulated volatilization / applied dose derived from the solution concentration	6%	10%	2.8%
% cumulated volatilization / applied dose derived from the deposit on filters	-	9%	3.7%



Benoxacor	T-MM1 (bare soil)	T-MM3 (crop residue)	Field
% cumulated volatilization / applied dose derived from the solution concentration	19%	24%	1.1%
% cumulated volatilization / applied dose derived from the deposit on filters	-	19%	1.8%

- The volatilization losses found for both compounds were in accordance with their physico-chemical properties
- Metabolites OA and ESA were only found in the end of the experiment in the soil of T-MM3 and within plant residues

Volatilization flux dynamics

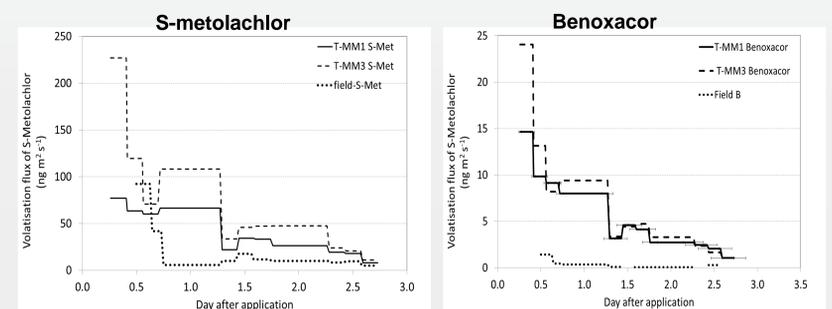


Figure 4: Measured volatilization fluxes ($ng/m^2/s$) with the wind-tunnels and at the field scale

- Volatilization fluxes were large immediately after application, decreased afterwards and showed a diurnal cycle
- The dry soil conditions found in the field, and to a lower extent in T-MM1, might have led to pesticide gaseous adsorption to the soil matrix which decreases the volatilization rates
- The crop residues on soil surface were shown:
 - to modify the dynamics of the volatilization, enhancing the volatilization rate mostly just after application
 - to enhance S-metolachlor degradation

CONCLUSION:

The crop residue on the soil surface modified soil surface conditions – primarily soil water content essentially, the degradation of S-metolachlor and the dynamics of volatilization loss.

Further studies are required to quantify the spray application intercepted by the crop residue and the subsequent dissipation of the pesticides within the crop residues. Improving knowledge on the volatilization process under conditions of current practices, such as conservation tillage, is necessary to improve emission models as well as to identify the best potential strategies to reduce such losses.