Determination of the plant uptake factor (TSCF) of trifluoroacetic acid from field rotational crop studies by inverse modelling

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Abstract

Plant uptake constitutes one of the dissipation pathways of pesticides in the environment. The uptake of trifluoroacetic acid (TFA) was experimentally studied in 17 field rotational crop studies in 4 European countries in cereals (wheat and barley) as target crop and with bare soil applied flufenacet. TFA residues in the above-ground biomass were inversely evaluated with the PEST optimization tool and the SWAP model in order to derive one TSCF for the entire growth period.

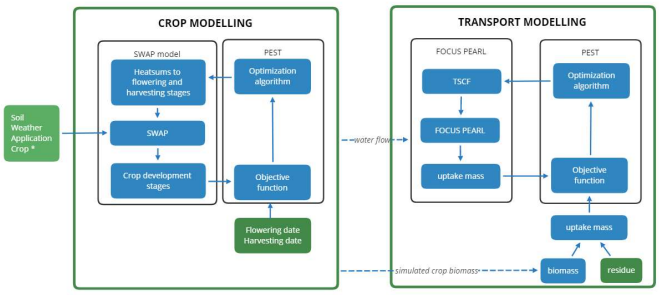

Fig. 1: Modelling approach

Materials and Methods

Crop residue studies:

- Only soil characteristics (texture, pH, % carbon) of the topsoil were reported
- Mostly loam-based soil type (sandy loam, silt loam, clay loam), organic carbon 0.96 to 3.14%
- Spring barley, winter barley, and winter wheat grown, partly in rotation crop systems with potatoes as precrop
- Single applications in the range of 0.06-0.24 kg a.s./ha
- TFA residues determined in green material (BBCH 48-51) and grain and straw (BBCH 89)

A stepwise approach with the detailed WOFOST (Boogaard et al. 1998) crop model for cereals was conducted (Fig. 1):

- Firstly, the soil-water-atmosphere-plant model SWAP was coupled with the parameter optimization tool PEST to fit the crop phenological development
- Experimentally determined TFA concentrations in the above soil plant material and the biomass simulated with SWAP were combined yielding the total TFA mass uptake of the investigated field plants
- TFA formation fraction of 0.733 from parent (mean value)
- Finally, the measured mass of TFA taken up by the total biomass was fitted against the simulated TFA uptake mass by coupling PEST and FOCUS PEARL model

Results

Measured residues in plants are displayed in Tab. 1. Since TFA can be formed from many sources in the environment, this leads to background levels in the control plots. In the treated plots, the highest residues were observed in the green material and straw, the lowest residues were in grains. For the inverse model evaluation, concentrations in the treated plots were corrected for the background levels.

The TSCF for all evaluated crop rotation studies resulted in a mean value of 0.32 (Tab. 2), independent of the crop type (wheat or barley).

Tab. 1: Statistical overview of measured residues of TFA from field studies

BBCH	Sampling material	Number of residue values	TFA [mg/kg] from control plots			TFA [mg/kg] from treated plots		
			Min	Ave	Max	Min	Ave	Max
48-51 (shoot development)	green material	20	< 0.01	0.02	0.13	0.01	0.27	1.40
89 (harvesting)	grain	20	< 0.01	0.03	0.22	0.03	0.15	0.34
	straw	20	0.014	0.04	0.20	0.06	0.31	0.95
Total		**60**	**< 0.01**	**0.03**	**0.22**	**0.01**	**0.24**	**1.40**

Tab. 2: Average plant uptake factor of TFA in barley and wheat, differentiated for the European countries

Country	Count [-]	Average [-]	Confidence interval 90%	
			Lower limit	Upper limit
Germany	4	0.29	0.13	0.45
Netherlands	5	0.54	0.22	0.85
France	3	0.26	0.12	0.39
United Kingdom	5	0.15	0.12	0.18
Overall	**17**	**0.32**	**0.20**	**0.43**

The employed approach did allow to make use of the environmentally broad information from the field rotational crop studies to obtain a reliable TSCF (transpiration stream concentration factor) value which can be used for modelling.

Conclusions

The TSCF for all evaluated crop rotation studies resulted in a **mean value of 0.32**, suggesting plant uptake of TFA as major dissipation path from soil.

This result confirms the outcome from better controlled container studies with a mean TSCF of 0.37 (see platform presentation O-17 by Klaus Hammel).

Future assessments would substantially benefit from additional measurements of soil properties and especially crop development.

Field residue data from crops other than cereals could only be evaluated after a detailed crop model was developed.

Ref.: Boogaard, H. L., Van Diepen, C. A., Rotter, R. P., Cabrera, J. M. C. A., & Van Laar, H. H. (1998). WOFOST 7.1; user's guide for the WOFOST 7.1 crop growth simulation model and WOFOST Control Center