Influence of the irrigation practices on leaching and their simulation

Jolanda Persolja[1,2]
Matteo Balderacchi[2]
Federico Ferrari[2]
Ettore Capri[2]

[1]University of Ljubljana, Biotechnical faculty, Department of agronomy, Institute of Phytomedicine, Jamnikarjeva 101, 1000 - Ljubljana, Slovenia

[2]Istituto di Chimica Agraria ed Ambientale, Facoltà di Agraria, Università Cattolica del Sacro Cuore, Via E.Parmense 84 29100 Piacenza, Italy
http://www4.unicatt.it/icaa

INTRODUCTION

It is well known that bad agricultural practice influences the leaching of different chemicals used in agriculture. If pesticides degrade in soil after application in different metabolites, the irrigation gets very important because it can accelerate the leaching during the time period when metabolite concentrations in leachate are at the highest level. Border irrigation is a common practice used in northern Italy mainly on cornfields. The aim of the study was to estimate the herbicide concentration of the parent compound (acethochlor and terbutylazine) and their metabolites: t-sulfonic acid (ESA) and t-oxanilic acid (OXA) of acetochlor and desethyl-terbuthylazine (DET) and hydroxy-terbuthylazine (HT) of terbutylazine in leachate below soil. Influence of different irrigation scenarios on leaching simulated with two models with different hydrological approach (PELMO and MACRO) were examined.

Figure 1: Border irrigation in Cavenago

Figure 2: Pesticide application in Cavenago

METHODS

Simulation was preformed for two experimental grain maize fields in Lombardia region Martinengo and Cavenago. The formulation of two pesticides containing acetochlor and terbuthylazine has been distributed in preemergence stage of maize on these two fields. Active substance data were obtained from literature and phytopharmaceutical firm, soil data were taken from soil profile database of Lombardia, climatic data were obtained from nearest meteorological stations and application data were obtained from the correlated field leaching studies. Some of missing data was taken from other models. Selected fields vary in soil, weather and pesticide application.

Three irrigation events per growth season of grain maize and scenario without irrigation were applied in the models. The amount of irrigation was estimated according to the common practice in the study regions: one real irrigation scenario with 35 mm of water and two worst case irrigation scenarios with 50 and 100 mm of water (situation with border irrigation).

Two models with different hydrological approach were used to simulate the fate of two herbicides and their metabolites in experimental fields: PELMO 3.22 (with FOCUSPELMO shell 3.2.2) which has the ability to simulate multiple metabolites of one parent compound and MACRO 5.0 model able to simulate preferential flow of water and solute. In PELMO the irrigation water was added to the climatic file. Two years of warming up the models were applied. Terbuthylazine and one of its metabolites (DET) content in groundwater under the field (groundwater depth: Martinengo 4±1m, Cavenago 5.5±1.5m) were analysed and compared with the modelling results.

Figure 3: Border irrigation in Martinengo

Figure 4: Border irrigation in Martinengo

RESULTS AND DISCUSION

Both models predicted higher metabolite leaching in Cavenago experimental filed than in Martinengo, due to different climatic and soil conditions.

Acetochlor simulation:

- In all of applied irrigation scenarios the predicted concentrations of acetochlor didn't exceed the legal thresholds for drinking water 0.1 µg/L (the highest monthly value was predicted by MACRO: 0.031 µg/L in scenario with 100 mm of irrigation water).
- In all of applied irrigation scenarios both models predicted concentration of ESA in leachate below soil core that exceeded 0.1 µg/L.
- Results of simulation OXA with PELMO exceeded 0.1 µg/L only in scenario with amount of 100 mm irrigation water while MACRO predicted concentration above 0.1 µg/L in three irrigation scenarios (Figure 5). Predicted leaching of OXA was lower than of ESA due to its comparably high sorption and low half-life.

Terbuthylazine simulation:

- In Cavenago, simulation results for terbuthylazine and its metabolites with PELMO and MACRO didn't exceed 0.1 µg/L in leachate below soil core for all irrigation scenarios.
- In Martinengo, simulation results with PELMO didn't exceed value of terbuthylazine and its metabolites 0.1 µg/L of in leachate below soil core for all irrigation scenarios while MACRO predicted concentration of terbuthylazine and its metabolites above 0.1 µg/L in case of 100mm of irrigation (Table 1).
- As in case of acetochlor and its metabolites concentrations increased with increased irrigation and PEC was higher in MACRO.
- The parallel results of groundwater measurements under the experimental fields show exceeded values of terbuthylazine and its metabolite DET. This can be explained with the lack of data about pesticide application in previous years. Additional simulations of repeated applications showed that terbuthylazine appears below soil core after few years.

In all cases predicted concentrations were higher in the second year of application (except in Cavenago where terbuthylazine was applied only in second year). With rising amount of irrigation the time step for appearance of metabolites was shorter.

Table 1: Results of MACRO compared with analyitical data for Martinengo experimental field (monthly values).

Month	Terbuthylazine MACRO (µg/L)	Terbuthylazine MACRO (µg/L)	Terbuthylazine measured (µg/L)
	35 mm irrigation	100 mm irrigation	
April 2005	1.09E-09	0.12	0.04
June 2005	4.74E-08	0.10	0.00
August 2005	5.08E-06	0.11	0.35
October 2005	3.73E-04	0.24	0.12
December 2005	1.35E-03	0.22	0.13

Month	DET MACRO (µg/L)	DET MACRO (µg/L)	DET measured (µg/L)
	35 mm irrigation	100 mm irrigation	
April 2005	4.29E-08	0.04	0.15
June 2005	5.23E-07	0.04	0.00
August 2005	7.18E-05	0.07	0.20
October 2005	1.99E-03	0.11	0.64
December 2005	3.94E-03	0.10	0.26

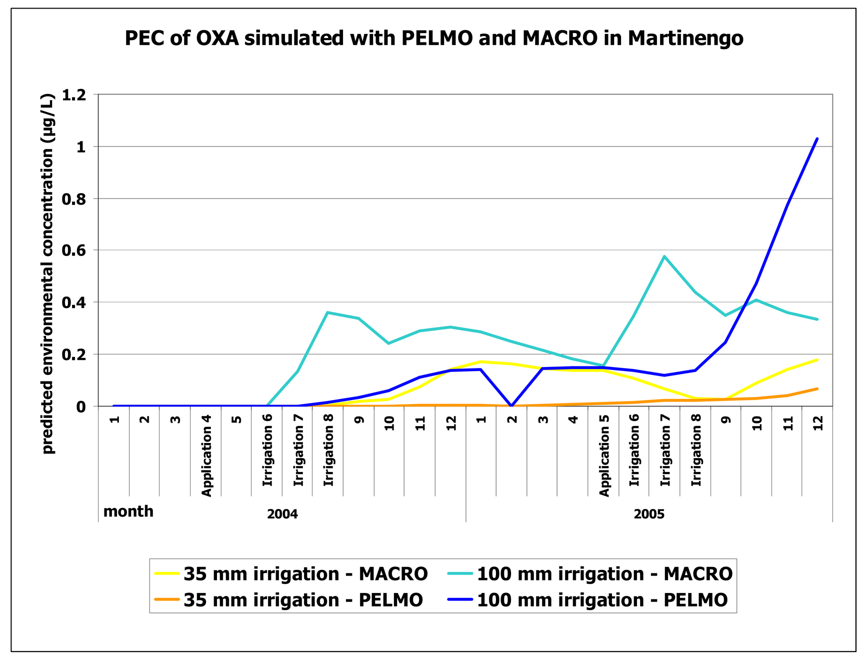

Figure 5: PEC of OXA in leachate below soil core simulated in leachate below soil core with models PELMO and MACRO in different irrigation events (35 and 100 mm).

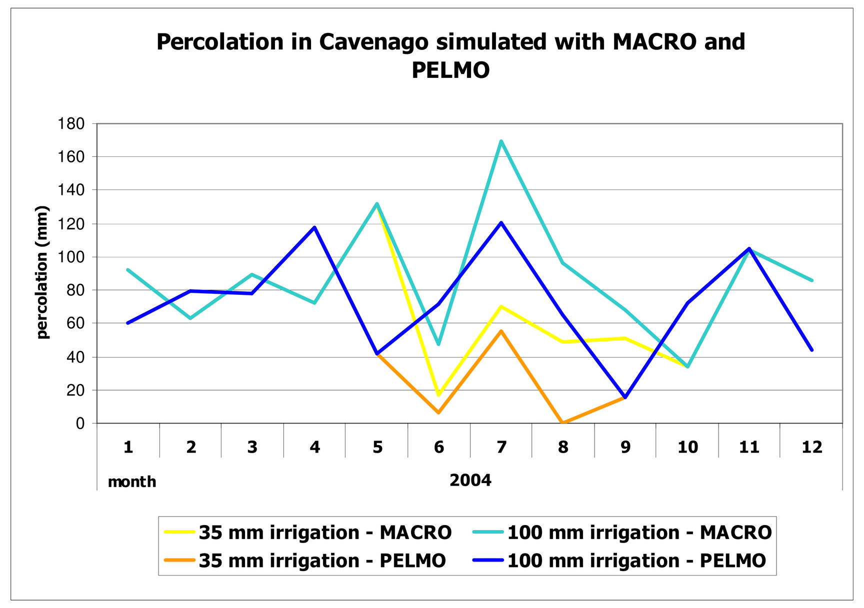

Figure 6: Comparison between simulated percolation with PELMO and MACRO model at amount of 35 and 100 mm irrigation water.

CONCLUSIONS

Amount and technique of irrigation are important factors in leaching of pesticide and their metabolites thus also in their simulation with models. MACRO predicted different behaviour of pesticides and their metabolites in relation to the leaching than PELMO. MACRO model predicted much higher metabolite leaching than PELMO, probably due to three reasons: 1. preferential flow which occurs in experimental fields, 2. MACRO can simulate border irrigation better (irrigation in PELMO was simulated as rainfall) and 3. MACRO algorithms don't allow simulation with more than one metabolite.

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