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### REGIONALISED USE OF A SIMULATION MODEL TO EVALUATE CROPPING SYSTEMS IN TWO AREAS OF THE EMILIA ROMAGNA REGION, ITALY

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#### Introduction

The application of models to cropping systems provides the ability to evaluate complex interactions that regulate the response of the soil-plant system to variations induced by climate and agricultural management, and allowing also the evaluation of the stochastic component of the climate. As a consequence, simulation models can be used to estimate the environmental impact resulting from different scenarios of agricultural management options. The Po Valley in Italy is an area of intensive agricultural activity. There is great public concern about the potential for deep water pollution caused by farming, but there is yet no clear evidence of the pollution caused by various cropping systems. Nitrogen fertilization is in general applied based on the yield expectation. The objective of this study is to develop a sample application to perform comparative evaluation of yield, drainage and nitrate leaching of cropping systems in two intensively cultivated areas of the Low Po Valley in Italy.

#### Methods

In this study, diverse cropping systems in two areas from Emilia Romagna were evaluated using the simulation model CropSyst (Stöckle and Donatelli, 1997) and the software Arc/View which was used both to produce the soil maps and to visualize the output produced by the simulations. We considered two areas, each corresponding to four soil maps in the scale of 1:25000, situated in the provinces of Modena and Piacenza, in the Po Valley, Italy. With the Cropsyst model, traditional cropping systems, and other innovative systems, in the two areas were simulated for a 50 year period. The predominant effects on the water balance and nitrogen fate were examined in the different systems. The following table reports the rotations simulated.

**Table 1. Rotations simulated.**

Rotation	years
sugarbeet - wheat	2
sugarbeet - wheat - wheat	3
sugarbeet - wheat - soybean - wheat	4
maize <sup>†</sup> - maize <sup>†</sup> - wheat	3
maize <sup>†</sup> - soybean <sup>†</sup> - wheat	3
sorghum - sorghum - wheat	3
soybean <sup>†</sup> - barley + sorghum <sup>†</sup> (summer sowing)	2

<sup>†</sup>irrigated crops

Table 2 reports the quantities per crop, to the net of the potential volatilization, of nitrogen fertilization. Given the crop sequence, the crop nitrogen input (two levels, see the following table), the average fertilization ranged from 50 To 260 Kg N/ha/year for the rotations simulated. The CropSyst option for crop residues to be incorporated into the soil was selected for all the crops.

**Table 2. Levels of nitrogen fertilization applied to the crops simulated at the two areas in the provinces of Modena and Piacenza.**

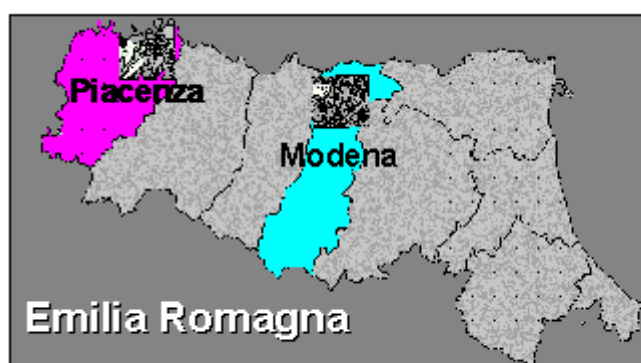
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Crop	“standard-high” (kg N/ha/year)	“medium” (kg N/ha/year)
Barley	150	100
Maize	300	220
Sorghum (spring)	250	150
Sorghum (summer)	100	0
Soybean	50	0
Sugarbeet	180	100
Wheat	180	100

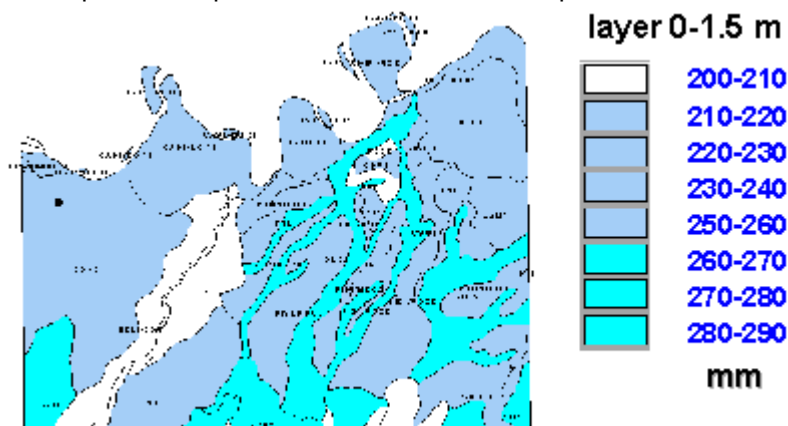
The long term average yearly rainfall was 697 mm for the area in the province of Modena, and 933 mm for Piacenza. The model parameter which sets the constant level of mineralization (which is then affected by different variables) was adjusted iteratively in order to obtain an initial mineralization of N from stable organic matter in a range of 90-100 kg N/ha/year.

### Results

The following figures show the areas under study:



From the soil map, the first output produced by estimating soil hydrologic parameters was the map of plant available water. As an example, the maps relevant to the area in the provincia of Piacenza are shown.



Several assumption were made to run this simulation study, the most important being:

- The runoff from a location doesn't constitute an input in the water balance of adjacent locations,
- Conditions of perched water tables are uncommon in the areas studied,

- The results of the simulations indicate, with respect to the quantities of percolation and leaching, that the simulation output should be interpreted mainly as means of comparison between systems.

**Table 3. Averaged leaching and percolation for 40 years of simulation of cropping systems at the "average" level of nitrogen fertilization (between parenthesis, the level "standard-high"); HWHC and LWHC stands for high and low water holding capacity respectively.**

<b>Modena</b>							
<b>Percolation (mm/year)</b>	Sb-W	Sb-W-W	Sb-W-Sy-W	M-M-W	M-Sy-W	B+Sr-Sy	Sr-Sr-W
LWHC soils	97 (95)	108 (106)	120 (107)	124 (124)	108 (120)	111 (83)	101 (111)
HWHC soils	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
<b>N leaching (kg/ha/year)</b>	Sb-W	Sb-W-W	Sb-W-Sy-W	M-M-W	M-Sy-W	B+Sr-Sy	Sr-Sr-W
LWHC soils	0 (1)	0 (2)	1 (3)	21 (77)	0 (20)	0 (0)	2 (46)
HWHC soils	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
<b>Piacenza</b>							
<b>Percolation (mm/year)</b>	Sb-W	Sb-W-W	Sb-W-Sy-W	M-M-W	M-Sy-W	B+Sr-Sy	Sr-Sr-W
LWHC soils	148 (145)	158 (158)	165 (156)	162 (162)	160 (165)	157 (140)	163 (157)
HWHC soils	8 (5)	10 (11)	10 (9)	7 (7)	14 (10)	4 (3)	13 (4)
<b>N leaching (kg/ha/year)</b>	Sb-W	Sb-W-W	Sb-W-Sy-W	M-M-W	M-Sy-W	B+Sr-Sy	Sr-Sr-W
LWHC soils	4 (11)	5 (18)	10 (11)	32 (91)	6 (34)	1 (1)	21 (77)
HWHC soils	0 (0)	0 (0)	0 (0)	12 (47)	0 (8)	0 (0)	0 (13)

### Conclusions

The study indicates that similar cropping systems, on similar soils, produce risks of leaching appreciably different in function of the rainfall of the area in which the study was conducted. Furthermore, it identifies how the variability of the leaching phenomenon is positively related to the amounts of potentially leachable nitrogen in the cropping system. Given the methodologies used to run the simulations, these two results indicate that quantifying the optimal quantities of nitrogen fertilizer on the basis of the predicted uptake of a crop, i.e. without accounting for both the stochastic component of the climate and the history of the system, is ineffective in consistently containing nitrogen leaching. The cropping systems simulation model coupled to a GIS software proved to be a powerful tool for scenario analysis with reference to potential pollution problems caused by agricultural management.

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### References

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