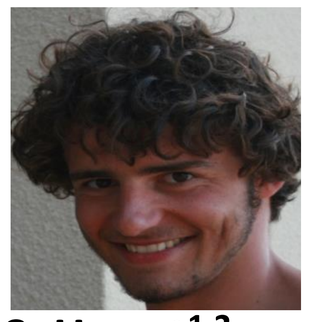
Optimization of Exogenous Organic Matter (EOM) use at the territory scale : maximization of Carbon Storage (CS) in soil and synthetic Nitrogen Savings (NS) in cropped soils

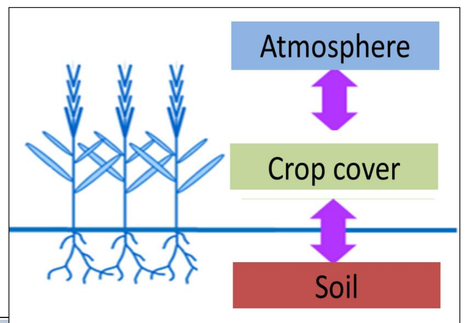


P.E. Noirot-Cosson[1,2](penoirot@grignon.inra.fr), E. Vaudour [2,1], C. Aubry[3], J.M. Gilliot [2,1], B. Gabrielle[2,1], S. Houot[1,2]

(1) INRA, UMR 1042 ECOSYS, F-78850 Thiverval-Grignon, France, (2) AgroParisTech, 1042 ECOSYS, F-78850 Thiverval, (3) INRA, UMR 1048 SAD-APT, AgroParisTech - 16, rue Claude Bernard, F-75231 PARIS Cedex 05

Introduction :

- **EOM can be recycled by agriculture to increase soil C and N availability**
- **EOM use can lead to environmental benefits and/or costs such as carbon storage, synthetic N savings, N leaching depending on EOM & soil types and Crop Production Systems (CPS) of the territory**
- **Mecanistic models can be used to understand and predict N and C dynamics**

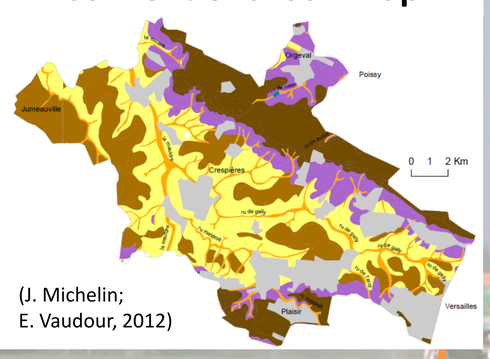


Methods:

1 Spatial characterization of the Versailles Plain territory (221 km²)

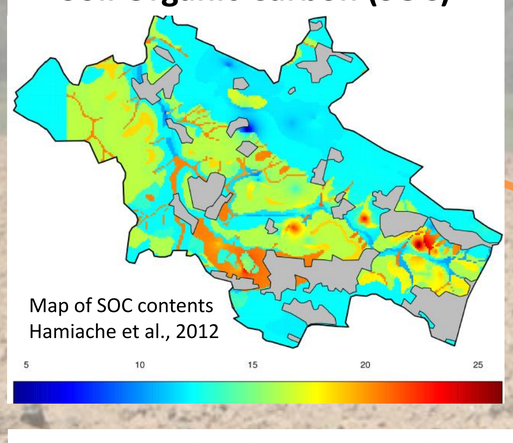
Conventional soil map

1 : Calcaric, rendzic cambisol
2 : Colluvic sandy cambisol
3 : hortic luvisol from loess deposits over limestone
4 : glossic luvisol from loess deposits over clay material



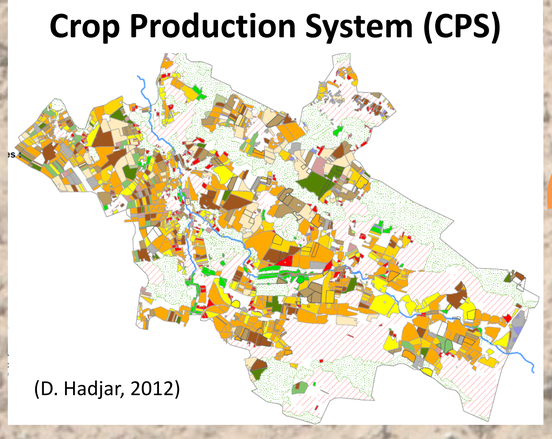
(J. Michelin; E. Vaudour, 2012)

Soil Organic Carbon (SOC)



Map of SOC contents Hamiache et al., 2012

Crop Production System (CPS)



(D. Hadjar, 2012)

EOM characteristics
C and N mineralization
(Francou et al., 2008; Houot et al., 2002)
+
NCSOIL optimization
(Molina, 1983, Barack et al., 1990)

Organic matter parameterization for all soil and EOM types

Initial SOC stocks

4 representative soil types parameterization

2 Spatialized model parameterization for each homogeneous spatial unit within the territory

CPS parameterization

Simulation on each homogeneous cropland area

Calibration on field experiment data of 1998-2011 (QualiAgro)

Use of the NCSOIL/ CERES-EGC crop model (Gabrielle et al., 2004)

20 years of simulation, climatic daily data averaged on the last 20 years

Meteorological parameterization

3 CPS and EOM use scenarios :

- **Quantity of EOM used limited by P crop needs and Water Framework Directive (max of 170kg N/ha)**
- **1 to 4 EOM applications**

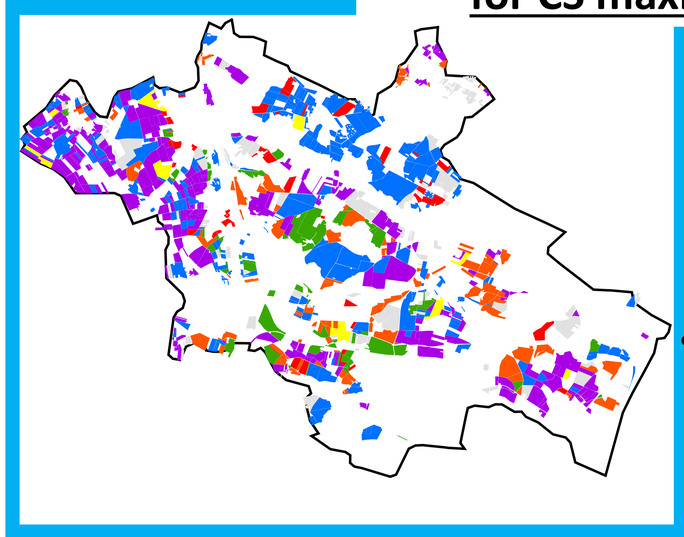
4 Reduction of N fertilization for both direct and indirect N supply from EOM: subroutine added to the model

5 20 years of simulations of the impacts of EOM uses on C and N cycles for all the spatial units of the territory

5 Optimization of the available EOM use over the territory: maximization of Carbon Storage (CS) in soil or maximization of Synthetic Nitrogen Saving (NS)

Results :

Fig 1 : Crop plots amended for CS maximization

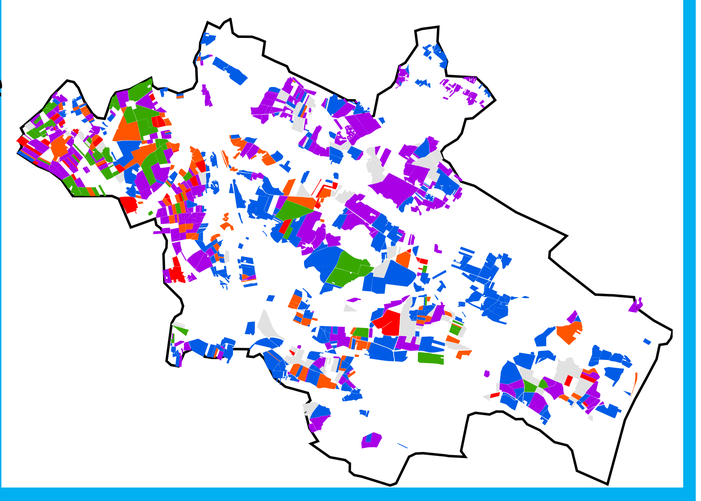


EOM types (total available quantity)

- Dried Sewage Sludge (SSd) (3515 t)
- Limed Sewage Sludge (SSl)(1430 t)
- Horse Manure (HM) (3672 t)
- Cow Manure (CM) (1450 t)
- Green Waste Compost (GW) (5340 t)
- Other EOM types (1578 t)
- No amendment

- **HM and SSd are widespreadly applied where other EOM are concentrated**
- **GW (stable) and HM (high CN ratio) applications mostly on calcareous soil 1 (low activity and low N supply)**
- **SSl (reactive EOM) mostly on reactive soil 3**

Fig 2 : Crop plots amended for NS maximization



- **HM and GW applications are concentrated where they are widespread for other EOM**
- **GW and CM applications mostly on reactive soil 3**

<= stable EOMs which increase soil organic matter active pool size

- **SSd (reactive EOM) mostly on soil 1**

Conclusion and perspectives :

- **Crop model allowed us to discriminate potential/risks of organic amendment in terms of many environmental services/costs such as carbon storage, mineral N savings on this territory after 20 years of simulations.**
- **Optimization methods are tools to find territorial EOM use patterns depending on the purpose**
- **Farmers constraints of calendar or equipment need to be taken into account for further investigation**

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References

- Barak, Phillip, J.A.E. Molina, Aviva Hadas, et C.E. Clapp, 1990. Optimization of an ecological model with the Marquardt algorithm. Ecological Modelling. 51, 3-4, 251-263
- Gabrielle, Benoît, Jeanne Da-Silveira, Sabine Houot, et Cédric Francou. 2004. Simulating Urban Waste Compost Effects on Carbon and Nitrogen Dynamics Using a Biochemical Index. Journal of Environment Quality. 33, 6, 2333.
- Houot, S., D. Clergeot, J. Michelin, C. Francou, S. Bourgeois, G. Caria, et H. Ciesielski. 2002. Agronomic Value and Environmental Impacts of Urban Composts Used in Agriculture. Microbiology of Composting. 457-472.
- Molina, J. a. E., C. E. Clapp, M. J. Shaffer, F. W. Chichester, et W. E. Larson. 1983. NCSOIL, A Model of Nitrogen and Carbon Transformations in Soil: Description, Calibration, and Behavior. Soil Science Society of America Journal, 47,1, 85-91.
- Hamiache J., Bel L., Vaudour E., Gilliot J.M., 2012a. Spatial stochastic modeling of topsoil organic carbon content over a cultivated peri-urban region, using soil properties, soil types and a digital elevation model. In: Digital Soil Assessments and Beyond, Minasny, Malone & McBratney (eds), CRC press, Balkema, pp. 161-166.
- Noirot-Cosson P.E., Bréchet L., Gilliot J.M., Eden M., Molina J., Rampon J.N., Gabrielle B., Vaudour E., Houot S., 2013. Simulation with the NCSOIL model of carbon and nitrogen dynamics in a loamy soil after various compost applications. In: 15th International Conference RAMIRAN 2013 : Recycling of organic residues in agriculture: From waste management to ecosystem services, INRA, VEOLIA Environnement, Versailles (FRA), 03-05/06/2013. (poster).
- Noirot-Cosson P.E., Vaudour E., Aubry C., Gilliot J.M., Gabrielle B., Houot S., 2014. Scenarios of organic amendment use to increase soil carbon stocks and nitrogen availability in cropped soils at the territory scale: spatial and temporal simulations with the NCSOIL/CERES-EGC crop model. In: International Conference EGU 2014: European Geosciences Union General Assembly, 27/04-02/05/2014. (poster)