Agronomic and environmental performances of organic field crop farms in the North of France

Turning back or moving forward ?

18 th Nitrogen Conference, June 2014 Lisbon

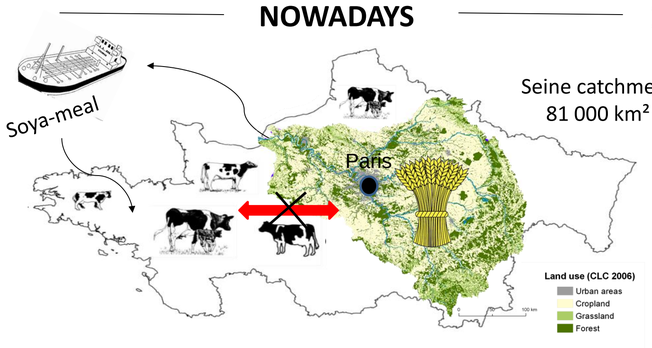
Juliette Anglade[1], Gilles Billen[12], Josette Garnier[12]

1 UPMC, UMR 7619 Metis, Paris

2 CNRS, UMR 7619 Metis, Paris

1. Context and objectives

NOWADAYS >> **IMMEDIATE FUTURE** >> **END BEYOND** >>



- Strong decoupling between animal and crop productions
- Groundwater contamination : 40 % of the 5000 drinking forages are endangered with nitrates and pesticides
- Costal marine eutrophication : algae bloom (non siliceous)

EU Directives

- Nitrates Directive
- Water framework

Regional fertilization decrees

- Optimal application of mineral fertilizers
- Catch crops

Will the application of French regulatory measures in favour of « good » fertilization practices be sufficient to satisfy the requirements of European directives ?

Organic farming

North France in 2010:
- < 3 % A.L.U
- 35 % of organic farms are specialized in crops

- No pesticides or synthetic fertilizers

What are the production performances of organic farming and what is the risk of environmental N losses ?

Self sustaining mixed farming system (19th century)

Julien Dupré « Bergère gardant son troupeau »

- Equilibrium between liverstock and crop

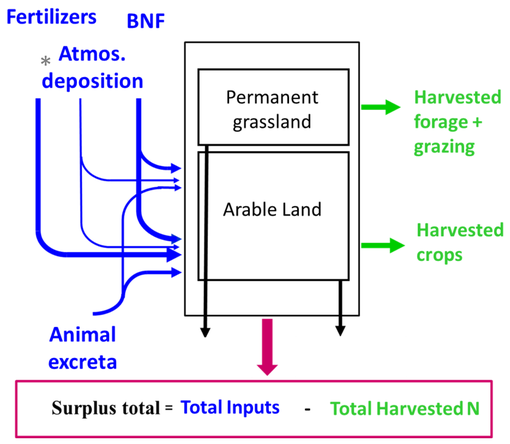
What were the production performances of traditional mixed farming and what was the level of environmental N losses ?

2. Material and methods

2.1 The Soil Surface Balance (SSB)

2.1.1 One indicator for 3 issues

Inputs amounts + origin | Protein exportation | Environmental losses



Surplus total = Total Inputs - Total Harvested N

* Estimated from the European Monitoring and Evaluation Programme

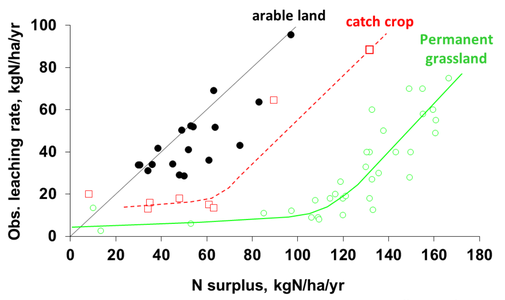
2.1.2 From N surplus to N leaching

Outputs for N surplus :

1) Leaching (~ 70 % on arable lands)

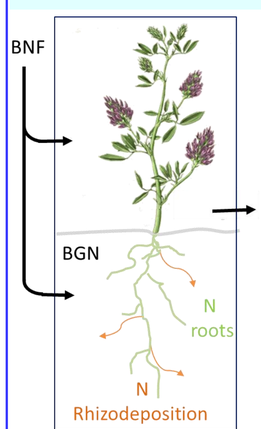
2) Volatilisation or denitrification

3) Accumulation in the soil OM pool



Billen et al., 2013

2.1.3 Zoom on Biological Nitrogen Fixation (BNF) estimation



① **Above-ground fixed N**

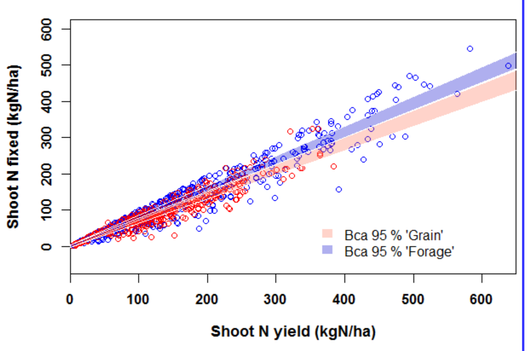
- Forage $Nfix_{shoot}$ =0.79 *NYield−0.49
- Grain $Nfix_{shoot}$ =0.70*Nyield+1.01

N yield

② **Below-ground contributions**

$$Nfix_{tot} = Nfix_{shoot} * R_{factor}$$

$$R_{factor} = 1 + \frac{(\text{root N} + \text{rhizo N})}{\text{Shoot N}}$$



Anglade et al., 2013

2.2 A variety of data sources to assess fertilization practices and yields

Organic farming

Individual enquiries

Rotations, fertilisation practices, yields, soils …

30 farms specialized in field crop
(no breeding activities)

Conventional farming

Mandatory requirements

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

- **Official fertilization Decrees (2012)**

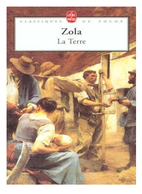
Mineral fertilization balance during the growth cycle

X (kgN/ha) = bN-P-Mh-Mcc-Mowp-SMN

Crop needs | Mineralisation of humus, catch crops, organic waste products | Soil min. N

Mixed farming (19th c.)

Historical archives



- **Realistic novel (Zola, 1887)**

One-farm routine, fertilization, herd management …

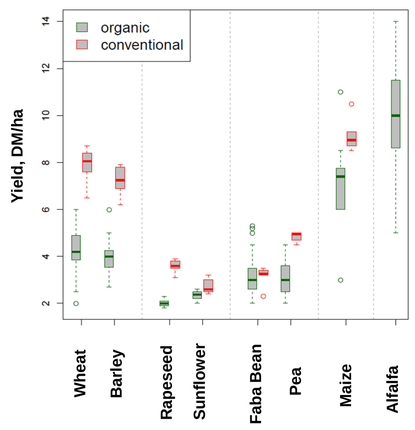
- **Surface and yields statistics (1870-1895)**

(Compiled from the French Ministery of Agriculture paper archives)

3. Results

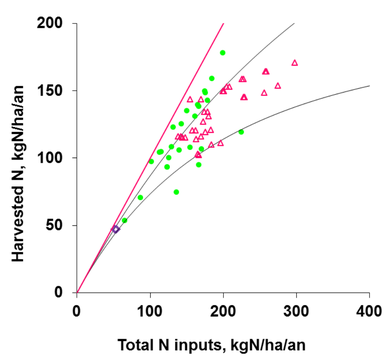
4.1 Comparing agronomic and environnemental performances

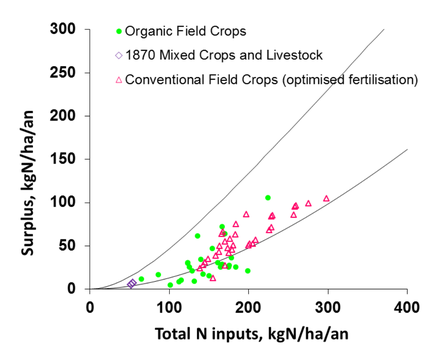
4.1.1 Organic vs Conventional yields



- **Organic cereal yields shows a 40% decrease compared to conventionnal means**

4.1.2 N-efficiency over the rotation : N inputs and N export

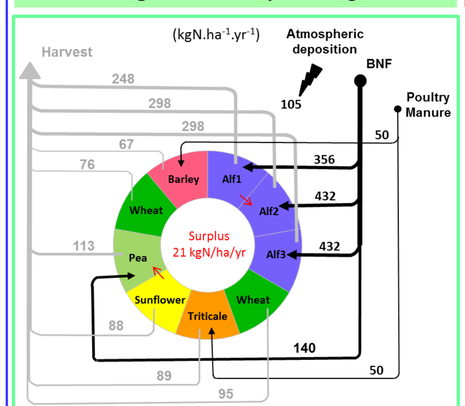




- **Organic crop rotation reach high protein yields that equalize or outperform conventional ones at similar fertilization rates.**
- **Organic surplus are on average 40 % lower than intensive cereal rotations managed with official fertilization practices.**

4.2 Breakpoints and common features of 3 contrasted agrosystems systems

Organic field crop farming

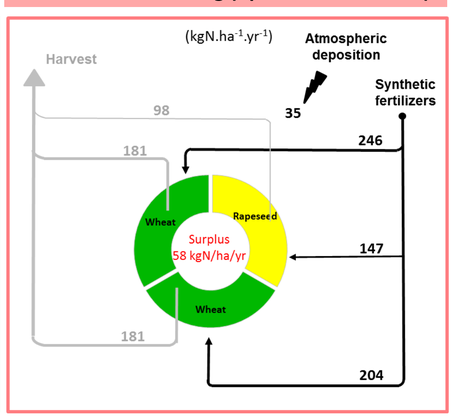


Harvested N (croplands) / Total N inputs

152 kgN/ha/yr / 174 kgN/ha/yr

Sub-root conc : 8,8 mgN/l

Conventional farming (optimal fertilization)

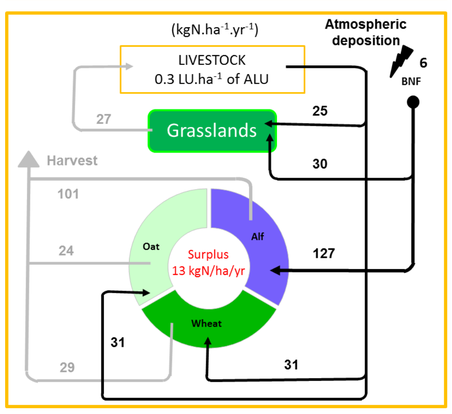


Harvested N (croplands) / Total N inputs

153 kgN/ha/yr / 211 kgN/ha/yr

sub-root conc : 24 mgN/l

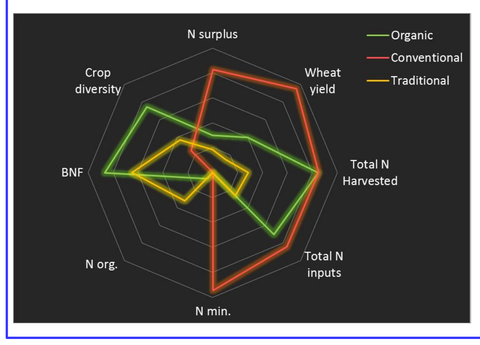
Traditional mixed farming (19th c.)



Harvested N (croplands) / Total N inputs

51 kgN/ha/yr / 64 kgN/ha/yr

sub-root conc : 5,4 mgN/l



- **The dominant cropping system (Rape-Wh-Wh) is characterized by high cereal yields (9tDM/ha), large synthetic fertilizers inputs and high N surplus leading to sub-root concentrations well above drinking water standards.**
- **N fluxes of cropland in the traditional 19th system were nearly in balance but total harvested N were reduced threefold compared to current agrosystems.**
- **The canonical complex organic crop rotation produces similar N yields than the conventional but wheat yield are reduced by half and around 60 % of the harvested material is intended for animal nutrition. Legumes are the main source of N inputs and exogeneous sources are minor.**

5. Conclusions

- ✓ **SSB is a robust indicator to compare different agricultural systems in terms of agronomic (N-yields, N-efficiency) and environmental (N sources, N losses) performances.**
- ✓ **Integrated over the crop rotation, organic surplus are lower (40 % on average) than conventional surplus (even strictly following the rules of rational and optimised application of fertilisers) because of high N yields due to the presence of N-rich legumes.**
- ✓ **The mere application of official fertilization recommendations, without reconsidering crop yields or rotations, are not sufficient to deliver sub-root water meeting the drinking standards of 11 mgN/l.**
- ✓ **The extension of organic agriculture, to meet water quality targets while maintaining high protein productivity, depends upon local opportunities of valorizing legume fodder cereal by-products, as was the case for pre-industrial mixed farming systems.**

References

Anglade, J., Billen, G., Garnier, J. (in review). New relationships for estimating .N_2 fixation in legumes: incidence on N balance of low-input cropping systems in Eucope.Ecological applications.

Billen, G., Garnier, J., Benoit, M., Anglade, J., 2013. La cascade de l'azote dans les territoires de grande culture du Nord de la France. Cahiers Agricultures. 22 : 272-281