Agronomical and environmental performances of organic farming in the Seine watershed, France.

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Implications

This work suggests that Soil Surface Balance is a robust indicator to compare the performances of organic agriculture with those of conventional agriculture, even strictly following the rules of rational and optimised application of fertilisers. The results of long term nitrogen budget calculation brought us to seriously reconsider the relevance of the need to increase crop yields, and more broadly to reconsider cropping patterns and production systems. In terms of policy levers for mitigating nitrogen contamination of water resources, only the shift to organic farming provides a possible way to reconcile agricultural production and water quality.

Further, this view points out the need for specific measures to encourage more mixed farming approach to organic farming on a territorial basis, thus reversing a 50 years trend to regional specialization into either crop or livestock farming.

Background and objectives

Nowadays, diffuse pollution of agricultural origin is the main cause of severe surface and groundwater contaminations with pesticides and nitrates in the Seine watershed, thus endangering the drinking water resources of Paris.

Organic farming appears as a credible alternative to the conventional input-intensive mode to restore and protect water quality. Positive effect on pesticide contamination is obvious but effects on nitrogen loads remain little known or controversial and deserve peculiar attention (Stopes et al. 2002, Torstensson et al. 2006, Aronsson 2007, Kelm et al. 2008). Since 1996, European Nitrates Directive (91/676/EEC) recommends an optimal nitrogen supply according to the need of the crops but due to insufficient application of the Directive the French Government was forced to establish new regional references (in 2012) to calculate precisely the appropriate rates of nitrogen fertilizers.

In this study, we attempt to assess long term effectiveness of organic farming practices in comparison with those recent mandatory requirements and current conventional practices on the Seine watershed in decreasing N leaching and meeting water quality targets.

Key results and discussion

Spatial organization of organic farming (3 % on average of the French Agricultural Land Use in 2010) surprisingly follows the same trends as conventional agriculture, i.e a strong decoupling of crop and animal farming. The Center of the Parisian Basin is devoted to cereals farming, while livestock farming concentrates in peripheral regions.

Organic farms specialised in crop production rely on complex crop rotations (7 to 14 years) involving legumes crops and forage. Symbiotic nitrogen fixation accounts on average for more than 50 % of total nitrogen inputs. Atmospheric deposition contributes for about 10 % and remaining part comes from exogenous sources (like distillery residues and animal manure). For mixed and dairy farms symbiotic fixation reach 85 % of total N inputs.

Yields of organic cereals show a decrease in the range of 25-40 % compared with conventional averages in the same areas. For relevance, organic and conventional farming were compared by integrating the complete rotation of both organic and conventional systems. When investigating N-efficiency by the relationship between total N input and total N export, it appears that the yield of organic farms expressed as N export is equal or higher than that of conventional farms at similar total fertilization rate,

although the latter generally receive larger nitrogen inputs. Most organic farms thus show a better N-efficiency and have therefore significantly lower N surplus than conventional farms, whatever the performances of the latter are calculated assessed for current practices or "good fertilization practices".

Farms having mixed livestock and crop farming structure internalizing manure for crop production appear to be the most N-efficient, with N surplus on arable land two times less on average than that of field crops farms. It should be noted that few farms specialized in the production of field crops reach a low level of N surplus (5 to 15 kgN/ha/yr), but with no sustainable nutrient management because largely depending on exogenous fertilizers.

Among the 40 organic farms investigated, more than two third were found to deliver sub-root water meeting the drinking standards of 11mgN/l. In the remaining third, we identify a combination of risk factors such as massive exogenous manure inputs coupled with a huge proportion of legume crops and clover in the rotation, and no harvest/export of high protein legume forage.

How work was carried out?

A survey of 40 contrasting organic commercial farms (face-to-face individual meetings) was carried out over the period 2011-2012 and covers the main types of farms, i.e. field crop, mixed crop and dairy.

We used the Soil Surface Balance, SSB (Oenema et al., 2003, De Vries et al., 2011), extended over a whole crop rotation cycle for a comparative analysis between conventional and organic farming of nitrogen use efficiency and impact on water resources. The N inputs accounted for are synthetic fertilizers, applied manure, grazing excreta, symbiotic dinitrogen fixation (estimated using an empirical model based on exported biomass and taking into account the contribution of residues and roots), atmospheric dry and wet depositions. Outputs are estimated as the N content of harvested crops and forage plus grazing.

Two kind of surplus were evaluated for conventional systems. The first one corresponding to current real practices was established at the administrative 'départements' level, using statistics data from the French Ministery of Agriculture. The second evaluation was in compliance to regulatory requirements to achieve equilibrium in nitrogen fertilization.

The SSB was calculated on both permanent grassland and arable land. Knowing the infiltration flux we have straightforward evaluated a theoretical sub-root nitrate concentration considering that most of the cropland nitrogen surplus is leached to the aquifers and the river waters.

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