Nitrogen leaching from organic agriculture and conventional crop rotations

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Implications

A great challenge to science is to elucidate how agriculture can feed the increasing world population without damaging the environment, while preserving other resources such as freshwater. In the Seine basin, characterised by intensive agriculture, most of surface and underground water is contaminated by nitrate. Conventional agriculture has regularly increased the use of industrial fertilisers since the WWII, leading to high nitrogen leaching, as shown by lysimeters or suction cup measurements. Such measurements are very scarce for other agricultural systems such as organic farming (Hansen et al. 2000; Haas et al. 2002; Mondelaers et al. 2009). The goal of our study is to investigate nitrogen leaching from organic agriculture, taking into account complete organic rotations (6-9 years). We hypothesize that leaching for organic farming is less than for conventional farming, although factors such as different practices, types of soil and age of conversion need to be taken into consideration. This work should have an impact on nitrogen sufficiency and management of organic practices.

Background and objectives

Due to the massive introduction of reactive nitrogen in the biosphere: aquifers, surface waters and atmosphere (Sutton et al. 2011), many directives for improving water quality by some changes in agricultural practices and have failed (e.g. European Water Framework Directive (2000) requiring "good ecological status" of water masses by December 2015). Long time series of sub-root crop concentrations in conventional agriculture are available for the Seine Basin, and average 25 ± 4 mg $N\text{-}NO_3.L^{-1}$ (standard for drinking water is 11 mg $N\text{-}NO_3.L^{-1}$) in different types of soil, crops and climatic conditions. However, no data still exists for organic agriculture in this area. Therefore, a scientific project supported by the Ile-De-France Region and the Water Agency of the Seine Basin has been launched in 2012. Several farms and experimental sites of arable crops have been equipped with suction cups in all their rotations, for several pedoclimatic situations, in order to determine concentrations and fluxes of nitrogen leached under complete organic rotations.

Key results and discussion

According to our first results (2011-2012), the sub-root concentrations were the highest at the beginning of the drainage period and then decreased progressively. Sub-root nitrogen concentrations in ceramic cups (N=24) have different average concentrations according to crops : 15 mg $N\text{-}NO_3.L^{-1}$ for wheat after two years of alfalfa; 7 mg $N\text{-}NO_3.L^{-1}$ for crops after legumes and 1.5 mg $N\text{-}NO_3.L^{-1}$ for alfalfa (Figure 1).

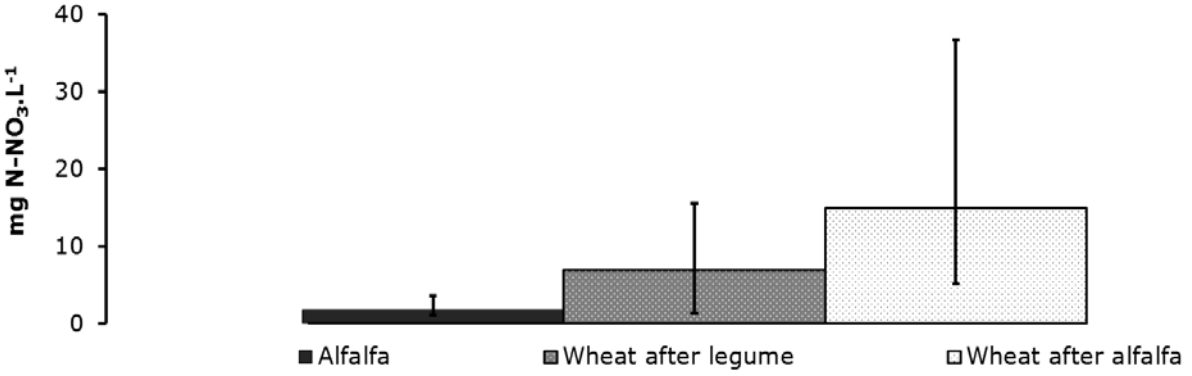

Figure 1 : Averages, minimums and maximums of nitrate concentrations in organic crops during the six months washout period (2011-2012)

Regarding legumes, this figure is in well agreement with the one mentioned for biological nitrogen fixation (Berg et al. 1999). Further results (2012/2013) will integrate all the terms of eleven rotations to determine nitrogen leached from complete rotations in different conditions (organic and conventional practices, climate and soil characteristics).

How the work was carried out?

Several farms within four pedoclimatic poles of the Seine Basin (France) were equipped for each term of their rotations with 6 suction cups set vertically to a depth of 90cm (Table 1). At this stage, 39 parcels have been studied for organic agriculture and 7 for conventional one (i.e. about 275 suction cups). After 48h under vacuum, the sub-root water is collected from the suction cups with a vacuum pump. Samples are taken once a week throughout the period of drainage (Lord et Shepherd 1993; Stopes et al. 2002; Bowman et al. 2002). Additionally, soil samples were analyzed at three soil horizons over the 90 cm, for nitrogen concentrations, granulometry and physicochemical properties. Nitrogen concentrations (ammonium, nitrite and nitrate) were determined with a colorimetric autoanalyzer (Quaatro, Bran & Luebbe, Inc.).

Table 1: Nitrate leaching equipment in the Seine Basin (France)

Period	2011-2012	2012-2013
Number of farms	2	8
Number of parcels	8	46
Number of suction cups	24	234

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