Nitrogen balances of Swiss agriculture from 1975 to 2009

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1. Background & Objectives

The progressive intensification of Swiss agriculture after World War II, characterized by growing inputs of nitrogen (N), resulted in a strong increase in productivity but also in rising environmental and health problems. An efficient reduction of ammonia and nitrous oxides emissions to air and nitrate losses to water requires a thorough knowledge of N flows in agriculture, e.g. by calculating N balances. In 1994 the first farm-gate balance of N was calculated for Swiss agriculture on behalf of the International Commission for the Protection of the Rhine (ICPR) and the Oslo and Paris Conventions for the Prevention of Marine Pollution (OSPAR). In 1996 N balance became a major agri-environmental indicator for monitoring the environmental performance after the introduction of direct payments bound to integrated production (IP), organic agriculture and other ecological programmes. The objective of this paper is to present the time course of N balances of Swiss agriculture in the last decades.

2. Materials & Methods

The farm-gate balance is mainly encouraged by OSPAR and essentially considers the agricultural production system to be a "black box". This balance is calculated as the difference between total imports from abroad and other economic sectors into agriculture, on the one hand, and total exports of agricultural products, on the other (OSPAR 1995). Inputs into agriculture comprise imported feedstuffs, mineral fertilizers, recycling and other fertilizers (sewage sludge, compost, etc.), imported seed (negligible for Switzerland and, therefore, not presented in the following), biological N fixation and atmospheric deposition. Outputs from agriculture encompass plant (bread cereals, table potatoes, etc.) and animal foodstuffs (milk, meat, eggs, etc.) and other animal products (by-products of meat production such as hides, animal meal, etc.). The balance, i.e. the difference between nutrient inputs and outputs, is in most cases positive (= surplus) and comprises the changes in soil nutrient stocks (increase or decrease in nutrient contents of soil) and total nutrient losses. A detailed description of used methods is found in Spiess (2011).

3. Results & Discussion

In 2009, 150 kg N ha^{-1} of utilized agricultural area (UAA) entered the agricultural sector of Switzerland, with mineral fertilizer, imported feedstuffs and biological N fixation being the largest input sources (Fig. 1a). In contrast, 44 kg N ha^{-1} left agriculture, with N quantities in animal foodstuffs and other products being more than three times larger than N in plant foodstuffs (Fig. 1b). The resulting surplus amounted to 106 kg N ha^{-1}. As changes in soil stocks are generally supposed to be insignificant for N, most of the N surplus may be lost through ammonia volatilization, nitrate leaching and denitrification.

Between 1975 and 1996, N input in imported feedstuffs was halved (Fig. 1a). Demand for feed decreased because of lower animal numbers and N contents of pig feed. On the other hand, imported feedstuffs were partly replaced by a higher domestic production. Since 1996, however, imports of feedstuffs have been increasing by some 20 kg ha^{-1}. More soybean meal has been imported following the ban on feeding animal meal due to the mad-cow disease (BSE) crisis in Switzerland. Use of mineral N fertilizer nearly doubled between 1975 and 1988. It then decreased until 1997 and has been more or less constant since then. The use of recycling and other fertilizers

decreased after 1997 because of the ban on sewage sludge application announced for 2006. Biological N fixation, mainly originating from the large grassland area with grass-clover swards, remained constant over the whole period. N deposition steadily decreased after a slight increase until 1980. Not only nitrogen oxides emissions from traffic and industry but also ammonia emissions were reduced, the latter following a reduction in the animal population and thus the quantity of animal manure produced.

N outputs in foodstuffs and other products changed only slightly over time (Fig. 1b). N surplus initially rose sharply to a maximum of 145 kg ha^{-1} in 1980, then decreased to 106 kg ha^{-1} in 1997 and remained at the same level until 2009. The accentuated reduction between 1992 and 1997 was principally due to the introduction of direct payments for ecological programmes such as integrated production in 1993. As a result, many farmers had to reduce their fertilizer use in order to comply with an equilibrated whole-farm nutrient balance. In 1997, most farmers were already participating in these programmes. Regarding the input items, substantial decreases were seen especially in deposition over the whole period and mineral fertilizer from 1988 onwards. The overall reduction in surplus between 1980 and 2009 amounted to 29%.

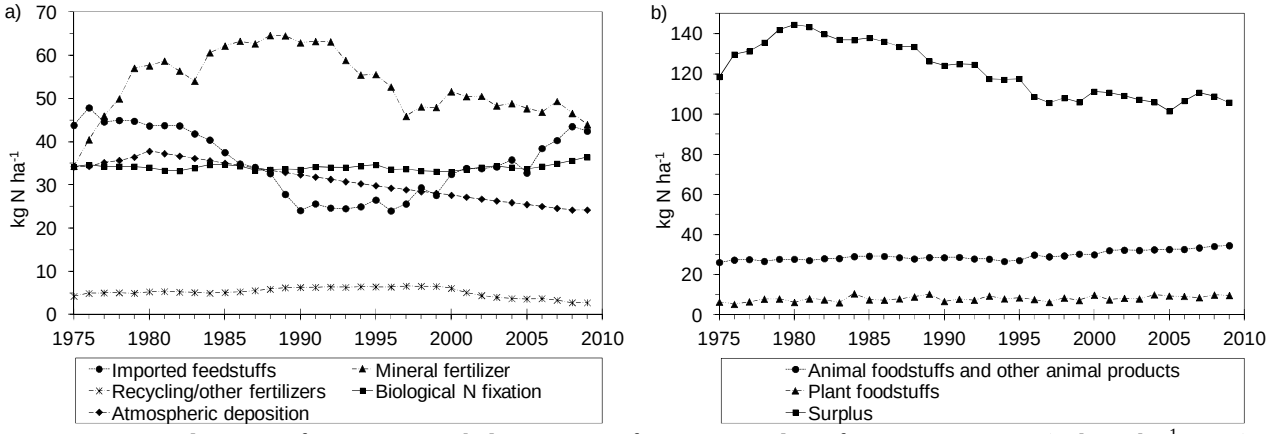

Figure 1. Development of N amounts in balance items of Swiss agriculture from 1975 to 2009 (in kg N ha^{-1} UAA). a) Input items. b) Output items and surplus.

4. Conclusion

Mineral fertilizer and imported feedstuffs turned out to be the major input items of N balance of Swiss agriculture. A further decrease in surplus requires farm managers to reconsider the size of these inputs into their farms. This might be achieved by increasingly using feeding and nutrient management plans, leading above all to lower nutrient excretion of livestock and an improved application of manure in time and space. Mineral fertilizer use, in return, might be reduced by better manure management.

References

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