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IS THERE A NITROGEN DEFICIT IN ROMANIAN AGRICULTURE?

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Abstract

Nitrogen (N) is a key nutrient in agriculture production. While most of the European countries have a highly positive N gross balance (Leip et al., 2011; EUROSTAT, 2017), Romania had a negative gross N balance in the year 2013. A positive N balance indicates the risk of pollution by nitrate ($N0_3^-$), ammonia (NH_4^+) and nitrous oxide (N_20). In contrast, a negative N balance might show the risk of soil depletion. We estimated an N soil surface balance and assessed the potential uncertainties in the data as well as the relation between N inputs and N outputs. The Romanian agriculture has a high N use efficiency of 0.99. Over the last 20 years we observed a slightly positive N soil surface balance of 0.1 kg per ha. The average N inputs accounted for around 40 kg N per ha. The fluctuation of the N soil surface balance between the years is high and mainly caused by the high fluctuation of N outputs, as due to weather fluctuations and plant pest, the yield does not achieve its' potential yield. However, the method of soil surface balance has some drawbacks, as farm internal fluxes are separated. Therefore, the calculation of an N farm gate balance would add some benefits as it is regarded as more precise due to the consideration of animal production.

Key words: *Nitrogen surplus, Romanian agriculture, Ammonia emission, soil surface balance.*

INTRODUCTION

Due to the collapse of the socialist regime, Romania has undergone drastic changes in regards to agriculture practices since 1989. On the one hand, agriculture land was abandoned (Müller et al., 2009). On the other hand, the amount of agricultural input decreased substantially (INSSE, 2017). One of this agriculture inputs is nitrogen (N) fertilizer. The input halved within one year. N is not only a limiting nutrient for crop production, but also essential for the productivity in animal production.

Romania has according to EUROSTAT (2017) a slightly negative N gross balance, due to the reduction of N inputs. Leip et al. (2011) showed that Romania had the lowest N balance of all European countries in the period of 2001-2003.

N balances are a common method to assess the N use efficiency of agriculture production of a country as well as of a farm. An N surplus indicates a potential loss of environmentally harmful substances like ammonia (NH_4^+), nitrate (NO_3^-) and nitrogenous oxide (N_2O). A negative N balance might show the risk of soil depletion

There are different methods to estimate a N balance; some, like the soil surface balance (see Figure 1), consider as system boundaries the soil surface and therefore give evidence of the source of N pollution, while others, like farm gate balances, consider the farm as system boundary and thus integrate also losses from animal production (Oenema et al., 2003). The advantage of a soil surface balance is the possible identification of pollution especially caused by nitrate (Spiess et al., 2010).

In this study, we estimated N balances using a soil surface nitrogen balance for the total agricultural sector of Romania over the last 25 year.

MATERIALS AND METHODS

The N balance for the agricultural sector of Romania is estimated according to the soil-surface approach developed by the OECD (OECD and EUROSTAT, 2007). N balance is defined as the difference between nitrogen input and output.

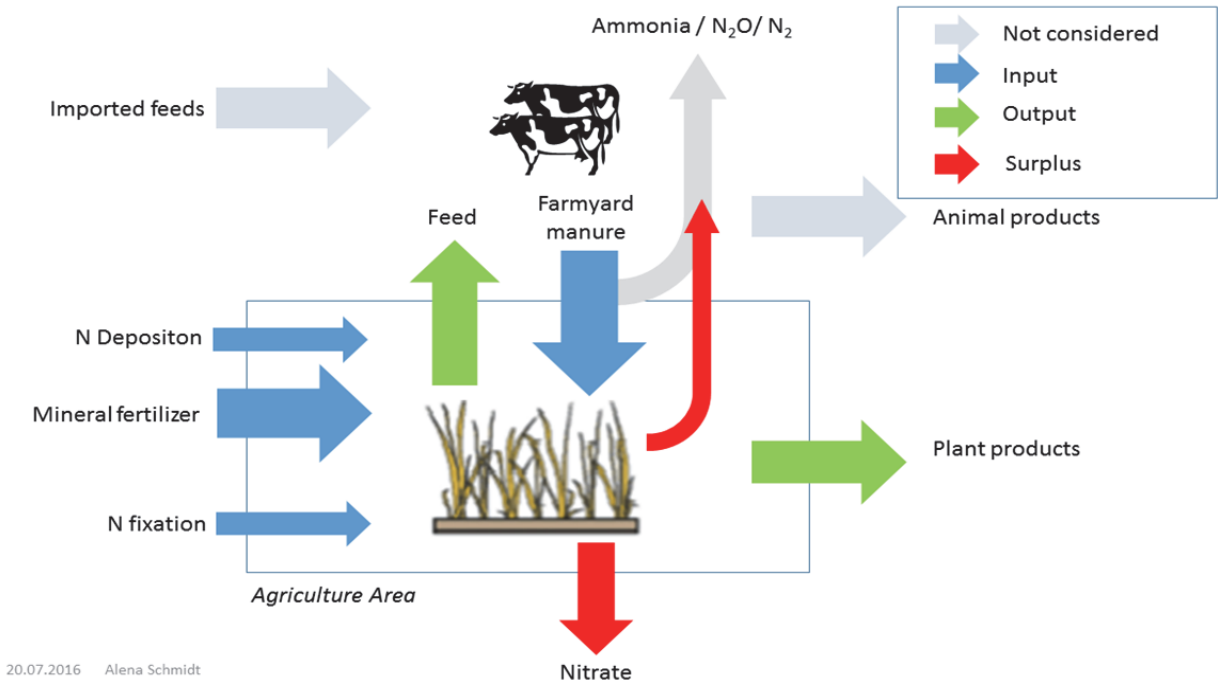


Figure 1. N soil surface balance

Nitrogen input accounts for the following elements: fertilisers (inorganic fertilisers, livestock manure and any other organic fertilisers), biological nitrogen fixation, atmospheric deposition, and nitrogen contained in seeds and planting material (OECD and EUROSTAT, 2007). Nitrogen output comprises nitrogen removed with the harvested crop (including fodder crop) or with the grazed fodder crop or grass (OECD and EUROSTAT, 2007). For this study, we used sectoral data provided by the Romanian national institute for statistics (INSSE, 2017). Sectoral production quantities were multiplied with average N content coefficients. The latter were estimated by dividing the amount of protein with the value 6.25, which is an average value for the conversion of protein to N content (Janssen & Oenema, 2008). If possible we used N values provided by CHEMINOVA (2017) and Flisch et al. (2009). Sectoral N fertilizer data was provided by INSSE (2017). For estimating N fixation, we used average fixation rates provided by literature (Baddley et al., 2014; Butler et al., 2001) for different legumes as well as grasslands and multiplied them by the corresponding cultivated area in Romania. For the N deposition, we used data from Gauss et al. (2008). For the missing years, we took the average value of the years 1991 to 2006.

Uncertainty analysis

For estimating the uncertainty of the results, we conducted a Monte Carlo simulation for the most uncertain parameters such as N deposition and N fixation, as well as N contents in outputs. The uncertainty analysis was conducted in GAMS (GAMS, 2013) with 1000 loops. For N deposition, we varied for the missing years the data between the maximum and minimum values from 1991 to 2006. For highly uncertain inputs like N fixation and N content in manure the values were varied by 20%. For fertilizer inputs, the data were considered less uncertain and therefore, the variation was only set to 1%.

RESULTS AND DISCUSSIONS

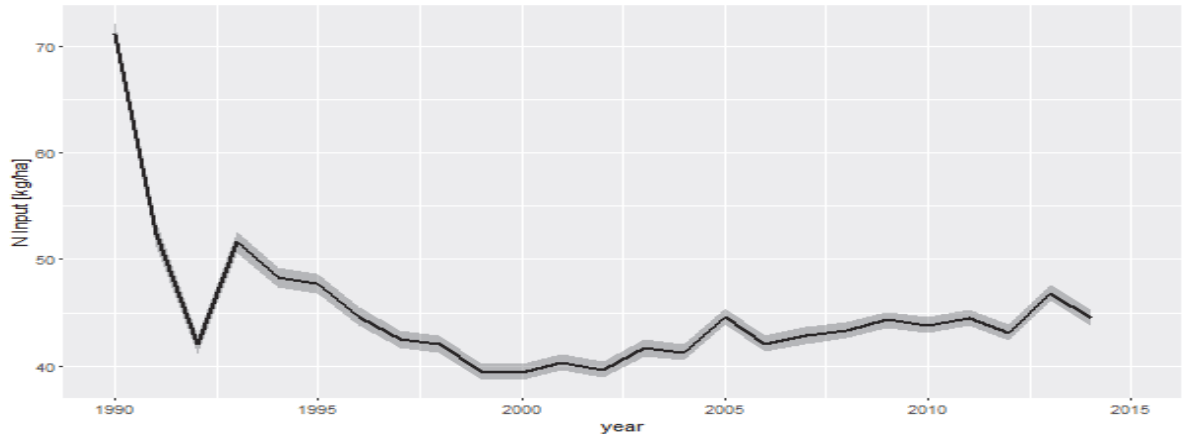
N surplus of Romania showed a high fluctuation over the years 1990-2015. On average we observed a surplus of 0.1 kg ha^{-1} (Figure 2 c).

Uncertainty is higher for N inputs (Figure 2 a) than for N outputs (Figure 2 b). N inputs decreased in 1990 after the revolution sharply. Since the year 2002 N inputs have increased slowly.

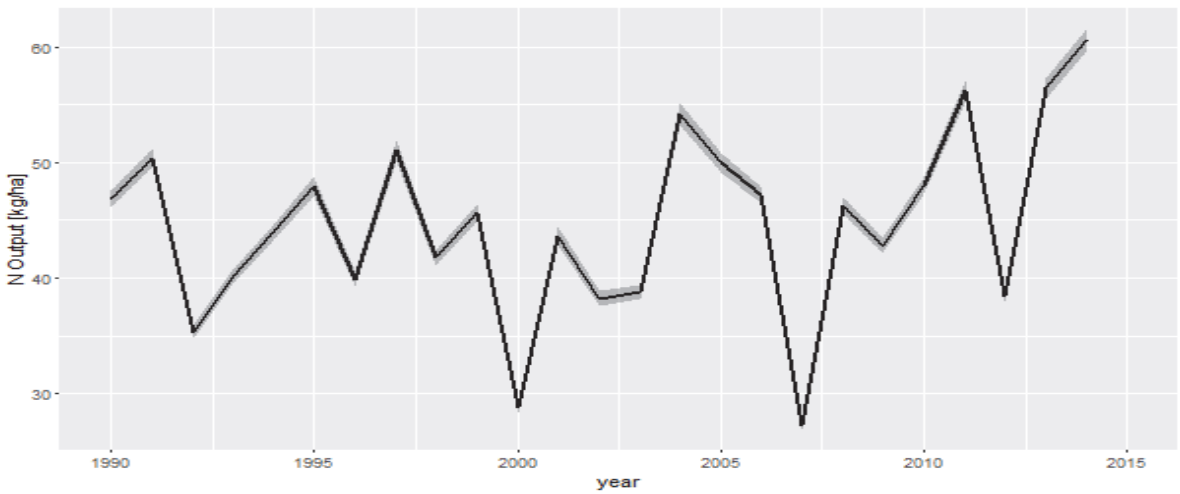
In Romania, the inputs for fertilizer and pesticides are still lower than in other countries. The high N balance fluctuations (Figure 2c) between the different years are driven by N output fluctuations, which are caused by

several factors that influence the yields like weather and plant pests. After the 1990 yield fluctuations even increased because the irrigation system collapsed (Prăvălie, 2013).

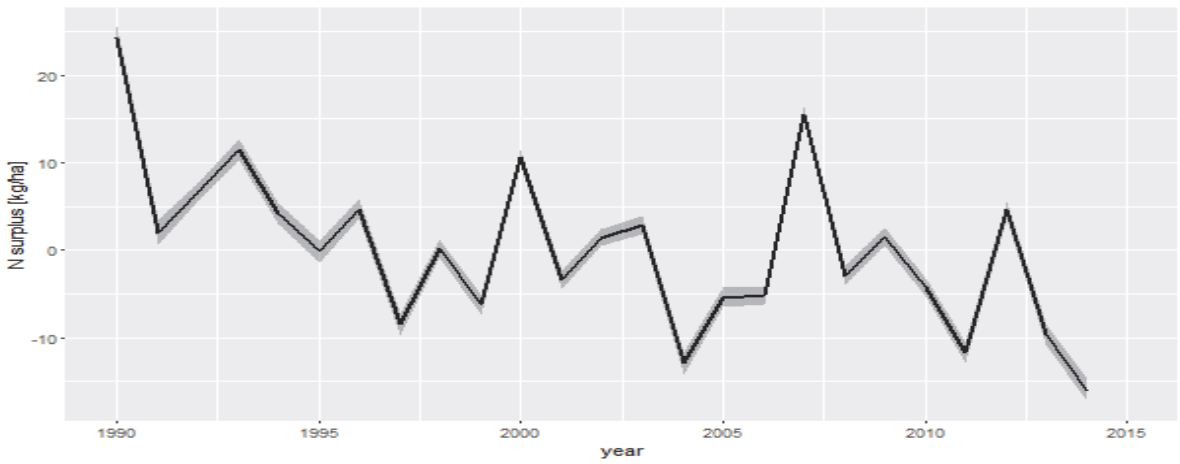
Although, irrigation would have the possibility to increase N outputs, it could have also a negative impact on the environment (Faulstich, 2015).



a)



b)



c)

Figure 2. a) N input [kg/ha] b) N outputs [kg/ha] and c) N surplus [kg/ha] of Romania from 1990 to 2015

The degree of uncertainty is higher for N inputs than for N outputs because N inputs are mainly determined by natural, more instable processes. E.g., N fixation is determined by the soil structure, plant composition and weather. The inputs for N in manure has different uncertainty levels. Firstly, the N content in manure varies from animal to animal and secondly, the number of animals includes also some uncertainties as non-farm households in rural areas have usually one or two pigs for private consumption which might not be registered. Also, some outputs may not be covered as they result from subsistence farms or private gardens.

In average, the N surplus of the Romanian agricultural sector over the years 1990-2015 is 0.17 kg ha^{-1} (Table 1).

Table 1. Average N balances for Romanian agriculture for the year 1990-2015 (in kg ha^{-1} UAA and in % of total input, respectively)

	kg.ha^{-1}	%
N Input	45	100%
Mineral Fertilizer	20	45%
N fixation	5	12%
N deposition	0.01	0%
N manure	19	43%
N output	19	100%
N surplus	0.17	0.4%

The N use efficiency is with 0.99 very high, indicating that 99.60% of the N inputs are taken up by crops. The most important N inputs are fertilizers and manure (Figure 3). While most of the European countries show higher N inputs from mineral fertilizer than from manure, in the agricultural sector of Romania N inputs from manure reach almost the level of those from fertilizers (Figure 3).

N fixation and deposition play only a minor role for the inputs. Mineral fertilizer had strongly decreased after 1990. Manure production has decreased since 1990 by 30% and the number of livestock by 37% (Figure 4).

Even though Romania has a high N use efficiency, there is space for improvements. With better application techniques, better timing and adapted doses, it might be possible to close the yield gap (http://www.scritub.com/geografie/ecologie).

In addition, Romanian agriculture risks to deplete the soil. Moreover, the spatial distribution of the nutrient application also plays an important role in sustainable farming practice. Anyway, information should be provided for the farmers in order to implement best agriculture practice to avoid the risk of too high losses of N inputs.

N soil surface balance has the advantage that the data needed are usually available. The disadvantage of the method is, that coefficients for N content in farm yard manure as well as in outputs strongly affect the results (Spiess et al., 2010). These uncertainties could be reduced by calculating a farm gate balance. Farm gate balances do not consider internal fluxes and therefore are considered as more precise (Spiess et al., 2010). N farm gate balances include also losses from animal production. Therefore, the calculated N use efficiency is usually lower than in a soil surface balance (Oenema et al., 2003).

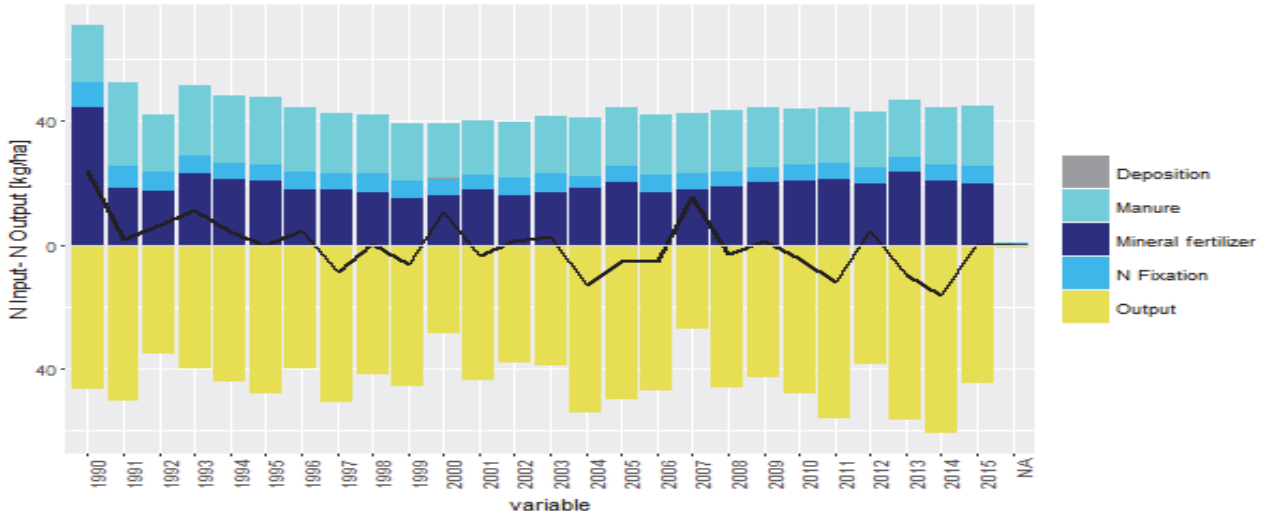


Figure 3. N Input and N Output balance split by types of input

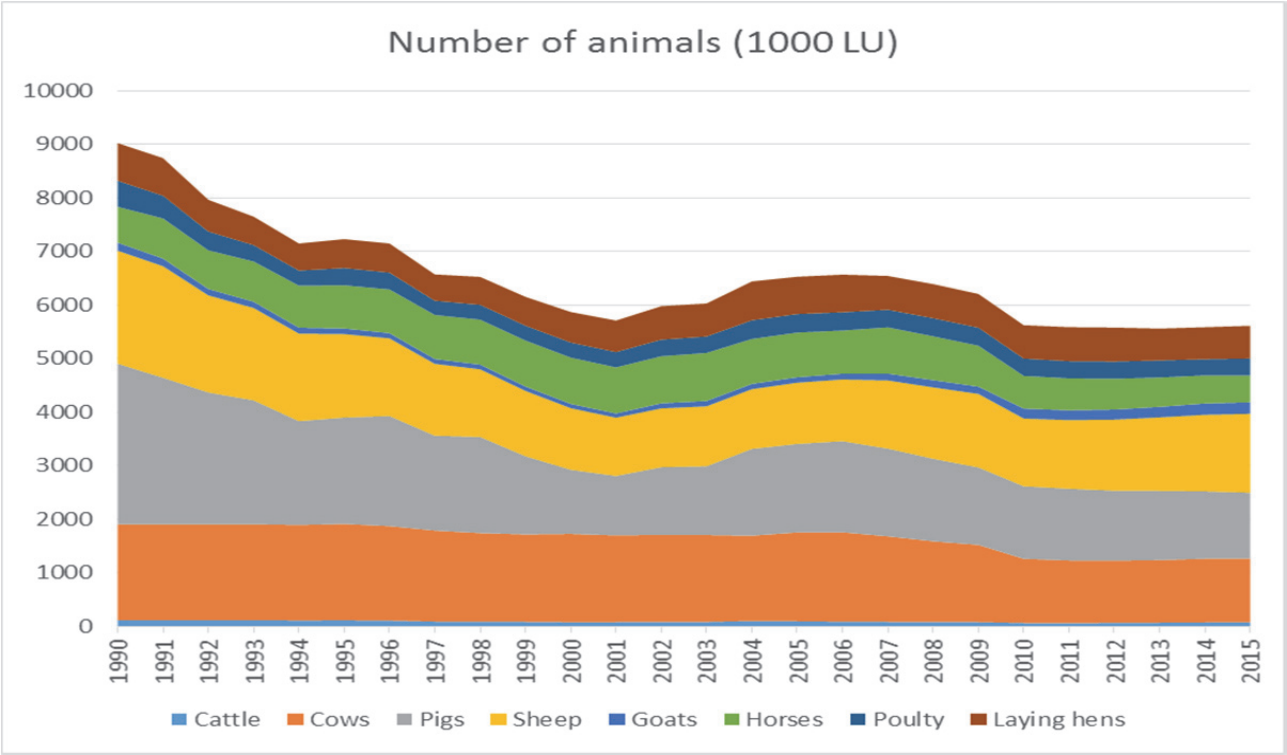


Figure 4. Number of animals (LU)

CONCLUSIONS

N soil surface balance is an agri-environmental indicator that estimates potential losses of nitrate, ammonia and nitrous oxides. In average, we found for the Romanian agricultural sector an N surplus of 0.17 kg ha^{-1} by calculating a soil surface balance.

The variation between the years is high. The calculated N surplus is similar to the values published by EUROSTAT (2017).

Romanian agriculture has a high N use efficiency of 0.99, meaning that 99% of the N input is taken up by plant products. However, there remains space for improvement.

The variation of the N surpluses between the years is mainly caused by high N output fluctuations. These are caused by weather fluctuations and plant pest that reduce the potential yield.

The advantage of an N soil surface balance is the data availability. However, as farm internal fluxes are separated, the estimated N content ad higher uncertainties. Therefore, calculating an N farm gate balance can add some more insights in the potential losses in animal production and provide more precise results.

ACKNOWLEDGEMENTS

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