

## Farm gate nutrient budgets in organic farms – a case study in Germany

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Low nutrient availability, especially of nitrogen (N) and phosphorus (P), is one of the major constraints on crop yields in organic farming. In addition, soil reserves of nutrients e.g. P are often limited (Cooper et al. 2018). To avoid soil nutrient depletion, a balance between nutrient inputs and outputs should be the goal of any sustainable nutrient management strategy. A valid approach for assessing current nutrient management practices in organic farming, with regard to sustainability and the implication on soil fertility, is farm gate nutrient budgets in combination with soil analysis (Watson et al. 2002). Following this approach, our study aims to investigate a) the sustainability of the nutrient supply for N, P, potassium (K), sulphur (S) and magnesium (Mg) of organic farms in Germany by farm gate nutrient budgeting, b) the factors determining the magnitude of nutrient budgets, in particular the share of N supplied by biological fixation, the yield level in terms of total nutrient output, and the stocking rate, and c) the relation between farm gate nutrient budgets and soil fertility.

We investigated farm gate nutrient budgets of 20 stockless or low stocked organic farms in Germany. On average, there was a slight surplus of N, S, K, and Mg (19, 12, 8, and 8 kg ha<sup>-1</sup> respectively) and a small deficit of P (-1 kg ha<sup>-1</sup>). However, the results vary highly from farm to farm, mainly due to different shares of N supplied by legumes, followed by livestock density of the farm. With increasing reliance on legumes, the nutrient budgets were increasingly negative, especially for P and K. With increasing stocking rate, however, the budgets were more positive. Surprisingly, total farm nutrient output had almost no influence on the nutrient budgets. Most soil nutrient contents were not correlated to the farm gate budget. However, extractable soil P and the share of extractable P of total P increased with the P budget.

Even though there is, on average, a slight surplus of N, S, K, and Mg, the results imply that external inputs are required to achieve a balanced nutrient supply. Our results indicate that the biggest challenge in organic nutrient management is the supply of P. Since the P budget directly affected the soil P level, negative P budgets lead to a depletion of soil P. On soils with low P content, depletion can lead to growth limitation over a mid- to long-term temporal perspective. Conversely, if soils are well supplied with P, due to high historical P application, then a slightly negative P budget might not affect crop productivity in the near future, and therefore oversupply should be avoided.

In conclusion, the results show that it is possible to ensure sustainable nutrient management in organic farming systems, although this demands judicious use of external inputs. However, insufficient use of external inputs inevitably results in a lack of P, K and Mg which, particularly for P, can result in mining the soil of its nutrient reserves.

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Watson, C.A., H. Bengtsson, M. Ebbesvik, A.-K. Løes, A. Myrbeck, E. Salomon, J. Schroder, and E.A. Stockdale (2002): A Review of Farm-Scale Nutrient Budgets for Organic Farms as a Tool for Management of Soil Fertility. *Soil Use and Management* (18), 264–73.