Environmental impacts of cropping systems: lessons learnt from LCA studies

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Life cycle assessment (LCA) is a method to evaluate the impacts on the environment of human activities such as agriculture. It is characterised by three main features: the consideration of a full life cycle, the assessment of all relevant environmental impact categories, and the calculation of the impact per unit of a reference, a so-called functional unit. The bulk of LCA studies is focussed on single products, such as bread wheat, milk or lettuce in so-called product LCAs. Although there is a clear need for such information on products and production methods, this is not sufficient, as it is difficult or even impossible to capture all relationships between different crops or crops and animals. Therefore, such product LCAs have to be completed with system LCAs, considering whole cropping systems, farming systems, or farms. A number of LCA studies of cropping systems have been carried out during the last two decades. The comparison of organic to integrated or conventional systems has been one of the focus research questions. These LCA studies lead to the following general conclusions: Organic systems tend to have clearly lower impacts per area, while impacts per unit of product depend on the system context and can be similar, lower or higher. Per product unit, different patterns can be identified according to the impact category considered. Due to lower yields, land occupation is higher in organic farming. Fossil energy demand tends to be lower, due to the ban of energy-intensive mineral N fertilisers, while for water consumption, systematic studies are lacking, which prevents a clear conclusion. As to climate change, no systematic difference was found; the global warming potential can be lower, similar or higher. Acidification and eutrophication, driven by loss of nutrients, tend to be higher as they depend largely on practices in animal husbandry and manure management, and organic agriculture uses more manure. Due to the ban of synthetic pesticides, ecotoxicity tends to be clearly lower and biodiversity potentials to be higher. This finding, however, is relativised if other pollutants such as heavy metals are considered, and if the additional land use to produce the same amount of product is considered. Soil quality in organic systems is clearly improved when compared to conventional systems with purely mineral fertilisation.

The eco-efficiency analysis shows that the optimisation of organic farming systems is mainly output-driven, while for integrated and conventional systems it is mainly input-driven. To analyse the environmental impacts of cropping and farming systems, we can rely on three pillars: 1) LCA of experimental cropping and farming systems, such as the DOK trial, 2) LCA of representative, modelled systems based on a combination of various data sources such as statistics, pilot farm networks, extension services, etc., an 3) LCA of pilot farm networks. 1) allows detailed measurements and model validation, 2) enables to calculate representative results, and 3) allows to capture the variability of individual farms and to estimate representative average impacts (given a sufficiently large sample). Only by combining these three pillars in a smart way, we can get a full picture of the environmental impacts, and identify adequate mitigation measures. In particular, we learn from pilot farm networks that a large variability exists among organic farms; this applies even more to integrated and conventional farms. Therefore, a good environmental performance is not only a question of the choice of a farming system like organic or conventional, but of its implementation within the given context and its management.