Nitrogen budgets and soil nitrogen stocks of organic and conventional cropping systems: how reconcile efficiency and sustainability of nitrogen use?

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Organic and conventional cropping systems differ in the nature and amounts of nitrogen (N) inputs, which may affect efficiency and sustainability of N use. In the DOK (bio-Dynamic, bio-Organic, Konventionell) field experiment, organic and conventional cropping systems have been compared since 1978 at two fertilization levels (with level 2 being typical for the respective system and level 1 receiving half of this dose). Nitrogen inputs via manure and/or mineral fertilizers and N exports from plots with harvested products have throughout been recorded. For all treatments, N outputs with harvests have exceeded the inputs with fertilizers. Over the past years, symbiotic N_2 fixation by soybean and clover grown in the trial has additionally been assessed using ^{15}N isotope techniques. The estimates indicate average annual inputs from about 90 to 120 kg ha^{-1} yr^{-1} of N fixed from the atmosphere, depending on the treatment. Soil surface budgets opposing N inputs via fertilization, symbiotic fixation, seeds and deposition to N outputs via harvested products have been computed at the plot level for the duration from 1985 to 2012. The resulting balances range from negative values of about -20 kg N ha^{-1} yr^{-1} (in the non-fertilized control where outputs exceed the sum of said N inputs) to surpluses of about +55 kg N ha^{-1} yr^{-1} in the conventional treatment with mixed organic-mineral fertilization. The budget based N use efficiency (NUE; N output via harvested products divided by sum of N inputs) in the case of negative balances suggests irrationally high NUE (>100%), while positive balances are related to lower NUE for treatments with inputs exceeding outputs. Negative budgets indicate soil N mining, while surpluses point to a risk of N losses and/or N accumulation in the soil. Estimation of soil N stock changes based on yearly total N concentration measurements in the topsoil layer are ongoing. Preliminary results suggest that soil N stocks in the topsoil decreased under all treatments more than expected from the N balance and that positive N balances are needed to maintain topsoil N stocks. No increase in soil N concentration was observed in any of the treatments. In conclusion, the results indicate an efficiency-sustainability trade-off. Soil N stocks decrease more in treatments with a higher NUE than those with a lower NUE. At the same time, treatments with lower NUE suggest higher N losses from the studied crop-topsoil system. The presentation will address the role of the different fertilizer N forms and doses and will expand the budget based NUE with difference method based NUE estimates, so as to discuss on how to best reconcile N use efficiency, N losses and maintenance of soil N stocks.