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The turnover of soil organic matter on different farm types

By **Bjørn Molt Petersen** and **Jørgen Berntsen**, Danish Institute of Agricultural Sciences.

One of the prime factors determining soil fertility is the content of soil organic matter. A huge amount of nitrogen (N) is bound in organic matter, and the yearly mineralisation of N in the field is only a small fraction of the total organic nitrogen.

The release and incorporation of organic N is of special relevance for organic farms, where the crop supply mainly depends on N mineralised from organic matter.

In order to study the long-term balance between build-up and degradation of organic matter, a simple simulation model was made, calibrated on the basis of long-term data from Sweden, U.K. and Denmark. Briefly, it is a 3-pool model (**Figure 1**) employing first-order kinetics, which is implemented in **C-TOOL**. The long-term build up or breakdown of organic N is assumed to follow carbon in the ratio 1:10.

Three simplified, conventional model-farms were studied: a cash-crop farm, a pig farm and a dairy farm, situated on loamy sand. The two former farms have an identical crop rotation dominated by cereals, while the dairy farm has a crop rotation with 50% clover grass mixture. Based on estimated carbon inputs from crop residues, the three farms have an input of respectively 3.5 t, 4.1 t and 6.5 t carbon (per ha per year). In addition, the two latter farms have an input from animal manure of 0.6 and 1.8 t carbon respectively. Hence, there is a large span in the total carbon input between these farm types.

To illustrate the changes in soil organic matter when converting from one farm type to another, several scenarios were made. **Figure 2** shows the modelled changes in soil organic matter when converting from a "steady state" cash crop farm to one of the above three farm types. The "steady state" level is illustrated by the dotted line. The organic bound N increased most rapidly for the dairy farm, with 102 kg N/ha/year in the first five years, while the pig farm displays a more moderate increase of 23 kg N. **Figure 3** shows the same three farm types, but this time converted from a "steady" state dairy farm. Here, the cash crop farm will decrease the soil N with 97 kg/ha/year.

The yearly net mineralisation will also depend heavily on the content of organic N. Roughly estimated the "old" dairy farm soil could be fertilised with 49 kg N/ha less than the "old" cash crop soil, and still have the same yield.

As seen from the figures, the time scale for changes in soil N is very large. A given field can therefore, regardless of the management for the last one or two decades, be situated within the whole span of the previous figures. Thereby standard values for fertilisation may result in enhanced loss of N to the environment for some fields and farms, while other fields and farms may suffer from insufficient N supply at the same amounts of fertiliser. In the case of organic farms, much more effort will have to be put into the N household at a “low” fertility level, then at a higher. It may even not from an economic viewpoint be recommendable to attempt a slow recapture of soil fertility within the frame of an organic cash crop farm where there has been a long previous period of low inputs of carbon to the soil. Here, an organic dairy farm, with its far higher carbon inputs, may be preferable.

When attempting to connect the total N surplus on a farm to its N loss to the environment, the development of the soil N is of major importance. A dairy farm with medium to high stocking intensity may have a farm-level N surplus in the order of 200 kg N/ha. In the example where this farm is initiated on an old cash crop soil, this surplus should be adjusted by the 102 kg N/ha build up in the soil, so that the total loss to the environment may only be 98 kg N/ha. This is obviously a rather coarse calculation, neglecting the many feedback mechanisms. Nevertheless, one can only set environment loss of N equal to farm surplus on soils where a steady state is achieved. As yields, management and land use constantly changes, only a minority of soils may be close to steady state.

The simulated tendencies and orders of magnitude in this study coincide well with the measurements in the Danish grid net, where **Heidmann et al**. (2001) found that fields given cattle manure on average had a rise of 51 kg N/ha/year in 0 – 50 cm depth, while fields only given mineral fertiliser on average fell 45 kg N/ha.

Both model calculations and field measurements thus indicate that significant yearly changes in soil organic N may occur. Still withstanding is an operational and economically realistic method to quantify the net N mineralisation potential of a single field. Once, such a method was developed, the fertiliser management could be improved on conventional as well as ecological farms, with simultaneous beneficial effects on farm economy and environment.