Effects of applying anaerobically digested slurry on soil available organic C and microbiota

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Implications

Anaerobic digestion of animal slurries and plant residues is a valuable technology to produce bioenergy and fertilizers in organic farming systems, while at the same time reducing propagules of weeds and parasites in the input material. However, the digestion changes the quality of the slurry by reducing its content of organic matter and increasing mineral nitrogen (N) levels. This may have profound impact on soil fauna and microorganisms as well as the biogeochemical processes they drive. Organic farmers fear that application of digested materials may have negative implications for soil fertility by reducing the input of organic matter to the soil, compared to fertilizing with traditional animal slurries or green manures. Hence, it is important to gain knowledge about the short- and long-term effects on microflora and carbon (C) balance in soils fertilized with digested slurry.

Background and objectives

The Norwegian project SoilEffects (2010-14) is a field study where the soil is applied with untreated cattle slurry or anaerobically digested slurry in two cropping systems: arable crops with annual ploughing and without legumes, and a grass system with perennial grass-clover ley. The objective of this study was to assess how application of the two types of manure influenced the soil content of readily available organic matter (supposed to govern the community dynamics of the soil microbial community (Johansen et al., 2013), as well as the microbial community structure and activity in the two cropping systems. Data from 2011-2012 are presented.

Key results and discussion

In 2011, the intrinsic soil content of CWEC was about 30% lower in the arable system than in the grass system (Fig. 1a and 1b). This was to be expected, since the topsoil content of total C was on average 3.5% and 6.4 % in the arable and grass system, respectively. Application of slurries did not change the level of CWEC in the grass system, while in the arable system it increased slightly, by 10-20% at high manure levels (UH and DH). In 2012, the general level of CWEC was 30-50 % lower than in 2011 (Fig. 1); most pronounced in the arable system. The general decrease in CWEC in the arable system may be explained by soil tillage in 2011 and 2012, causing enhanced decomposition of soil organic matter. In the grass system, the general decrease in CWEC levels may have been caused by the colder and drier spring in 2012 than in 2011, decreasing the turnover rate of the organic matter. It is interesting to see that in 2012, the CWEC levels reflected the applied amounts of manure quite well in both cropping systems. Incubating soil sampled five days after slurry application (2011) in a respirometer showed that microbial turnover (respiration) of the respective materials was positively related to the amount of fertilizer applied to the soil (data not presented).

Phospholipid fatty acid (PLFA) analysis performed on the 2011 samples showed that the microbial biomass was not influenced by the slurry applications (data not shown). However, treating the PLFA data in a principal component analysis indicated that the soil microbial community composition in the two cropping systems was different (Fig. 2) as their respective data points separated totally along the PC1 (66% of meaningful variation) axis. This may be due to the differences in the soil content of available organic C. PC2 explained only 10% of the variation, but seemed to reveal that the soil microbial community composition was also affected by the type of slurry applied, since the samples with digested or undigested slurry were grouping up in the bottom or top of the plot, respectively. Hence, the type of cropping system had more impact on the microbial community composition than the type of fertilizer; maybe in combination with the enhanced level of organic matter in the grass system. The present results reveal short-term effects, and observations from more seasons are obviously needed to reveal long-term effects of applying different types of slurry.

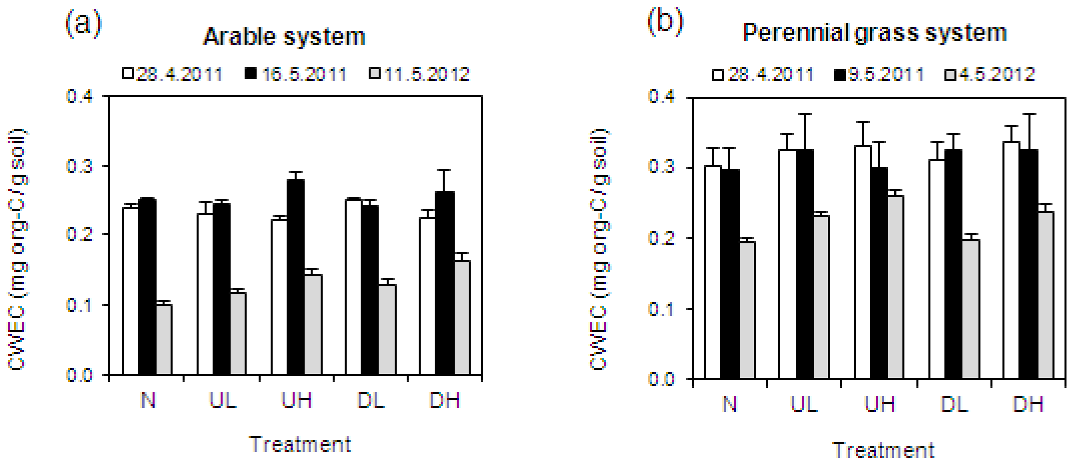

Figure 1. *Cold-water extractable organic carbon (CWEC) in soil amended with: Nothing (N), Undigested slurry at Low/High level (UL/UH), Digested slurry at Low/High level (DL/DH). The slurries were applied to the arable (a) or perennial grass-clover ley (b) cropping system 5 days before the sampling dates (shown above the plots), except for the sampling at 28.4.2011 where soils were not amended. Bars represent SEM (n=4).*

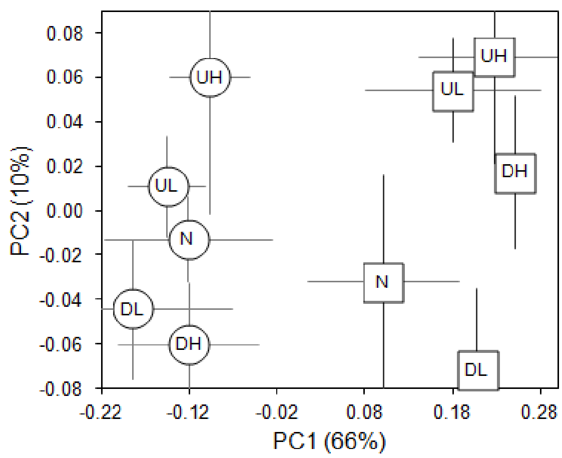

Figure 2. *Score plot from a principal component analysis of PLFAs from soil sampled in the arable (squares) and grass (circles) cropping system; five days after application of slurries in 2011. Abbreviations of manure treatments (N, DL, DH, UL, UH) are explained in Fig. 1. Bars represent SEM (n=4).*

How the work was carried out

Topsoil (0-20 cm) from the experimental plots within the two cropping systems was sampled in spring 2011 (just before slurry application and five days later) and 2012 (two days after slurry application) and analysed for contents of readily available organic carbon (cold-water extractable C; CWEC). PLFA profiling was employed to measuring the structure and growth dynamics of the soil microbiological communities (Johansen et al. 2013).

Reference

Johansen A, Carter MS, Jensen ES, Hauggaard-Nielsen H, Ambus, P (2013) Effects of digestate from anaerobically digested cattle slurry and plant materials on soil microbial community and emission of CO_2 and N_2O. Applied Soil Ecology 63, 36-44