Anaerobic digestion of manure – consequences for plant production

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Summary: Anaerobic digestion (AD) of animal manure to produce biogas may reduce fossil fuel usage and emissions of greenhouse gases. However, there is limited information on how the recycling of digested manure as a fertilizer impacts soil fertility in the long run. This is of concern because organic matter in the manure is converted to methane, which escapes the on-farm carbon cycle. In 2010, a study of this was initiated on an organic research farm in Tingvoll, Norway. Anaerobically digested manure produced at a local biogas plant is compared with undigested slurry in perennial ley and arable crops. Effects on crop yields and several soil characteristics are studied. AD seems not to influence yield levels, but to favor grass in leys.

Implications

On-farm biogas production converts organic substrates to energy, and may reduce dependency on fossil fuels and GHG emissions. On the negative side, a biogas plant is expensive and the technology not well adapted to cold climatic conditions. A further concern is reduced input of organic matter to the soil. What happens to soil life when we reduce the input of organic carbon in manure by anaerobic digestion?

Objective

The aim of the project SoilEffects (2010-14) is to compare crop yields and soil characteristics after application of untreated versus anaerobically digested slurry. Botanical composition, dry matter (DM) yields, soil physics, chemistry, microbiology and fauna are studied in arable crops and perennial grass-clover ley.

Figure 1. Oats at the day of harvest, September 8, 2011. Right side: Plot where no manure was applied. Left side: Plot where high level of anaerobically digested slurry was applied. In the background: Harvested ley plots.

Methods

A biogas plant was installed on Tingvoll research farm in 2010 to digest the slurry from 25 dairy cows. The digested slurry (D) is compared with undigested slurry (U) in two cropping systems; arable crops and perennial ley (Fig. 1), at low (L) and high (H) fertilization levels. The soil is silty sand with on average 3.47 % total C in the arable plots and 6.41 % in the grass system plots. Plot size = 3 m x 8 m, 4 replicates of 5 treatments.

In the arable system, slurry is applied in amounts corresponding to 85 or 170 kg total N ha^{-1} y^{-1}. In the grass system, manure application is split to 2/3 in spring and 1/3 after the 1st cut, and the amounts correspond to 110 or 220 kg total N ha^{-1} y^{-1} (Fig. 2). Compared to untreated slurry, digested slurry has a greenish grey colour, a softer smell reminding of soil, and infiltrates more readily into the soil.

Figure 2. Spreading manure on a grass system plot of the experimental field, May 4, 2011.

Less legumes with AD?

Slurry application reduced the proportion of clover in the perennial ley (Table 1). Over time, digested slurry seemed to favor the grass more than untreated slurry.

	2011, G/C/W %		2012, G/C/W %	
	1st cut	2nd cut	1st cut	2nd cut
N	40/59/1	49/15/36	58/28/14	55/35/10
UL	50/48/2	57/12/31	59/26/15	56/34/10
UH	55/44/1	67/ 8/ 25	55/31/14	77 / 15 / 8
DL	41/59/0	55/15/30	77 / 19 / 4	70 / 26 / 4
DH	41/58/1	51/11/38	69/14/17	74 / 18 / 8

Table 1. Botanical composition of grass-clover ley in treatments with application of no manure (control, N), low (L) or high (H) levels of undigested slurry (U) or anaerobically digested slurry (D). Proportions (%) of grass (G), clover (C) or weeds (W).

Similar yield effects

Application of manure significantly increased the yields of grass-clover ley (Table 2). There was no clear difference between untreated and digested slurry with respect to yield increases.

In the arable system, yield increases by slurry application were not statistically significant (Table 3). This was surprising, since high amounts

Treat-ment	2011	2011 rel.	2012	2012 rel.	2012/2011 * 100
N	6.6 a	100	5.4 a	100	82
UL	8.1 ab	122	9.0 b	167	112
UH	8.8 b	133	10.5 bc	193	119
DL	8.2 b	124	9.0 b	165	109
DH	8.4 b	128	11.6 c	213	137

Table 2. Total and relative yields of perennial ley (sum of 2 cuts), ton DM ha^{-1}. Statistically significant differences within year (P<0.05) suffixed by abc.

of fertiliser were applied and significant effects were obtained in ley. An explanation may be gaseous losses of N between manure application and plant uptake. Significant losses of nitrous oxide (N_2O) were measured in the arable crop system in 2012 (Rivedal et al. 2013). Accumulated emissions of N_2O-N comprised about 2 kg ha^{-1} from manure application on May 22 until July 10 in UH and DH treatments, and about 1 kg in the control treatment. The arable cropping system suffers from severe competition with weeds, and demonstrates the challenges to maintain a long-term organic field experiment with arable crops

Treat-ment	2011 cm	2011	Rel.	2012	Rel.	2012/2011 * 100
N	65 a	5.35 a	100	2.23 a	100	42
UL	69 a	5.80 a	108	2.56 a	115	44
UH	72 ab	5.98 a	112	2.75 a	123	46
DL	71 ab	5.60 a	105	2.57 a	115	46
DH	78 b	6.11 a	114	2.64 a	118	43

Table 3. Straw length of oats (cm), and total and relative yields of arable crops, ton DM ha^{-1}. Crops were oats (straw + grain) in 2011, and late sown ryegrass (sum of 2 cuts) in 2012. Statistically significant differences within year (P<0.05) suffixed by ab.

Thanks and references

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