Influence of undigested and digested cattle slurry on grassland yield compared to mineral fertilizer

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Abstract

The of production biogas from cattle slurry is increasing in Estonia, but there is not enough information about the efficiency of using its by-product digestate as grassland fertilizer. Therefore a farm experiment was conducted to study the impact of cattle slurry digestate, undigested (raw) cattle slurry and inorganic compound fertilizer on grassland yield. Organic fertilizers were applied in amounts to provide 25 kg ha^{-1} P yr^{-1}. The application rates of cattle slurry digestate and cattle slurry provided 80.7 and 61.1 kg NH_4^+-N ha^{-1} yr^{-1} respectively, and the mineral compound fertilizer was 80 kg N ha^{-1} yr^{-1}. Grass yield was measured three times in the growing period. Our research showed that NH_4^+-N from cattle slurry digestate was not as effective as N from mineral fertilizer. Despite the higher NH_4^+-N application amount with digestate its yield was similar to the cattle slurry treatment.

Keywords: cattle slurry, cattle slurry digestate, grassland yield, fertilization

Introduction

In Estonia the production of biogas from cattle slurry is gaining popularity. It is promoted by the concentration of milk production in large dairy farms (60% of farms have more than 300 animals (Statistics Estonia, 2015)) and by the use of modern slurry technology on those farms. Digestate is the by-product of biogas production, and it is considered to be a valuable fertilizer due to the increased availability of nitrogen and the good short-term fertilization effect (Weiland, 2010). The use of digestate is considered to be environmentally beneficial since nutrient cycles can be closed and the need for mineral fertilizer reduced (Dieterich *et al.,* 2012).

Information about the fertilizer value of digestate for grassland remains inadequate, as most of the research has been conducted in small scale experiments, such as pot (Gunnarsson *et al.,* 2010; Fouda, 2011) or plot (Kováčiková *et al.*, 2013) experiments, and there is a lack of information about the use of cattle slurry digestate under farm conditions. Experimental results so far have shown that the yields when using digestate are comparable to those obtained when using mineral fertilizers at the same level of mineral N application (Gunnarsson *et al.*, 2010; Fouda *et al.*, 2011).

The aim of this research was to compare the effect of mineral fertilizer, cattle slurry and cattle slurry digestate on yield of meadow-type grassland consisting of red clover and grasses.

Materials and methods

An experiment was established in 2014 on grassland of Tartu Agro PLC, which consisted of red clover (*Trifolium pratense* L.) (25%), timothy (*Phleum pratense* L.) (30%), meadow fescue (*Festuca pratensis* Huds.) (30%) and perennial ryegrass (*Lolium perenne* L.) (15%). Treatments were: (1) control (no fertilizer was applied); (2) mineral fertilizer (NP 33-3); (3) cattle slurry; and (4) cattle slurry digestate in four replicates. Cattle slurry and cattle slurry digestate were applied to the soil in quantities according to a P rate of 25 kg ha^{-1}, which is the maximum permitted amount of manure application as determined by the Estonian Water Act. The application rates of NH_4^+-N when applying P 25 kg ha^{-1} were 80.7 and

61.1, with cattle slurry digestate and cattle slurry respectively. With mineral fertilizer 80 kg ha^{-1} yr^{-1} of N was applied to the grassland. All fertilizers were applied in three equal amounts: before the grass started to grow in spring, after the first harvest and after the second harvest. Organic fertilizers were applied with a slurry injector (Challenger Terra Gator 2244) and mineral fertilizer by broadcasting. Grassland yield and botanical composition were determined three times in the vegetative period: on 3 June, 21 July and 3 September. Yield was determined using a Haldrup plot harvester on 2×7 m plots (4 on each replication). The yield of one treatment was determined on total from 16 plots. The total experimental area was 21.0 ha.

All calculations were performed using the statistical package Statistica 12.0 (StatSoft.Inc) by one-way ANOVA and differences between averages were determined by the Fisher`s LSD test. The probability level was set at 0.05.

Results and discussion

Our results showed that the use of fertilizers did not have a significant (P>0.05) impact on total grassland yield (Table 1). When compared to the control, average yield was slightly higher (P>0.05) only when using mineral fertilizer; in both organic fertilizer treatments they tended to be lower (P>0.05). A significant (P<0.05) difference in yields appeared only between mineral and both organic treatments. The effect of cattle slurry and cattle slurry digestate on grassland production was similar. The limited impact of fertilization in this experiment was probably due to the high red clover content in the sward, which was on average 62.9%.

Sward total yield was significantly the highest (P<0.05) when using mineral N-fertilizer only in the first cut, when both the red clover and grasses fractions in the sward were high (Table 2). In the second and third cut the fraction of red clover in the sward declined and that of grasses increased. The increase in yield of grasses did not compensate for the decrease of the red clover fraction in the sward and therefore the total yields of the sward receiving mineral fertilizer in the second and third cut were slightly lower than for the control.

In both organic fertilizer treatments the red clover fraction of second and third cut was slightly higher when compared to the mineral treatment, but in contrast the grasses fraction there was lower. For this reason the yield of both organic fertilizer treatments was lower that of the treatment that received mineral fertilizer. We speculate that the lower effect of cattle slurry and its digestate on grassland yield may have been caused by the mechanical damage by injection method, as indicated also by Rodhe and Halling (2010). The total herbage yields of the cattle slurry and digestate treatments were similar, although yields of red clover and grasses in the sward were affected somewhat differently. Due to the higher NH_4^+-N application amount the yield of the grasses fraction in the digestate treatment was higher, and that of red clover lower, when compared to the cattle slurry treatment, although this difference was not statistically significant (P>0.05).

Table 1. Dry matter yields, Mg dry matter ha^{-1}.[1]

Treatment	Cut			Total
	1st	2nd	3rd	
Control	3.94^{A}	3.99^{A}	2.20^{A}	10.13^{AB}
Mineral	4.46^{B}	3.77^{A}	2.12^{AB}	10.35^{B}
Cattle slurry digestate	3.88^{A}	3.83^{A}	1.82^{B}	9.53^{A}
Cattle slurry	3.87^{A}	3.67^{A}	1.85^{AB}	9.39^{A}

[1] Within the same column, values with different letters are significantly different (P<0.05).

Table 2. Dry matter yields (Mg ha^{-1}) of species functional groups in different cuts.[1]

Treatment	Red clover	Sown grasses	Unsown species
1st cut			
Control	2.84^{A*}	0.95^{A}	0.15^{A}
Mineral	2.72^{A}	1.60^{B}	0.14^{A}
Cattle slurry digestate	2.57^{A}	1.17^{AB}	0.14^{A}
Cattle slurry	2.41^{A}	1.17^{AB}	0.29^{A}
2nd cut			
Control	2.58^{A}	1.21^{A}	0.21^{A}
Mineral	2.00^{A}	1.65^{A}	0.12^{A}
Cattle slurry digestate	2.08^{A}	1.54^{A}	0.21^{A}
Cattle slurry	2.32^{A}	1.14^{A}	0.21^{A}
3rd cut			
Control	1.75^{A}	0.43^{A}	0.02^{A}
Mineral	1.02^{B}	1.05^{B}	0.05^{A}
Cattle slurry digestate	1.14^{B}	0.66^{AB}	0.02^{A}
Cattle slurry	1.26^{B}	0.54^{A}	0.05^{A}

[1] Within the same column and cut, values with different letters are significantly different ($P<0.05$).

Conclusions

Our research showed that in well-established grassland with high legume content NH_4^+-N from cattle slurry digestate is not as effective as N applied with mineral fertilizer. The main difference between digestate and mineral fertilizer was mainly expressed in their impact on the yield of the grasses fraction of the sward, which was slightly lower ($P>0.05$) when digestate was applied. The yields of cattle slurry and cattle slurry digestate were similar, in spite of the higher amount of NH_4^+-N application with digestate when compared to cattle slurry.

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