THIN FRACTION OF PIG SLURRY: NITROGEN FERTILIZER VALUE ON GRASSLAND. PRELIMINARY RESULTS.

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1 INTRODUCTION

In the Netherlands several initiatives were taken to separate animal manure into a thick fraction, containing mainly organic nitrogen (N) and phosphorus (P) and a thin fraction containing mainly ammonium N (NH_4-N) and potassium (K). Compared with unprocessed manure, separated manure gives the farmer more opportunity to apply the minerals where they are of most use or export the manure fraction containing any minerals that may be surplus to the requirement in the source farm. In the Netherlands animal manure is usually managed as slurry which contains both organic- and NH_4-N. In pig slurry the ratio is approximately 40% organic - 60% NH_4-N and in cattle slurry 50% - 50%. The N fertilizer value in the year of application is mainly determined by the NH_4-N content (Schröder et al., 2005). After separation the thin fraction contains 85-95% NH_4-N. Therefore we expected the thin fraction to have only a slightly smaller N fertilizer value than (liquid) mineral fertilizer. Only ammonia volatilization and the fraction of organic N would decrease it. To determine the N fertilizer value on field scale, Wageningen UR has started field trials with thin fractions of pig slurry on both grassland and arable land. The experiments take place in 2009 and 2010. This paper reports and discusses the preliminary results of the 2009 grassland trials.

2 MATERIALS AND METHODS

In the grassland trials thin fractions of pig slurry from three producers were compared with ammonium nitrate (AN) solution and granular calcium ammonium nitrate (CAN). The process used to make the thin fractions was ultra filtration (UF) followed by reverse osmosis (RO).

In February 2009 two locations with permanent grassland on different soil types were chosen: sand in the eastern part of the Netherlands (Lemelerveld) and young marine clay in the Flevopolder in the middle of the Netherlands (Lelystad). The experiment was a randomized block trial on two soil types (clay and sand) with two replicates of combinations of four N levels (0, 100, 200 and 300 kg N ha^{-1}), five fertilizer types (three thin fractions, CAN and diluted AN) and three numbers of fertilized cuts (one, two and three cuts fertilized).

Plots, fertilized with the thin fractions (liquid, 0.5 to 0.9% N) were compared with plots fertilized with CAN (27% N) and AN solution (18% N). The N in the thin fractions was 90-96% NH_4-N and 4-10% organic N (Table 1). In CAN and in diluted AN 50% is nitrate N and 50% NH_4-N. The plots were 3 m x 10 m. During the growing season, on all plots five cuts were harvested. The N fertilizations was given in three N-levels. The N levels and division over the cuts for all five fertilizer types and all numbers of fertilized cuts were:

- 40, 30, 30 kg N ha-1 for cut 1, 2 and 3 (100 kg N ha-1 in total)
- 80, 60, 60 kg N ha-1 for cut 1, 2 and 3 (200 kg N ha-1 in total)
- 120, 90, 90 kg N ha-1 for cut 1, 2 and 3 (300 kg N ha-1 in total)

The first fertilizer applications were made on the 23rd (clay) and 24th (sand) of March 2009, as soon as the soil was dry enough and the grass started growing (temperature sum from 1st of January ca. 200ºC). The next fertilizer applications were made on the harvest day of the former cut or the next day. The CAN was spread with an accurate spreader for field experiments. The thin fractions and AN were spread with a machine, especially developed for this experiment. This machine cuts small slits of 5 cm depth in the grass with rigid tines. In the slits the liquid fertilizer is placed with tubes on the edge of the tines. The dosage is accurately regulated by a pump and nozzles, as used in spraying machines. The width of the machine is 3 m with 18 tines. Four plots per replicate did not receive any N fertilization: three plots with slits in one, two or three cuts to estimate the yield decrease of the grass by the slits and an unfertilized reference (0N). All plots received the same amount of P and K, equal to the largest P and K fertilization applied as thin slurry fractions. The thin fractions contained a relatively large concentration of potassium (7.8% K) but little phosphorus (0.21% P) (Table 1). The dressing was given as superphosphate (20% P_2O_5) and kornkali (40% K_2O) with the same spreader as CAN. All plots received more sulfur than recommended in the thin fractions and/or in superphosphate and kornkali so no separate sulphur fertilization was applied. The thin fractions were sampled before and after fertilization.

The first cut was aimed to be harvested at a yield of 3500 kg dry matter (DM) ha^{-1} on the fastest growing plot. The next cuts were aimed to be harvested at 2500 kg DM ha^{-1} or after 5 to 6 weeks, depending on the growth rate. The time of harvest was determined on sight. The grass was harvested from an area of 1.5 m x ca. 8 m with a Haldrup forage harvester. From every plot the fresh weight was determined, samples of the grass were taken and the harvested area was measured. The grass samples were dried at 70 °C for 48 hours for analysis of DM content and sent to a laboratory for analysis on N content.

The data for annual DM and N yield were analysed with Genstat (12th edition) with the technique of Restricted Maximum Likelihood (REML) (Harville, 1977). With the REML technique a model is fitted on the data including a random and a fixed part. The random part was comprised of factors that are not controllable but have a (possibly) significant influence on the results. In these analyses the factor “location.plot” were the random model. The fixed part of the model was formed by the treatments: “Location”, “Fertilizer type”, “N fertilization level” and “Number of fertilized cuts”. All interactions were tested, all non-significant interactions ($P>0,05$) were deleted from the model. We used linear equations because we concluded from the data that the responses were linear and did not reach a maximum response to N fertilization.

The final fertilizer values of the thin fractions will be calculated with the data from both 2009 and 2010 by fitting the curves of all five fertilizers and comparing them (Schröder et al., 2005). For this paper we calculated a preliminary fertilizer value with a simplified method. The measured results from the plots that were fertilized for three cuts are used. The results of plots that were fertilized for 1 and 2 cuts will be used in the final analysis. The N fertilizer value is calculated per fertilizer type and N level through the Apparent Nitrogen Recovery (ANR):

ANR at level X = ((N yield at N level X) – (N yield at N level 0))/kg N fertilization level X

N fertilizer value fertilizer type Y = (ANR fertilizer type Y)/(ANR reference fertilizer) (van der Meer et al., 1987). The fertilizer values are calculated with both CAN as liquid AN as the reference fertilizer.

TABLE 1 **Analyses of applied thin fractions, g kg^{-1}**

	Total N			**N-NH_4**			**K**			**P**		
Fraction	A	C	D	A	C	D	A	C	D	A	C	D
Mean content	6.6	8.7	5.1	6.2	7.8	4.9	8.3	8.7	6.4	0.21	0.34	0.10
# samples	11	9	11	7	7	7	2	2	2	1	1	1

3 RESULTS

The DM and N yields of all five cuts were summed to calculate the annual yield. The REML analyses showed that the effect of all factors were significant on DM and N yield (Table 2, $P<0.001$). All two-way interactions of “Location” and all of “N fertilization level” and the interaction “Location . Fertilizer type . N fertilization” were significant for both DM and N yield ($P<0.05$).

TABLE 2 **REML analyses for annual DM yield and N yield of grass. F probability of main terms and significant interactions ($P<0.05$).**

	F probability	
Term	DM yield	N yield
Location	<0.001	<0.001
Fertilizer type	<0.001	<0.001
Number of fertilized cuts	<0.001	<0.001
N fertilization	<0.001	<0.001
Location.fertilizer type	0.002	<0.001
Location.number of fertilized cuts	0.003	0.002
Location.N fertilization	<0.001	<0.001
Fertilizer type.Nfertilization	<0.001	<0.001
Number of fertilized cuts. N fertilization	<0.001	0.040
Location.fertilizer type. Nfertilization	0.015	<0.001

The DM and N yields were greater on clay than on sand (Figure 1 and 2). On the control plot without slits on clay yielded 1200 kg DM and 9 kg N ha^{-1} more than on sand. On the 300 N level the difference was 3900 kg DM and 78 kg N ha^{-1}. On both soil types the DM and N yields of the CAN objects were highest, followed by the yields of the liquid AN objects. The yields of the objects fertilized with the thin fractions were the lowest and comparable amongst each other. The N yields of the thin fractions and the AN differed relatively less among each other than the DM yields. In all objects the N fertilization increased the DM and N yields, as expected.

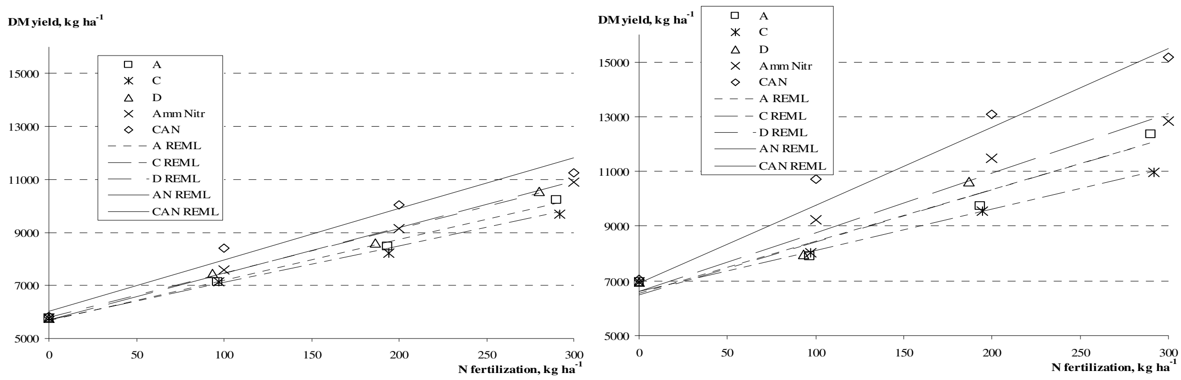

FIGURE 1 **Annual DM yield of 5 cuts, fertilization in three cuts. A, C and D: thin fractions. Measured data and reml model. Left sand (ANreml and Dreml are on top of each other) , right clay (Areml and Dreml are on top of each other).**

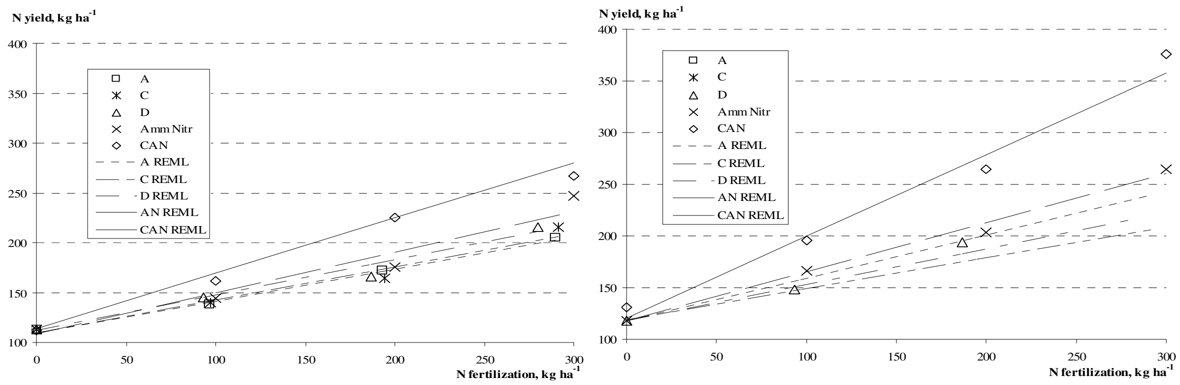

FIGURE 2 **Annual N yield of 5 cuts, fertilization in three cuts, clay. A, C and D: thin fractions. Measured data and reml model. Left sand, right clay.**

Based on the calculation the estimates for the N fertilizer value for the thin fractions are:

- On sand the N fertilizer value of the thin fractions based on N yield, all N fertilization levels and CAN varies from 57 to 64% and based on AN from 84 to 94% (Table 3).
- On clay the N fertilizer value of the thin fractions based on N yield, all N fertilization levels and CAN varies from 43 to 55% and based on AN from 65 to 81% (Table 4).

TABLE 3 **Calculated fertilizer value for N (in percentage) based on N yield in five cuts (total year), fertilized before first, second and third cut, sand.**

	Fertilizer value (%) based on CAN kg N ha^{-1}				Fertilizer value (%) based on AN kg N ha^{-1}			
Fertilizer	100	200	300	mean	100	200	300	mean
A	55	55	62	57	85	98	72	85
C	58	47	68	58	90	84	79	84
D	71	50	72	64	110	90	82	94
Amm Nitr	64	56	87	69				

TABLE 4 **Calculated fertilizer value for N (in percentage) based on N yield in five cuts (total year), fertilized before first, second and third cut, clay.**

	Fertilizer value (%) based on CAN, kg N ha^{-1}				Fertilizer value (%) based on AN kg N ha^{-1}			
Fertilizer	100	200	300	mean	100	200	300	mean
A	37	43	60	47	51	67	101	73
C	45	46	37	43	62	72	62	65
D	49	60	No data	55	67	95	No data	81
Amm Nitr	74	64	60	66				

4 DISCUSSION

On sand and on clay the thin fractions had a N fertilizer value < 100%, based on CAN. Surprisingly the N fertilizer value of the AN was also , < 100% when compared with CAN. The lesser fertilizer value of the liquid fertilizers may have been caused by a number of factors. Three factors will be quantified in 2010.

- The slits made by the application machine caused damage. In the first cut the yield on plots with slits (0N) was less than without slits but this was on clay partly and on sand completely compensated during the season (Figure 1 and 2). Possibly the compensation was less when the grass was fertilized with N.
- Ammonia volatilization from the thin fractions. However, the weather was rainy and/or cloudy on most application days. This would normally limit the potential for ammonia volatilization. Volatilization is not likey to be the reason for the lesser fertilizer value of AN. On the other hand, on clay the fertilizer values of the thin fractions were less than on sand. The pH of clay was higher than on sand which increases the risk of volatilization on clay.
- Possibly the soil-complex influences the availability of NH4-N in the thin fractions negatively. However, this would not account for the lesser fertilizer value of AN.

The dosages of the thin fractions were not exactly the target dosages. There was a difference between planned and realized N fertilization. The fertilizer value was calculated with the realized N fertilization.
The calculations of the fertilizer values are based on data from one year (2009). In the final statistical analyses data of both years will be included and a more detailed method of calculation will be used.

5 CONCLUSIONS AND RECOMMENDATIONS

The fertilizer values of the thin fractions of separated pig slurry were less than expected.

- On sand the N fertilizer value of the thin fractions based on N yield, all three N fertilization levels and CAN varied from 57 to 64% and based on AN from 84 to 94% in 2009.
- On clay the N fertilizer value of the thin fractions based on N yield, all three N fertilization levels and CAN varied from 43 to 55% and based on AN from 65 to 81% in 2009.

Three factors that may have caused these smaller-than-expected fertilizer values will be assessed in 2010. These are damage by the slits of the application machine, ammonia volatilization during application and a lesser efficiency of ammonia-N than of nitrate-N. To quantify the effect of these factors, plots with an acidified thin fraction, with slits in all N levels of CAN and fertilized with a 100% ammonia fertilizer, will be added to the experiment in 2010.

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