INJECTION OF ANIMAL SLURRY TO WINTER CEREALS – EFFECTS ON CROP YIELD AND EMISSIONS OF ODOUR AND AMMONIA

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1 INTRODUCTION

Considerable amount of nitrogen (N) is lost from livestock production as ammonia (NH_3) (ECETOC, 1994). The loss of NH_3 causes a loss of plant available nitrogen, and thereby need for additional mineral fertiliser, or risk of lower crop yield. Besides, the loss of NH_3 to the atmosphere may cause various environmental problems, such as eutrophication of aquatic and terrestrial ecosystems (Burton and Turner, 2003). In Denmark it has been estimated that livestock production contributes approximately 96% of the total Danish NH_3 emission, and that more than 20% of the NH_3 emission is derived from the spreading of livestock manure (NERI, 2007). Besides, the odour emission from land application of livestock manure is a major nuisance in many rural areas. Therefore, there is a need for technologies to abate the odour and NH_3 emissions arising from land applications of livestock manure.

It is well documented that the emission of ammonia following land application of slurry can be reduced by trailing-hose spreading technologies (Morken, 1991; Sommer et al., 1997; Smith et al., 2000), by trailing-feet techniques (Huijsmans et al., 1997; Smith et al., 2000), and even more so by slurry injection techniques (Thompson et al., 1987; Rubæk et al., 1996; Huijsmans et al., 1997; Smith et al., 2000). To increase the utilization rate of the manure nutrients, and because of regulations designed to protect the environment a steadily increasing amount of Danish livestock manure is applied to growing crops. However, while injection of slurry is increasingly used to mitigate odour and ammonia emissions from animal slurry applied to un-cropped land and grassland, injection of slurry to winter cereals rarely takes place. The reasons for this is expected to be the potential crop damage caused by the injection devises and by the additional tramlines, but also that the actual knowledge is limited regarding how injection in winter cereals affects crop yield and emissions of ammonia and odour.

The aims of the present study were therefore to generate improved knowledge regarding how shallow injection of animal slurry to winter cereals affects

- Emission of odour
- Emission of ammonia
- Crop yield

2 MATERIALS AND METHODS

All studies were performed as field scale studies by use of commercial application technologies. The odour and yield studies were conducted on a field located in Western Jutland, DK-7560 Hjerm, Denmark. The field was planted with winter wheat at growth stage 31 on the Zadoks scale (Zadoks et al, 1974). The soil was sandy loam, after the USDA soil classification. The ammonia emission measurements were done on a stubble field after harvest located near Research Centre Foulum, DK-8830 Tjele, Denmark. The soil was loamy sand, after the USDA soil classification. Pig slurry was applied by commercial technologies to experimental plots at a rate of 30 m^3 ha^{-1} in the spring of 2008 and 2009. The application of the slurry was in all studies performed by a shallow disc injector (disc injector), a trailing shoe injector (trailing shoe), and a trailing hose applicator (trailing hose).

The odour concentration in air sampled in static odour chambers situated above the applied slurry were quantified ten minutes after the application of slurry by dynamic dilution olfactometric analyses, and by quantification of key odour components thermal desorption (TD) tube sampling coupled to individual quantification of concentrations of specific key odour components by GC-MS analyses. All measurements were triplicated.

The emission of ammonia from the applied slurry was measured by the Integrated Horizontal Flux (IHF) technique using the Z_{inst} method (Wilson and Shum, 1992). This technique involves a measuring mast placed centrally in each plot, and a background measuring mast located outside the plot for monitoring the background NH_3 level. Every mast was equipped with two measuring units. NH_3 volatilisation (g NH_3-N) was measured continuously over 6 days following application of the slurry.

The impact of injection on crop yield was quantified by measurements of harvested yield of grain and protein. All measurements were replicated four times in each trial and three identical trials were conducted in different fields within a distance of appr. 10 km. As commercial equipment was used for manure application in the trials, the slurry was applied to large plots, and within each plot a harvest plot of 30 m^2 was established. For the purpose of making a response curve for nitrogen, four treatments of different levels of nitrogen in mineral fertiliser (50-200 kg N per hectare) were included. At harvest yield of grain and contend of protein in the grain were quantified.

3 RESULTS AND DISCUSSION

3.1 Efficiency of injection

The efficiency of injection was quantified during the study. Injection by use of the disk injection system created slits that enabled that the majority of the applied slurry could be held in the slits, while slits created by the trailing shoe devices were too small to hold the volume of the applied slurry (Table 1).

TABLE 1 **Application rate and mean injection depth and efficiency of the two injection technologies. Overflow is the number of injection slits that were unable to hold the volume of slurry applied.**

	Applied slurry, m^3 ha^{-1}		Depth of injection, cm		Overflow of slits, %	
Technique	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
Trailing hoses	27.5	33	0	0	-	-
Trailing shoe	27.5	33	2-4	1.5	15	80
Disc injector	27.5	33	4-5	4.1	5	10

3.2 Odour emission

The odour reducing impact of the injecting was found to be highly depending on the efficiency of the injection. Compared to trailing hose application, injection by trailing shoe did not reduce the concentration of odour in air sampled above the applied slurry (Fig. 1). This is expected to be caused by the low injection efficiency achieved by use of the trailing shoe injection system. Contrary, the more efficient injection performed by disk injection devices was found to reduce the odour concentration between 15 and 60 % compared to slurry applied by trailing hoses (fig. 1).

FIGURE 1 **Odour concentration in air sampled above pig slurry injected to winter cereals in 2008 and 2009 by trailing shoe and dick injector techniques.** All results are given as per cent of the odour concentration in air sampled above pig slurry applied by trailing hoses. Control represents the odour concentration in air sampled above agricultural land without applied pig slurry.

3.3 Ammonia emission

For practical reasons, ammonia volatilization from trailing shoe application was not measured. The results in figure 2 show that the emission of ammonia after application with trail hose was about 60 % higher than following application by disc injection. This difference is expected to be due the restricted slurry/air contact area of slurry placed into the open slots created by the discs of the soil injection machine.

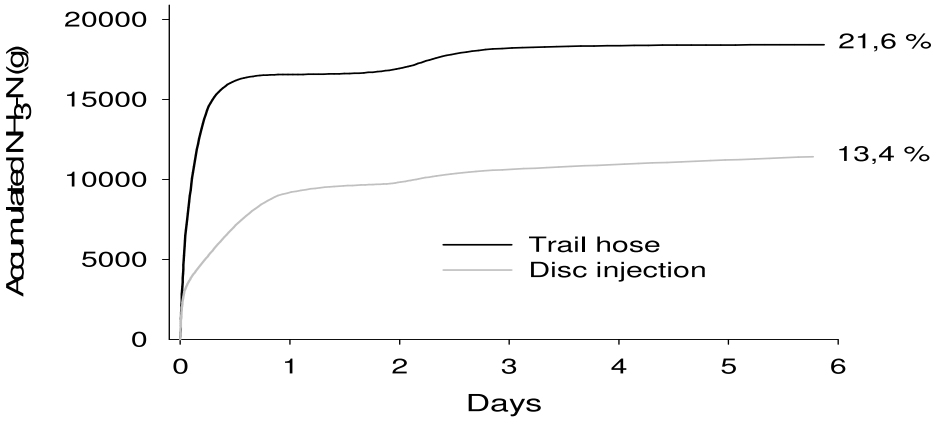

FIGURE 2 **Accumulated ammonia emission in g NH_3-N ha^{-1} following trail hose application and disc injection of pig slurry**. Percentage numbers represent the loss of ammonia-nitrogen in per cent of the applied ammoniacal nitrogen. Time zero is equal to the timing of slurry application.

3.4 Crop yield

The effect of injection on crop yield varied between years and used technology (figure 3). The differences found were not statistical significant. The study indicate that injection neither increase nor decrease the yield compared to trailing hose application. A better utilisation of nitrogen due to a reduced ammonia volatilisation is counteracted by the mechanical damage by the injection units. The results support conclusions from earlier trials.

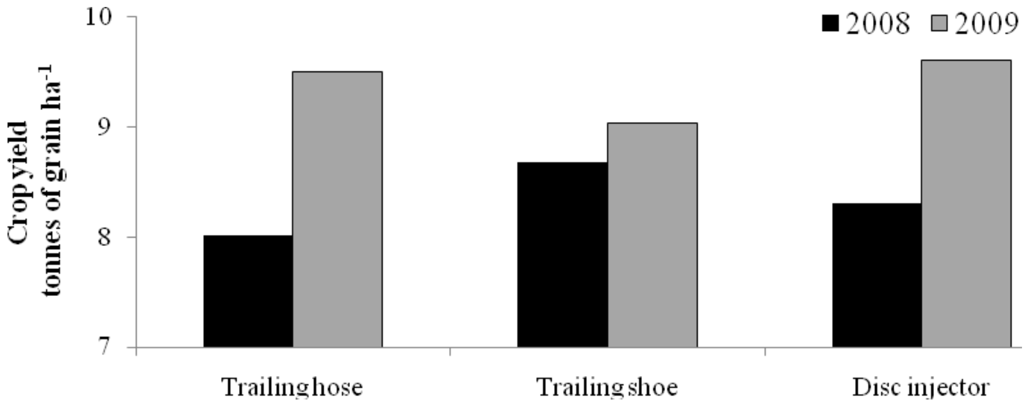

FIGURE 3 **Crop yield in wheat applied pig slurry in 2008 and 2009 by different types of application technologies.**

4 CONCLUSIONS

Trailing shoe injection did not allow an efficient injection of the slurry, and was not found to abate the odour concentration of air sampled above pig slurry applied to winter wheat, while the more efficient injection performed by disc injection devices was found to reduce the odour concentration between 15 and 60 % compared to slurry applied by trailing hoses. Shallow injection of slurry in open slits by means of the disc injection devices was found to reduce the ammonia emission by 38 per cent compared to trailing hose application. The effect of injection on crop yield varied between years and used technology, however, the differences were not statistical significant.

REFERENCES

Burton C H, Turner C 2003. Manure management, Silsoe Research Institute, Bedford, UK

European Centre for Ecotoxicology and Toxicology of Chemicals 1994. Ammonia emission to air in Western Europe. Technical Report no. 62. ECETOC, Brussels, Belgium.

Huijsmans J F M., Hol J M G, Bussink D W 1997. Reduction of ammonia emission by new slurry application techniques on grassland. p. 281–285. In: Gaseous nitrogen emissions from grasslands, (Jarvis S.C. and Pain B.F. ed). CABI Publishing, Wallingford, UK.

Morken J 1991. Slurry application techniques for grassland: effects on herbage yield, nutrient utilization and ammonia volatilization. Journal of Agricultural Science. 5: 53–162.

NERI 2007. Projection of the ammonia emission from Denmark from 2005 until 2025. NERI technical report No. 239. Auth. Gyldenkærne S., Mikkelsen M.H. National Environmental Research Institute, University of Aarhus, Denmark.

Rubæk G H, Henriksen K, Petersen J, Rasmussen B, Sommer S G 1996. Effects of application technique and anaerobic digestion on gaseous nitrogen loss from animal slurry applied to ryegrass (*Lolium perenne*). Journal of Agricultural Sciences. 26: 481–492.

Smith K A, Jackson D R, Misselbrook T H, Pain B F, Johnson R A 2000. Reduction of ammonia emission by slurry application techniques. Journal of Agricultural Engineering Research. 77:(3) 277–287.

Sommer S G, Friis E, Bach A, Schjorring J K 1997. Ammonia volatilization from pig slurry applied with trail hoses or broadspread to winter wheat: Effects of crop developmental stage, microclimate, and leaf ammonia absorption. Journal of Environmental Quality. 26:(4) 1153–1160.

Thompson R B, Ryden J C, Lockyer D R 1987. Fate of nitrogen in cattle slurry following surface application or injection to grassland. Journal of Soil Science. 38: 689–700.

Wilson, J D, Shum W K N. 1992. A re-examination of the integrated horizontal flux method for estimating volatilisation from circular plots. Agricultural and Forest Meteorology 57(4): 281-95.

Zadoks J C, Chang T T, Konzak C F 1974. Decimal Code for Growth Stages of Cereals. Weed Research 14(6): 415-21.