
Valuable fertilizer from animal manure

In Denmark abatement of environmental pollution caused by livestock production has focused on enhancing efficient recycling of animal manure. Technologies for the implementation of the policy have aimed at reducing ammonia emission and nitrate leaching. At the same time, utilization of nitrogen in manure has increased dramatically, and use of nitrogen in mineral fertilizer has decreased by 50 percent.



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■ For two decades a lot of effort has been made to reduce nitrogen loss from agricultural sources in Denmark. Especially animal manure has been in focus. The idea has been that improvement of nitrogen utilization in manure will be compensated by a decrease in consumption of nitrogen in mineral fertilizer. A reduced impact of the environment and an improved economy for the farmer would be the result. A number of different techniques have been used in order to achieve that target. In 2006 about five percent of all manure was digested in biogas plants and 35 percent injected at application, but only about one percent of the slurry was separated and less than one percent acidified.

In house acidification of slurry

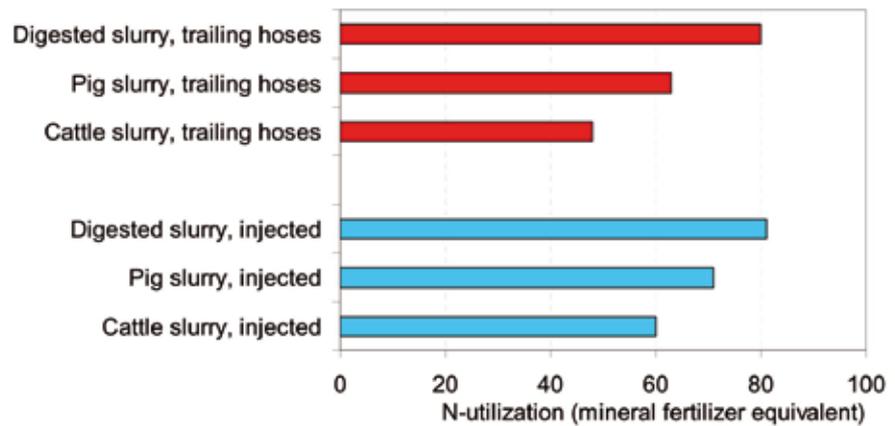
A new Danish manure management system based on the acidification of slurry has been developed and validated under practical farming conditions for more than two years. Sulphuric acid was used in house to acidify the slurry to $\text{pH} < 6$. The system has been constructed to prevent foaming in the animal house as well as during storage.

Acidification reduced ammonia emission from the animal houses by 70 percent compared with standard housing. Little or no emission was observed from the stored slurry and ammonia emission from the applied slurry was reduced by 75 percent. In consequence, a 54 percent increase in N fertilizer value was measured in field studies. The technology has been installed at about 40 Danish livestock farms. Taking the increased fertilizer effect into account the cost of reducing emission of one kg nitrogen is about six €.

Slurry store technology

To achieve correct amounts of N applied and at the right time for crop uptake, all slurry stores must be large enough to contain about nine months' production of animal slurry. To reduce ammonia volatilisation, liquid stores without a cover or natural surface crust should be sealed by means of an ammonia-impermeable covering material, which is defined as, e.g., a roof, floating plastic cover, floating expanded clay granules or a layer of straw. These covers decrease ammonia losses to less than 10 percent of those from

Figure 1. Utilization of nitrogen in digested slurry compared with pig and cattle slurry in field trials at Danish Agricultural Advisory Service. Average of 11 trails with digested slurry, 15 trials with pig slurry and 15 trials with cattle slurry.



uncovered slurry. A roof or tent on the store will also reduce rain uptake, thereby increasing storage capacity and reducing the amount of slurry that has to be transported.

Digestion of slurry in biogas plants

The physical and chemical process that takes place in the biogas plant changes the fertilizing effect of the slurry in the field. Among other things organic nitrogen is converted into ammonium. The higher content of ammonium is advantageous to the crops as they are primarily capable of utilizing ammonium nitrogen. It is important to make allowance for this when the fertilizing plans are prepared and also when handling and spreading the slurry. In other words: It is often possible to replace nitrogen from commercial fertiliser by digested slurry and thus save money.

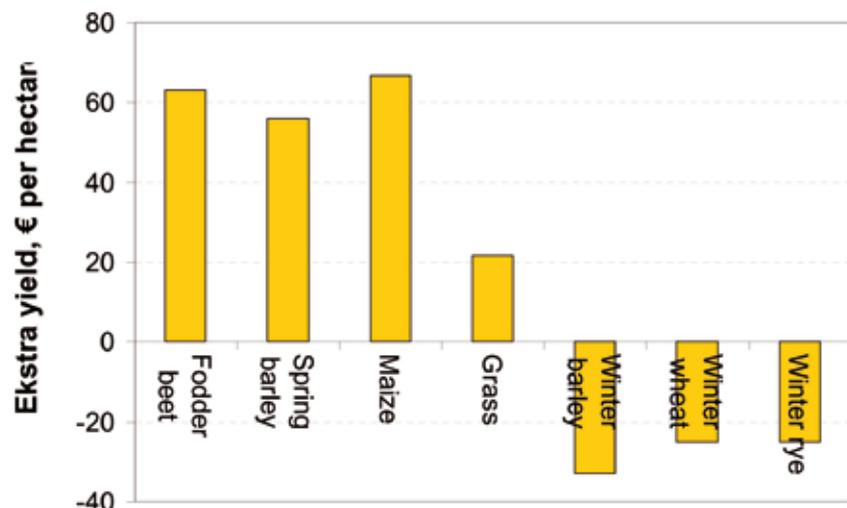
Field trials with digested slurry in winter wheat have demonstrated a higher nitrogen utilization than pig slurry and much higher than cattle

slurry (Figure 1). This means, for example, that if a farmer fertilizes a field of winter wheat with 140 kg of total nitrogen in digested slurry instead of 170 kg of nitrogen in pig slurry, he can save about 25 kg of nitrogen of mineral fertilizer and still get the same yield!

Separation of slurry

Slurry is produced in large amounts and has a low concentration of nutrients. Thus, the cost of transporting nutrients from livestock farms with a nutrient surplus to arable farms with a nutrient deficit can be high. However, the cost of transporting nutrients can be reduced by separating slurry into a high dry-matter (DM) and nutrient-rich solid fraction and a liquid fraction, so that a much smaller volume of manure will need to be transported from one farm to another. The costs vary widely, often reflecting the sophistication and efficiency of the technique, from cheap screen separators to the more costly decanting

Figure 2. Net extra income (or loss) for the farmer when injecting the slurry instead of trailing hoses. The net income is calculated by extra yield minus extra tracks minus extra application costs.



centrifuges. About 30-50 farmers have installed mechanical screen separators and there are less than 10 centrifuges in use on livestock farms and biogas plants.

When slurry is separated in a solid and a liquid fraction, most of the organic nitrogen in the slurry ends up in the solid fraction and most of the ammonium ends up in the liquid fraction. Higher utilization of nitrogen in the liquid fraction than from the solid fraction can therefore be expected. This is valuable information when making fertilizer plans including fractions from slurry separation. However, trials and calculations show that the total utilization of nitrogen is unchanged compared to unseparated slurry. What is gained in the liquid fraction is correspondingly lost in the solid fraction.

Injection of slurry at application

When slurry is injected in the soil at application, ammonia evaporation can be restricted or completely avoided. Especially injection in bare soil can be efficient, since relatively thorough soil tillage can be done without damaging the crop. Injection of slurry in growing crops must be done moderately in order to spare roots and leaves from mechanical damage. In Denmark about one third of all slurry is injected. It is common to inject cattle slurry before sowing maize, spring barley etc. or in grass in spring or summer. A large number of field trials have been conducted in order to establish the economic outcome of injection compared to application with trailing hoses. In Figure 2 the net extra income (or loss) for the farmer when injecting the slurry instead of trailing hoses is shown. A positive economic result compared to application with trailing hoses can be expected with injection in bare soil or in grass, but a negative result can be expected in winter cereal. ■