REDUCE THE NITROGEN LOSS AND MAINTAIN THE INCOME - THE ECONOMICS OF MANURE HANDLING

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ABSTRACT

In this paper, an economic analysis of different ways to cover the slurry tank and apply the slurry to the field has been carried out. It is found that covering slurry tanks with either straw or a floating lid is profitable. New field application techniques have become more profitable since an N-norm of 10% under the economic optimum was adopted in Denmark. This has increased the shadow price of nitrogen. When applying animal manure, injection is a profitable alternative to trailing hoses in spring crops before sowing and in many forage crops, as it gives higher yields and sometimes also higher protein content. Injection of animal manure can in some cases eliminate the negative economic effect of a nitrogen norm. There are no clear advantages of using injection in winter crops, but it is a technique that more Danish farms will use in the years to come. The paper finishes by outlining different whole manure chain systems where for example separation techniques will be analysed further. Theses systems are constructed in order to ensure that the nutrients are maintained in the different links of the N-chain.

Keywords: *Cost of slurry storage, cost of manure application, marginal value of Nitrogen.*

INTRODUCTION

The manure handling in Denmark has for many years been guided by detailed legislation covering restrictions on the N-application (fertiliser account) and application time, as well as the requirements concerning storage capacity. This legislation has implications for the choice of storage and how the application of the manure to the fields is actually made. Although the choice of technique at the farm level can seem fairly easy, deciding the most optimal application technique is not always easy. Considerations concerning availability and the use of own labour, as opposed to contractors, also influence the choice.

As it becomes more important to utilise the nitrogen in animal manure efficiently, more farmers are interested in systems which ensures that gains in one link of the nitrogen chain are maintained throughout the entire manure chain from stable to field.

Also the pressure from the public is increasing and farmers today have to be aware of e.g. the wind direction when they are spreading the manure and weekends are often avoided. It is clear that farmers today do many things to reduce the ammonia emission and the smell in the local community. On the other hand the demands from the public is increasing.

Investigations show that animal manure in Denmark in most cases are transported less than 3 km from storage to field and very few transport the manure more than 6 km (e.g. Miljøstyrelsen, 1999). But the transportation of manure is an increasing problem, as more area is needed for each livestock unit. From 2002 the requirement will be maximum 140 kg N (ab storage) per hectare of animal manure on pig farms and 170 kg N per hectare on dairy farms. At the same time the definition of one livestock unit will be changed to 100 kg N (ab storage). The number of animals in some regions has almost reached these limits. In these areas techniques to separate slurry are increasingly in demand.

In order to address these problems, a research program on "Optimal redistribution and Utilisation of Plant Nutrients from Animal manure" has been implemented. The project is a joint effort between Danish Agricultural Sciences and Danish Institute of Agricultural and Fisheries Economics. This paper presents some preliminary results from the project.

This paper looks at the economics of different ways to cover the storage and the cost of using different application techniques. The effect of new legislation on manure management is also investigated. In the last section of the paper, an outline is given of entire manure systems which can be set up in order to ensure the most cost effective manure management.

STORAGE

A storage capacity of 9 months is mandatory on animal farms in Denmark and most farms probably have a storage capacity of around 12 months. The slurry tank has to be covered in order to reduce ammonia emission. A top layer is created naturally in most cases, but on most pig farms, this is not the case due to the high ammonium content of the slurry. The cover has, therefore, to be made either with plastic or straw. However, surveys indicate that up to half of all pig farms do not have a cover on their slurry tank (Miljøstyrelsen, 2000).

The costs of creating a cover over the slurry tank are described in table 1. The cost of the investment is calculated in €/m^2. A concrete lid is the most expensive, but it also lasts the longest.

The return on the investment comes both as a higher value of the slurry and lower transportation and application costs. The lower application cost arises, as the precipitation no longer needs to be transported out into the field. This does not hold for a straw cover, as it does not prevent rainwater from coming into the tank. In this case the net precipitation of 440 mm yearly has been used. This might underestimate the actual increase in water in the slurry tank. The net precipitation amounts to 220 m^3 for a tank with a surface of 500 m^2. With a cost of 1.4 € per tonne, this lowers the application cost by at least 300 € or 0.6 €/m^2 surface area.

The emissions from a slurry tank without a lid can be as much as 10% of the total N-content on a dairy farm. The loss can hence be calculated 1,3 (pig farm) to 2 kg N pr. m^2 (dairy farm), which equals 1-1.6 € pr. m^2 of surface. It is assumed that the N, which is not lost is ammonium-N, which can be used 100%. The value of N is 0,8 € per kg due to the N-norms as discussed in the next section.

The economic calculations show that it is profitable to create a cover using straw. A floating lid has a very low net cost, but experiences in The Netherlands seems to suggest that this method has some disadvantage on larger slurry tanks why it is not often used. The Danish government are therefore considering making a lid either using plastic or as a tent compulsory on all pig farms from 2002.

Table 1. The cost of covering a slurry tank compared with no cover

Technique	Investment	Duration	Yearly cost	Reduced cost	Net cost
	€/m^2	Years	€/m^2/year	€/m^2/year	€/m^2/year
Straw	0.7	1	0.7	1,4	-0.7
Floating lid	13.4	10	1,7	1,8	0.1
Tent	23.4	10	5.9	2.3	3.6
Concrete lid	80.4	20	6,6	2.3	4.3

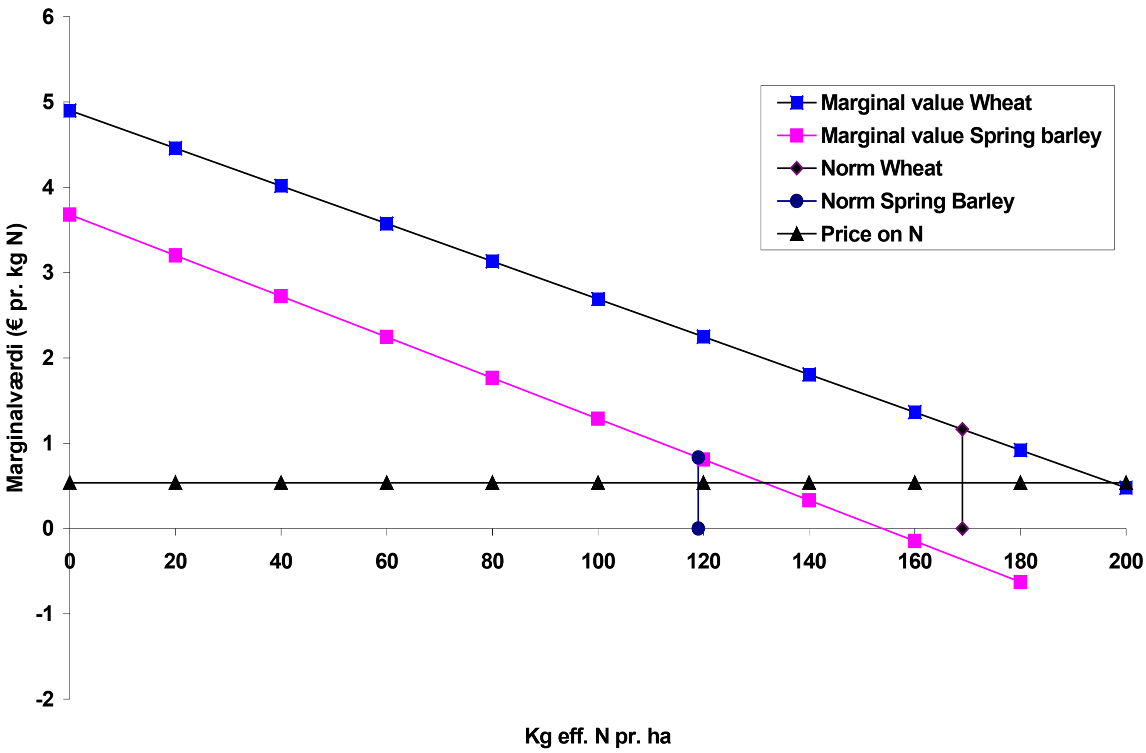
Comment: The slurry tank is 2.000 m^3 and the surface area is 500 m^2.
Shadow value of N = 0,8 € /kg

Source: The Danish Advisory Centre (1999) and own calculations

APPLICATION TO THE FIELD

With respect to the application of liquid manure, open spreading, trailing pipes and injection are the most commonly used techniques in Denmark. In Denmark approx. 28 million tons of liquid manure has to be applied every year. It is assumed that approx. 45-50% are applied using trailing hoze pipes, 45-50% using open spreading and 1-3% using injection (Andersen et al., 1999). The use of injection is a lot less than in e.g. The Netherlands. The cost of using the three application techniques is approx. 1, 1.3 and 2 € per tonne. The effect of the application varies with technique, crop and time of application. Also, other factors like the weather influence the effect, but they are not included in the calculations, as most farmers have a contractor to carry out the application. They can, therefore, not decide the exact application time.

In general, the 10% fertiliser norm reduction has increased the shadow value of nitrogen, which can make more expensive techniques viable. These effects are described in figure 1 for spring barley and winter wheat. Without N-norms, the marginal value curves would cross the price curve for nitrogen at the amount which is the optimal application. In figure 1 this is at around 190 kg N/ha for wheat and 135 kg N/ha for barley. The N-norms reduce the application to approximately 170 kg N/ha and 120 kg N/ha. The calculations show that the fertiliser norm endorsed in Denmark increases the marginal value of the last applied kilo of nitrogen. The value is found in the figure where the norm applications cross the marginal value curve. The shadow value of N increases



from 0.5 € (price of nitrogen) to 0.8 € for barley and 0.9 € per kg N for wheat, making it more profitable to use more costly techniques.

Figure 1. Marginal value for N-application at N-norm for Spring Barley and Winter Wheat

Source: Own calculations

In recent years more Danish farmers have started to use the injection technique. The reasons for this are several. With fertiliser accounts and requirements on the utilisation of animal manure, it can be costly not to use the manure efficiently. Currently, the required field effect (1 year effect) of nitrogen in animal manure used in the fertiliser accounts are 55% for pig slurry and 50% for slurry for dairy cows. This will increase to 65% and 60% in 2002/2003.

Secondly, the 10% reduction in the fertiliser norm restricts the total application. If farmers can use the animal manure more efficiently than the requirement, they can reduce or remove the yield effect of a reduction in the nitrogen norm. Trails have proven that injection of animal manure in several crops gives an increase in yield on top of the increase due to the higher application effects. This extra effect is called a place-effect, as the nitrogen now is placed where the roots need it (The Danish Agricultural Advisory Centre, 2000a). In some cases the protein content will also increase. This effect is illustrated in figure 2.

The gross output curve (no place effect) is the base production function. The economic optimum is at 131 kg N/ha, but the norm is only 119 kg N/ha (10% lower). The 119 kg N/ha are applied to the field, as 23 tons of pig slurry per hectare using trailing pipes (effect=60%) and the rest 50 kg/ha is mineral fertiliser. The gross output is then approximately 657 €/ha, whereas the economic optimum would have given a gross output of 665 €/ha.

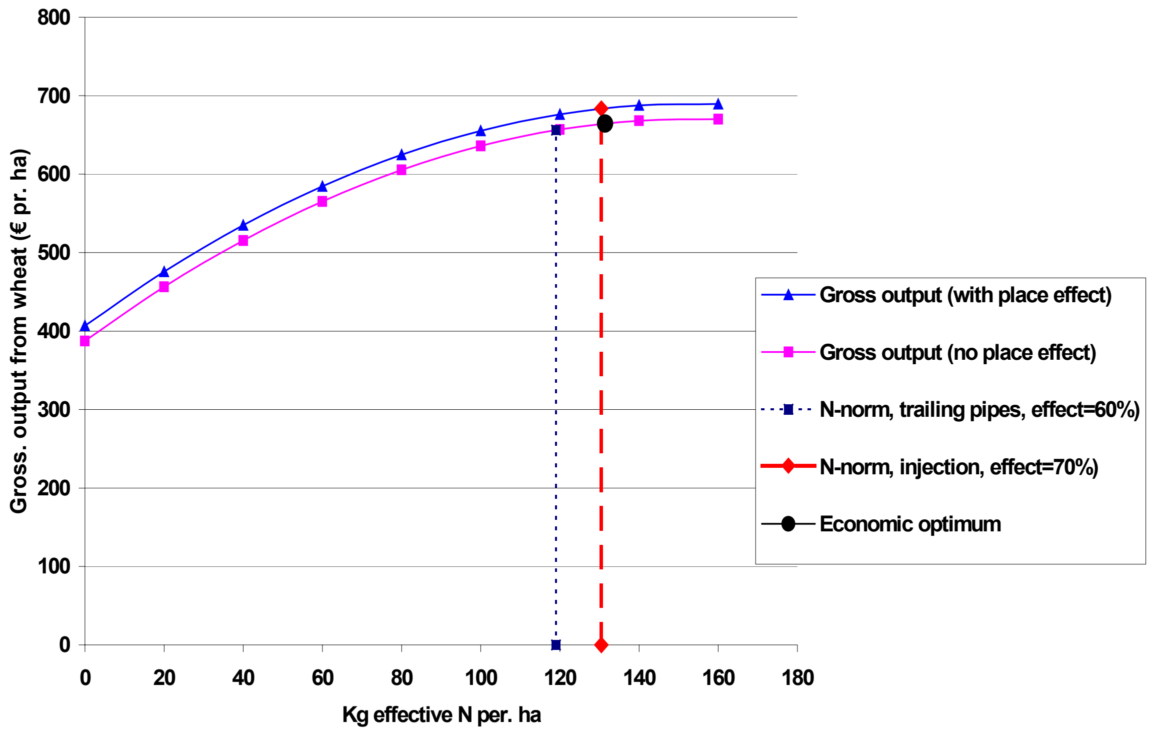


Figure 2. Gross output in Spring Barley with types of application techniques

Source: Own calculations

In the case where the farmer use the injection technique instead, he can still only apply 23 tonne of slurry per hectare, due to the N-norms, but the effect of the N in animal manure is now 70%. Therefore, he gives in effect 130 kg N/ha, as he still applies 50 kg N/ha in mineral fertiliser. Assuming that the injection technique gives a place effect of around 4%, this gives a gross output of about 683 €/ha. The extra cost of using the injection technique is 15€/ha. In other words, the injection technique gives the farmer an economic return, which is similar to the profit (665€/ha) before N-norms were introduced and higher than when using trailing pipes.

In table 2, a comparison of the different application techniques are carried out for pig slurry to winter wheat and spring barley. In the calculation of the value of the application, the prices on N,P (phosphorous) and K (potassium) are 0.5 €/kg, 0.9 €/kg and 0.3 €/kg respectively based on the price of the mineral fertilizer it replaces. The pig slurry contains 5.9 kg N, 1.93 kg P and 2.93 kg K (ab storage) per tonne (Kristensen and Damgaard, 1997).

When calculating the total effect of applying animal manure, the value of P and K can be difficult to estimate, as the value of the last applied P and K is often zero as the recommend application is exceeded. The calculations presented here include P and K, but if the value is zero the value would be reduced by approx. 2.4 € per tonne for pig slurry.

First the application of pig slurry to winter wheat is investigated. The calculation suggests that trailing pipes are the most economical technique, although open spreading gives almost the same economic return. Injection can give a higher return, but the harrowing can also damage the crop so much that the yield is lower. The yield effect is here 0. However, injection can lead to a higher protein content, which might be beneficial in the light of the higher requirements on protein content in wheat set by The European Union

Also for spring barley, trailing pipes are a little bit better than open spreading. For injection, the problem is to distinguish between the so-called place effect and a higher utilisation of manure. In the second to last row, only the improved utilisation is included. This does not make injection a preferable option. In the last row, the same effect (and amount per ha) as for trailing pipes is applied and the effect is measured on the yield. In this case the yield increase is around 5 hkg per ha, which makes injection the most profitable option.

Table 2. Effect and cost of using different application techniques for pig slurry

Crop	Technique	Time	Effect of manure	Cost of app.	Value of manure	Yield effect	Net income
			%	€/t	€/t	€/t	€/t
Winter wheat	Open spreading	Spring	50	1.1	4.0	0	2.96
Winter wheat	Trailing pipes	Spring	60	1.3	4.4	0	3.01
Winter wheat	Injection	Spring	75	2.0	4.8	0	2.82
Spring Barley	Open spreading	Spring	55	1.1	4.2	0	3.12
Spring Barley	Trailing pipes	Spring	65	1.3	4.5	0	3.16
Spring Barley (before sowing)	Injection	Spring	70	2.0	4.7	0	2.65
Spring Barley[1] (before sowing)	Injection	Spring	(65)	2.0	4.5	2.1	4.50

Source: Own calculations and The Danish Agricultural Advisory Centre (2000a +b)

Comments:

The value of N,P and K is 0.5 €/kg, 0.9 €/kg and 0.3 €/kg respectively

The content of nutrients in one tonne slurry is assumed to be 5,9 kg N, 1,93 kg K and 2,9 kg K.

1) The yield effect is assumed to be 5 hkg a 10.7 € = 53,6 €. Application is 23 tons slurry/ha.

Using injection before sowing on spring crops and in grass in Spring seems very profitable, whereas it can not be recommended to use this technique in winter crops as the injection damages the crops so much that there is no net gain. The use of the system today is mainly limited by practical restrictions, scepticism from farmers and availability of contractors in the area who supply this technique. The number of Danish farmers using the injection technique has increased over the last 2 years and will probably increase in the years to come, but few farmers will probably find it profitable to invest in the equipment themselves. Furthermore, the number of reactions from the public will be reduced with an increase in the use of the injection technique. So far, injection is mainly used on sandy soil, but it will also be possible to use this technique on mixed soils, whereas it can not successfully be used on clay soil and on hilly farms with the present set-up.

With respect to legislation, a plan on how to reduce ammonia emission and adjustments to a plan from 1998 on how to reduce nitrogen leaching will be agreed before summer. This will probably include a ban on the use of open spreading and a requirement on farmers to integrate slurry into the field within 6 hours as oppose to 12 hours which to-day is the minimum requirement.

CONSIDERATIONS AT THE SYSTEM LEVEL

The economic calculations in the research project will be based on the detailed analysis as described above, but will also include consideration with respect to use of separation techniques and the distance the manure has to be transported. The systems analysed will include both traditional and new systems, which are not widely adopted yet. These new approaches will involve separation techniques (Biorek, Manura etc.) and facilities were the slurry is pumped to the field. Another aim is to find systems, which might make it possible to use injection on sandy-clay soil in the Spring. Also the cost of trans-porting the manure over longer distances (over 10 km) will be analysed in more detail.

The farms investigated consist of pig, dairy and poultry farms of a size which will be typical for the farms in the years to come. As an example, the pig farms range from 100 sows to 1,000 sows. Calculations of the cost of farm bio-gas plants will only be carried out for the largest farms. The 2 year project finishes at the end of 2001. The focus of the systems will be to ensure a high N-efficiency from the stables to the field. Some pre-liminary results will be presented at the IFMA conference in July.

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Biographical Sketch

Brian H. Jacobsen is a senior researcher at the Danish Institute of Agricultural and Fisheries Economics. Brian H. Jacobsen is a graduate from the Royal Veterinary and Agricultural University (RVAU) in Copenhagen. He has a M.Sc. from Reading University and a Ph.D. from RVAU. He has worked with economic planning, non-parametric analysis and decision behaviour. He is currently involved in calculating the economic consequences of different measures aimed at reducing N-leaching, ammonia emission and methane emissions from agriculture. The calculations are carried out for the Danish Ministry for Agriculture, Fisheries and Food.