EFFECTS OF WATER PROTECTION MEASURES ON THE PROFITABILITY OF FARMS

Ute Schultheiß, Peter Jäger, Helmut Döhler, Brigitte Eurich-Menden

Association for Technology and Structures in Agriculture (KTBL)
Bartningstrasse 49, 64289 Darmstadt
email: u.schultheiss@ktbl.de, p.jaeger@ktbl.de, h.doehler@ktbl.de, b.eurich-menden@ktbl.de

ABSTRACT

The effect of different management measures on the nutrient losses from crop and animal husbandry systems, in particular nitrogen, and on the total income of model farming enterprises was investigated. Such measures are considered as powerful options for meeting the requirements of "cross compliance" within the Agenda 2000 midterm review of the CAP. Optimisation of the storage and handling of animal manure was shown to be the most important and cost effective measure to reduce nutrient losses on farms. Other measures such as protein and phosphorus adapted feeding, maintaining a year-round cover crop on arable land and conservation tillage were also effective and it is recommended that these are adopted into farming practices. In general, measures that have both a high potential to reduce nutrient losses and are cheap to apply, and therefore have little effect on the overall profitability of farms, should be given priority in water protection policies.

Keywords: common agricultural policy, diffuse water pollution, midterm review, model farms, profitability of farms, water protection measures

INTRODUCTION

The reduction of the diffuse pollution of water bodies by agricultural activities has become a major target of European environmental policies. The Agenda 2000 midterm review is expected to revise the allocation of subsidies of farms in order to encourage farmers to adopt water protection measures. In order to better shape the agri-environmental schemes there is a need for reliable information about the costs and the benefits of water protection measures which are applicable to practical farming. As part of a larger project supported by the German Federal Environmental Agency, the effects of implementing water protection measures on profitability at the farm level are investigated in this paper. The potential of agricultural policy measures in terms of reducing nutrient field balance surpluses and the corresponding cost of these reductions, as well as the maximum density of livestock and a district level tax on mineral nitrogen, have been analysed by MÖLLER et al. (2003). The overall objective of the present investigation is to improve the quality of the water bodies in agricultural landscapes. As the quality of surface and ground waters is interrelated and interdependent, water protection measures need to focus on both types of water resources.

METHODS

Four general farm types (reference farms), which are representative of typical farming conditions in Germany, were selected (table 1). The farm sizes were chosen to provide an adequate income or wage in comparison to other possibilities under present market and price conditions. A database has been established which includes detailed information on the different farm types, such as production processes, labour and machinery requirements, costs, yields, etc. The data was mainly derived from KTBL sources and supplemented by recent surveys on input factors and product markets. A model was developed which calculates the costs and margins on a total cost farm level basis. Calculations were made with the adoption of water protection measures and these were evaluated against the reference situation without such measures. The reference situation was defined as being compatible with the rules of "Good Farming Practice".

In order to reduce the loss of nutrients into the water bodies a broad range of protection measures have been developed and their effectiveness was investigated (table 2). Some of these measures have a specific reduction potential and give rise to particular production costs.

Table 1: Reference farms

farm type	(I) extensive field crop production	(II) intensive field crop production	(III) mixed farming fattening pigs / field crops	(IV) mixed farming dairy cows / field crops
production	60 ha winter wheat, 30 ha winter barley, 22.5 ha maize for corn, 22.5 ha winter rape, 15 ha set-aside low labour requirements	35 ha winter wheat, 20 ha winter barley, 15 ha summer barley, 5 ha potatoes, 20 ha sugar beets, 5 ha set-aside labour intensive	40 ha winter wheat, 20 ha winter barley, 15 ha maize for corn, 15 ha winter rape, 10 ha set-aside	25 ha winter wheat, 12 ha winter barley, 8 ha maize for silage, 5 ha set-aside, 50 ha grassland
livestock	-	-	1,600 places (fattening pigs); 2.4 rotations y^{-1}	100 dairy cows including next generation, 6500 kg milk y^{-1}
farm size (ha)	150	100	100	100
gross margin, farm (€ y^{-1})	88,939	101,456	238,718	167,183
farm income (€ y^{-1})	52,004	60,403	137,807	98,832

Table 2: water protection measures

plant production
- catch crops/green manures - interrow green manuring - underseeding - conservation tillage (minimum/zero tillage) and direct seeding - water margin buffer strips - turning arable land into extensive grassland - increasing set-aside period (10 years instead of rotational fallow) - tax on mineral nitrogen to increase the current price by 100 and 200 % - tax on pesticides to increase the current price by 20 %
animal production
- protein and phosphorus adapted feeding - reducing the stocking rate per ha from 2.24 to 1.5 and then further to 1.0 SLUs for fattening pigs, and from 1.5 to 1.0 SLUs for dairy cows - optimisation of the storage and application of animal manure

In the present investigation it was generally assumed that the suggested water protection measures reduce nitrogen losses by between 10 and 20 kg N ha^{-1} y^{-1} compared to the reference situation. Nitrogen was chosen as the key pollutant. The water protection measures were grouped according to their specific target, i.e. plant production including tillage, or animal husbandry (table 2) and their environmental benefit evaluated.

RESULTS AND DISCUSSION

Plant production

The most important measure to reduce nutrient losses from arable land is to adapt the fertiliser strategy to the requirement of the crop and to the availability of nutrients in the soil. The maintenance of a year-round cover crop on arable land is another effective way to reduce nutrient pollution from arable land into the environment (DVGW/LAWA 1999). A cover crop ensures a continuous uptake of the available soil nutrients and thereby prevents the leaching of nutrients with percolating water in late autumn and winter. If annual crops are grown, tillage and the establishment of the new crop should preferably be done in spring rather than in autumn. A living mulch can be established by sowing catch crops/green manures, underseeding or interrow greening in row crops, e.g. maize.

A main source of phosphorus pollution in surface water resources is the water runoff and soil erosion from arable land. Consequently phosphorus pollution from arable land can effectively be reduced by employing methods that control soil erosion and water runoff. An effective measure in this respect is the adoption of conservation tillage techniques, such as zero tillage, minimum tillage and direct seeding. In addition, maintaining a year-round soil cover of living or dead mulch, introducing water margin buffer strips, and shaping the arable fields in a way which reduces surface water runoff are effective measures to control phosphorus losses. Water margin buffer strips have an additional advantage with regard to contamination of surface water with pesticides.

It was estimated that the different techniques for establishing a living mulch (catch crops/green manures, underseeding, interrow greening) have the potential to reduce nitrogen losses from arable land into surface and ground water by, on average, 20 kg ha^{-1} y^{-1}. The related costs at farm level when adopting such techniques amount to between less than 1 % to about 4% of the total farm income (table 3), depending on the farm type. In order to calculate specific costs of water protection measures the costs of each measure were set against the potential reduction of nitrogen losses. The costs of plant production measures to reduce nitrogen losses range from 2.25 to 3.75 € kg^{-1} of avoided nitrogen loss or nitrogen saved. On an area basis, the costs range from 44 to 75 € ha^{-1} y^{-1}.The reason for the increased costs are that additional costs are incurred with the adoption of water protection measures, such as costs for seed, additional labour, and new technical equipment.

A particular advantage of the ten year fallow is the comparatively low costs in contrast to the rotational fallow - almost no management costs arise. Thus, an economic gain of up to 7.60 € kg^{-1} of nitrogen saved can be achieved (table 3). On the other hand, if the land has previously been used to produce cash crops, such as cereals or oil seed, these costs may amount to 2.25 € kg^{-1} nitrogen saved. These costs are similar to those that have been calculated for measures which maintain a cover of living mulch over the soil. Costs will even exceed this amount if the yields of the cash crops go down as a result of employing water protection measures. For direct drilling of sugar beet in a conservation tillage system it has been calculated that avoiding one kg of nitrogen loss per ha will cost 13 €, i.e. it is an expensive protection measure. The reason for this is that yield losses of 5% with an average sugar beet yield of 700 dt ha^{-1} may occur with conservation tillage practices. For other cash crops the situation is different as with conservation tillage the yields are not necessarily reduced and the farm income may even be increased as the production costs are lower than those for conventional tillage (see farm type I, table 3). The establishment and maintenance of water margin buffer strips is comparatively expensive (initially 95 € ha^{-1} and then 8.80 € kg^{-1} of nitrogen saved per ha) due to the additional costs for seed and the smaller size of the area to be sown. If a cash crop, e.g. winter barley, is replaced by a buffer strip the costs increase to up to 650 € ha^{-1} and more than 60 € kg^{-1} of saved nitrogen per ha, as no saleable product is produced.

The range of costs incurred when converting arable land into extensively managed grassland depends on the subsequent use of the land (e.g. fattening of bulls on pasture, suckler cow husbandry, fodder production for dairy farms) and the replaced crop. Assuming that 10 kg N ha^{-1} is saved, fattening of bulls leads to costs of 0.5 to 18 € kg N^{-1}, while for suckler cows higher costs are to be expected (46 to 64 € kg N^{-1} ha^{-1}). When the grassland is used for dairy production (farm type IV) the cultivation area for maize is reduced which incurs costs of 42.8 € kg N^{-1} ha^{-1}; table 3).

Tax on mineral nitrogen

In order to make the use of mineral fertilisers in practical farming more efficient and to reduce the overall application of fertilisers the introduction of a tax on nitrogen fertiliser has been suggested. In the present investigation it was assumed that a tax will raise the current prices for fertiliser nitrogen by 100 or 200 %. The tax revenues will be returned to farmers through a federal wide, direct payment per hectare of agricultural area. Increasing nitrogen prices will reduce farm income for farm types I but will have a positive effect on farm types II, III and IV (table 4).

With a tax on mineral nitrogen, cash-crop farms, because of their high proportion of costs for purchased mineral fertilisers, are discriminated against animal husbandry farms which often have high amounts of nutrients from animal manure.

Tax on pesticides

FISCHER (1996) has shown that the discharge of pesticides into surface water takes place primarily via sewage plants with contaminated sewage (e.g. from cleaning sprayers). A tax on pesticides could contribute to a reduction of both point source discharges and to a decrease in the intensity of area-wide applications of pesticides. In this scenario, a 20 % tax on the price of pesticides is levied. The revenue from the tax should be invested into training and consultancy services for farmers in order to further reduce the improper use of pesticides and any related point pollution (keeping proper distances, disposal of surpluses of spraying solutions and cleaning equipment in a way to protect the water). The calculations show that the tax, especially for farm type I, leads to a decrease in farm income by up to 10 % and that the farms which maintain livestock (farm types III and IV) are only slightly effected by such a tax (table 5). As is the case with the tax on mineral fertilisers, the cash-crop farms who manage according to the Code of Good Practice are discriminated against with this tax.

Table 3: Effects of employing crop-related water protection measures on farm income for the different farm types in comparison to the reference farm

	(I) extensive field crop production	(II) intensive field crop production	(III) mixed farming fattening pigs / field crops	(IV) mixed farming dairy cows / field crops
cash crops/green manuring				
farm income (%)	-2.7	-4.1	-0.7	-1.0
costs (€ kg N^{-1} ha^{-1})	-3.75	-3.75	-3.75	-3.75
underseeding maize				
farm income (%)	-1.8	-	-0.4	-0.7
costs (€ kg N^{-1} ha^{-1})	-2.20	-	-2.20	-2.20
interrow greening of maize				
farm income (%)	-1.2	-	-0.3	-0.5
costs (€ kg N^{-1} ha^{-1})	-2.79	-	-2.79	-2.79
direct seeding of sugar beets				
farm income (%)	-	-8.8	-	-
costs (€ kg N^{-1} ha^{-1})	-	-12.98	-	-
conservation tillage				
farm income (%)	-25.3 to +2.4	-8.7	-6.8	-5.0
costs (€ kg N^{-1} ha^{-1})	+0.85 to -8.77	-5.23	-9.38	-9.81
water margin buffer strips				
costs (€ ha^{-1} $y^{-1)}$	95 to 651	95 to 651	95 to 651	95 to 651
costs (€ kg N^{-1} ha^{-1})	-8.80 to -60.28	-8.80 to -60.28	-8.80 to -60.28	-8.80 to -60.28
turning arable land into extensive grassland				
farm income (%)	-6.7 to -0.1	-4.0 to -0.2	-2.3 to -0.7	-1.1
costs (€ kg N^{-1} ha^{-1})	-46.44 to -0.50	-47.92 to -2.0	-64.18 to -18.24	-42.84
set-aside (10 years instead of rotational fallow)				
farm income (%)	+2.2	-0.4	+0.6	+0.4
costs (€ kg N^{-1} ha^{-1})	7.59	-2.25	7.59	7.59

Table 4: Effects of a tax on mineral nitrogen (100 and 200 % on the current price) on the farm income (in percentages) in relation to the reference farm

	(I) extensive field crop production	(II) intensive field crop production	(III) mixed farming fattening pigs / field crops	(IV) mixed farming dairy cows / field crops
N-tax 100 % with reimbursement of 55.5 € ha^{-1}	-6.9	+3.0	+2.4	+4.5
N-tax 200 % with reimbursement of 83.4 € ha^{-1}	-21.8	+1.4	+2.9	+6.1

Table 5: Effects of a tax on pesticides (20 % of the current price) on the farm income in relation to the reference farm

	(I) extensive field crop production	(II) intensive field crop production	(III) mixed farming fattening pigs / field crops	(IV) mixed farming dairy cows / field crops
farm income (%)	-9.7	-5.2	-2.0	-1.5

Animal production

Feeding according to nutrient requirements

The provision of protein which is adapted to the requirements of cattle, pigs and poultry is one of the major measures which reduce the emission of nutrients from animal production. With a consistent implementation of an adapted protein feeding regime, especially in pig and poultry fattening and pig production, the level of nitrogen excreted is decreased and therefore the nitrogen content in manure is reduced. Additionally lower costs for feeding are incurred. The decrease in excreted N by adapting feeding to animal requirements varies according to animal species, development stage and the initial situation between 5 and 20 % on average and reductions up to 40 % are possible (DÖHLER et al. 2002a). The decrease is determined by how frequently the feeding is adapted to the N requirement during the fattening period (two, three, multi-phased feeding) and the proportion of amino acids added. The costs of the necessary equipment, for example computer controlled distribution and mixing technology, can be offset by savings in feed costs through the reduced use of protein compounds. When an amount of nitrogen of 9.4 kg ha^{-1} y^{-1} is saved due to a reduced level of N in the manure, the costs for the nitrogen decrease are 4.97 € kg N^{-1} ha^{-1}. With the reduction of feeding costs an increase in the farm income of up to 11.5 % can be achieved (table 6).

Table 6: Effects of a protein reduced feeding of fattening pigs on labour requirements, farm income and costs for avoiding nitrogen losses

farm type	(III) mixed farming fattening pigs / field crops
changes in labour requirements	small
farm income (%)	-3.4 to +11.5
saved nitrogen kg ha^{-1} y^{-1}	9.4
€ kg^{-1} y^{-1} avoided N loss	-4.97 to +16.6

The phosphorus excreted during pig and poultry production can also be clearly reduced - up to 40 % - by the use of phytase, adapting the composition of the diet to requirements and phased feeding.

Reduction of stocking rates

A reduction in the amount of animal manure used is possible through a stronger binding of animal husbandry to area, i.e. by the introduction of maximum permitted stocking rates for all livestock which is related to the total agricultural area. This measure aims to increase the efficiency of the use of animal manure and reduce surface balance surpluses.

Table 7 shows the effects of reduced stocking rates on farm income and the nitrogen supply in manure on animal husbandry farms. With a reduction in the N-supply from animal husbandry, a lower loss of income occurs for farm type IV (dairy cows - 8.3 € kg N^{1} ha^{-1}) than for farm type III (fattening pigs - 16.6 and 17.3 € reduced kg N^{-1} ha^{-1}).

Optimisation of the storage and application of animal manure

Ammonia emissions from animal production can be reduced by measures which optimise the storage and application of animal manure. Losses during storage can be reduced, for example, by covering the slurry storage tank. Application technology should comply with generally recognised engineering rules, ensure that appropriate amounts are applied with a low level of losses. When applying animal manure, ammonia emissions are to be avoided as much as possible by applying the slurry close to the ground. The state of the vegetation and the weather conditions, especially temperature and solar radiation, should be taken into account. When applying to bare ground, slurry should be immediately worked-in, i.e. within about 1 hour. Consequently a reduction in emissions of up to 90 % is achievable (DÖHLER et al. 2002b). The immediate working-in can be accomplished either with a second vehicle or in a combined operation when the slurry is applied. For crops on arable land the use of trailing hoses is recommended, and, on grassland, trailing shoes. The advantage of the use of this equipment is that it deposits the slurry directly on the ground and the slurry is better protected from solar radiation and wind - both of which increase emissions. This results in more nitrogen being available to the plants.

Table 7: Effects of reduced stocking rates on farm income and the nitrogen content of excrements on mixed farms (fattening pigs and dairy farms)

	stocking rate (SLU ha^{-1} of agricultural area)		
	(Reference) 2.24	**1.5**	**1**
(III) mixed farming fattening pigs / field crops			
farm income (€ y^{-1})	137807	82882	44769
farm income, relative (%)	100	60.1	32.5
reducing farm income (€ ha^{-1})		549.3	381.1
(€ reduced SLU^{-1} ha^{-1})		742	762
N in animal manure (kg ha^{-1})	102	68	45
(IV) mixed farming dairy cows / field crops			
farm income (€ y^{-1})		98832	64000
farm income, relative (%)		100	64.8
reducing farm income (€ ha^{-1})			348.3
(€ reduced SLU^{-1} ha^{-1})			697
N in animal manure (kg ha^{-1})		172	120

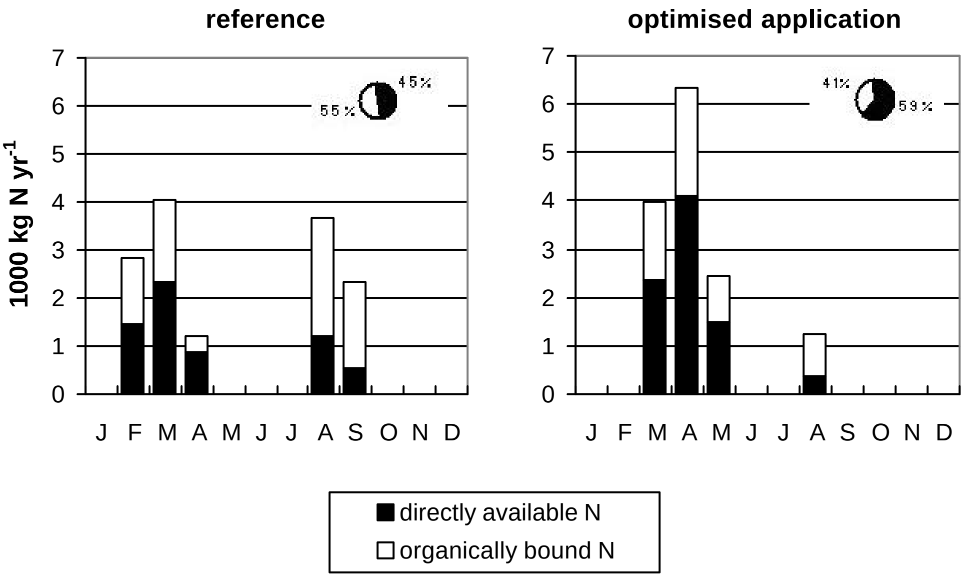

Figure 1: Optimisation of the application of slurry - trailing hose and trailing shoe instead of broad casting

To reduce ammonia emissions the Code of Good Practice requires a storage period of 6 months for pig producing farms and a minimum of 4 months for grassland farms (dairy production). With the shift of the application of some slurry from summer/autumn to the following spring the required storage period is increased for both type of farms to about 8 months.

CONCLUSIONS

Water protection measures need to be evaluated in terms of their potential to reduce nutrient losses and the costs incurred when implemented in crop and animal husbandry. Measures with low costs which also have a high potential to reduce the efflux of nutrients are particularly promising and will be more acceptable to farmers in practice. With regard to the environmental and the economic impact of a range of water protection measures the following conclusions can be drawn.

Optimisation of the storage and handling of animal manure, the implementation of nitrogen and phosphorus adapted feeding regimes and the introduction of living mulch systems in arable farming are effective and affordable measures. Within set-aside programmes for arable land priority should be given to permanent fallow rather than rotational fallow. Turning arable land into extensively managed grassland and introducing water margin buffer strips are highly effective measures to reduce nutrient and pesticide effluents into the water bodies, however they are relatively expensive and therefore difficult to achieve in farming practice. The introduction of taxes on fertilisers and pesticides is not considered suitable as it effects different farm types differently.

REFERENCES

DÖHLER, H.; DÄMMGEN, U.; EURICH-MENDEN, B.; OSTERBURG, B.; LÜTTICH, M.; BERG, W.; BERGSCHMIDT, A.; BRUNSCH, R. (2002a): Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationale Richtlinien sowie Erfassung und Prognose der Ammoniak-Emissionen der deutschen Landwirtschaft und Szenarien zu deren Minderung bis zum Jahre 2010. UBA-Texte 05/02

DÖHLER, H; MENZI, H.; SCHWAB, M. (2002b): Emissionen bei der Ausbringung von Fest- und Flüssigmist und Minderungsmaßnahmen. In: KTBL (Hrsg.): Emissionen der Tierhaltung Grundlagen, Wirkungen, Minderungsmaßnahmen. KTBL Schrift 406, Darmstadt, p. 163-178

DVGW/LAWA (1999): Gewässerschützende Landbewirtschaftung in Wassergewinnungsgebieten. Vergleichende Darstellung und Bewertung der Vorgehensweisen und von Fallbeispielen in der Bundesrepublik Deutschland. Abschlussbericht.

FISCHER, P. (1996): Quantifizierung der Eintragspfade für Pflanzenschutzmittel in Fließgewässer. In: Boden und Landschaft, Schriftenreihe zur Bodenkunde, Landeskultur und Landschaftsökologie. Band 12, 166 p.

MÖLLER, C.; KREINS, P.; GÖMANN, H. (2003): Impact and cost efficiency of alternative policy measures to reduce diffuse pollution caused by agriculture. This volume.