SLURRY SEPARATION COULD ALLOW A WIDER USE OF MANURE WITHIN THE EU NITRATES DIRECTIVE

Schröder J.J., Verloop J.
Agrosystems Research, Plant Research International, Wageningen University and Research Centre, P.O. Box 616, 6700 AP, Wageningen, The Netherlands. Tel: +31 317 480 578. jaap.schroder@wur.nl

1 INTRODUCTION

Intensive livestock farms in Europe import feedstuffs including the nitrogen (N) and phosphorus (P) that these feeds contain. This results in local nutrient surpluses because home-grown crops take up less N and P than available in the manure. The European Commission forces member countries to address the environmental consequences in Action Programmes (AP). AP's have set limits to manure application rates and confronted intensive livestock farmers with costs to export manure, mainly to better balance P inputs and outputs, and costs of additional mineral fertilizer N to compensate for the concomitant export of N in that manure. This stimulates measures to increase the amount of available N per unit applied manure P. Slurry separation may help to achieve this goal (Oh et al., 2005).

Separation results in a solid fraction (SF) and a liquid fraction (LF). The SF, rich in P, is less bulky and can be exported at lower costs to arable farms as a substitute for mineral fertilizer P (Schröder et al., 2009b). The widened N (largely ammonia-N) to P ratio of the remaining LF matches better with the requirements of forage crops. Livestock farms could thus substitute LFs for mineral fertilizer N, depending on the quality of the separation process. The lower organic N to total N ratio in the LF can contribute to a better synchronisation between N supply and demand, provided that the LF is injected and applied within the growing season. This, in combination with the lower P to total N ratio of the LF, could spare the environment and thus help to underpin requests to deviate from the standard threshold of 170 kg manure-N per ha ('derogations'), as required by the EU Commission in Nitrate Vulnerable Zones (NVZs; Anonymous, 1991). The present paper explores the effects of slurry separation on the room for manure use on livestock farms.

2 MATERIALS AND METHODS

Explorations were carried out by means of a simple grassland / maize land N leaching model. The structure, validation and parameter setting of the model are described in Schröder et al. (2007, 2009a, 2010). The model defines the N input to a field as the sum of manure-N (including N excreted during grazing), mineral fertilizer N, deposition of atmospheric N, and N mineralized from soil organic matter. The corresponding nitrate leaching to the upper groundwater is derived from the soil N surplus. This surplus is calculated as the difference between the inputs and the sum of crop N which is removed by grazing (grassland) and cuttings (grassland, silage maize), N investments in crop residues, N stored in the organic N fraction of manure (in as far as this N is not mineralized in the first year after application), and volatilized ammonia-N. The crop N output is determined by i) the fertilizer equivalency i.e. the availability to plants of N from various sources relative to mineral fertilizer N, ii) the uptake efficiency i.e. the fraction of the available N taken up by the crop whilst accounting for the reduction in uptake efficiency at higher input levels and iii) the harvest efficiency. The model converts soil N surpluses into nitrate concentrations by means of crop and soil specific leaching factors which are derived from a national monitoring program (Fraters et al., 2008). The P surplus is defined as the difference between the P in excreted or applied manure-P (deduced from the manure-N rate and the P to N ratios in manure) and the P removed by either grazing animals or cuttings (calculated as the product of crop N output and typical P to N ratios of crops). We subsequently used the MS Excel ™ Solver Tool to determine which combinations of manure N and fertilizer N would maximize the harvestable yield under the constraints that i) the N concentration in groundwater is at most 11.3 mg nitrate-N per litre, and ii) the P surplus is 0 kg per ha i.e. soil P pools are depleted nor augmented.

The focus of our study is on cattle slurry from dairy farms on sandy soils for which we defined scenario's differing in the extent to which the composition of manure had been changed by slurry separation. For the sake of simplicity we assumed that P was fully associated with solids. Hence, any P and organic N in the LF points at an imperfect separation which is not uncommon as the efficiency of separation (i.e. the fraction of the ingoing solids recovered in the SF) will generally range between values of 20-60% (Schröder et al., 2009b) if the separation is not followed by ultra filtration (UF) and reversed osmosis (RO). Our scenario's hence correspond with separation efficiencies up to 60%. The compositions of the resultant LFs are listed in Table 1, whilst assuming that the SF has a dry matter content of 25%.

As similar soil N surpluses result in approximately 2 times higher nitrate concentrations on dry sandy soils than on wet sandy soils, and 1.5 times higher nitrate concentrations on maize land than on grassland (Schröder et al., 2009a), we ran our scenario's for both soil types and for dairy farms in which up to one third of the grassland area was devoted to silage maize instead of grassland. We also explored the consequences of grazing, as slurry separation will have a smaller impact on the room for manure application if grassland is harvested via grazing. This is due to the fact that there is less manure to be separated in the first place and, secondly, because urine and dung excreted during grazing are exposed to greater losses than collected manures (Vellinga et al., 2001). We explored this effect by assuming that in farms with a mixed use of cutting and grazing, one third of the grassland is harvested via grazing and 65 kg N per ha per year is excreted outdoors (Aarts et al., 2008). To explore the potential of slurry separation for livestock farms that only grow maize, we also included scenario's with farms without grassland, using untreated slurry or LFs from either cattle or pig slurries (Table 1).

TABLE 1 **Explored scenario's in terms of the composition of the liquid fraction resulting from different slurry P separation efficiencies, assuming a dry matter content of 25% in the solid fraction (N / P_2O_5 ratio's of untreated slurries based on Van Dijk, 2003)**

Slurry type	P-separation efficiency (%)	N / P_2O_5	Ammonia N / total N
Cattle slurry	0	2.75	0.50
	33	3.25	0.58
	50	3.75	0.63
	60	4.25	0.68
Pig slurry	0	1.71	0.58
	33	2.07	0.65
	50	2.42	0.70
	60	2.77	0.74

3 RESULTS AND DISCUSSION

Without slurry separation, grasslands on Dutch dairy farms can, on average, utilize 375 kg total N per ha per year on dry sandy soils with a mixed use of cutting and grazing and 500 kg total N per ha per year on wet sandy soil with a 'cutting only' regime, without exceeding a target value of 11.3 mg nitrate-N per litre or accumulating P. The use of LFs would increase these permissible rates by another 20 kg N per ha, and, more interestingly, would enable dairy farmers to cover this demand to a much greater extent with manure instead of mineral fertilizer N (Figure 1). Substitution of maize for grassland, common on sandy soils, reduces the room for manure applications (Figure 2), because P uptake of maize is lower and N leaching per kg N applied is higher than on grassland. Even then, justifiable manure rates are higher than the 170 kg manure-N per ha stipulated by the EU Nitrates Directive in NVZs, which is even more so if LFs would be used. If, however, maize would be the sole crop grown, much lower rates than 170 kg manure-N per ha should be permitted to avoid accumulation of P. Rates higher than that, would only be justified with LFs from cattle slurry, not with LFs from pig slurry (Figure 3).

Our explorations indicate that manure application thresholds in NVZs should be differentiated for soil type, crop type, harvest regime and the composition of manure. Separation enables the users of LF to save on expenses for slurry export and mineral fertilizer N. Arable farmers using the SFs, obviously, receive less N per unit P than when they would have used untreated slurries. On heavier soil types, however, manures are preferentially applied to cereal stubbles, so that the N utilization by subsequent crops is low anyhow. Replacing slurries with SFs will therefore hardly affect the overall use of mineral fertilizer N on these arable farms. Energy consumption of separation techniques without UF and RO are sufficiently low to be fully compensated by the savings on energy use for fertilizer N production and slurry transport (Schröder et al., 2009b).

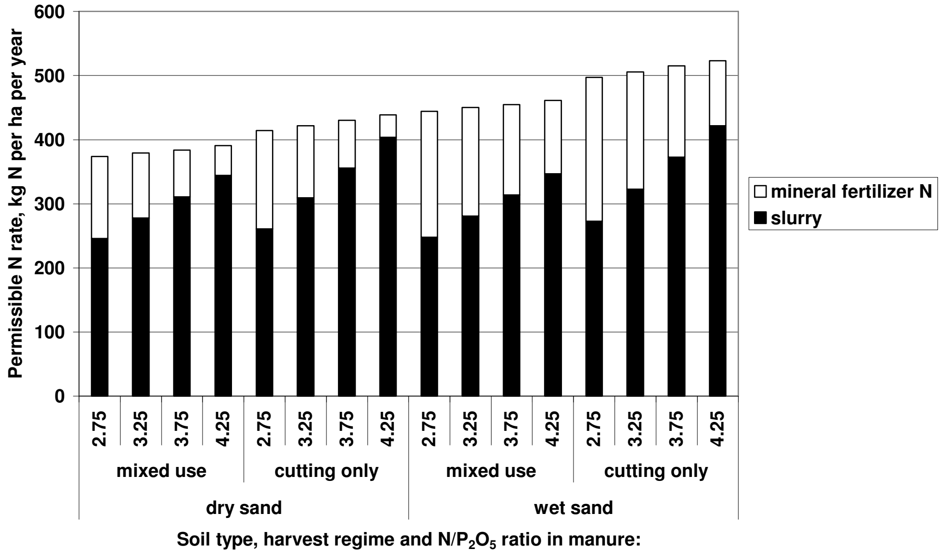

FIGURE 1 **Simulated cattle slurry and mineral fertilizer rates associated with a N concentration of 11.3 mg nitrate-N per litre upper groundwater and a phosphorus surplus of 0 kg P per ha**, as affected by the soil type, the harvest regime of grassland and slurry separation (reflected in N to P_2O_5 ratio's), on dairy farms growing grass only (under average growing conditions, average management quality and average leaching risks, *cf.* Schröder et al., 2009a).

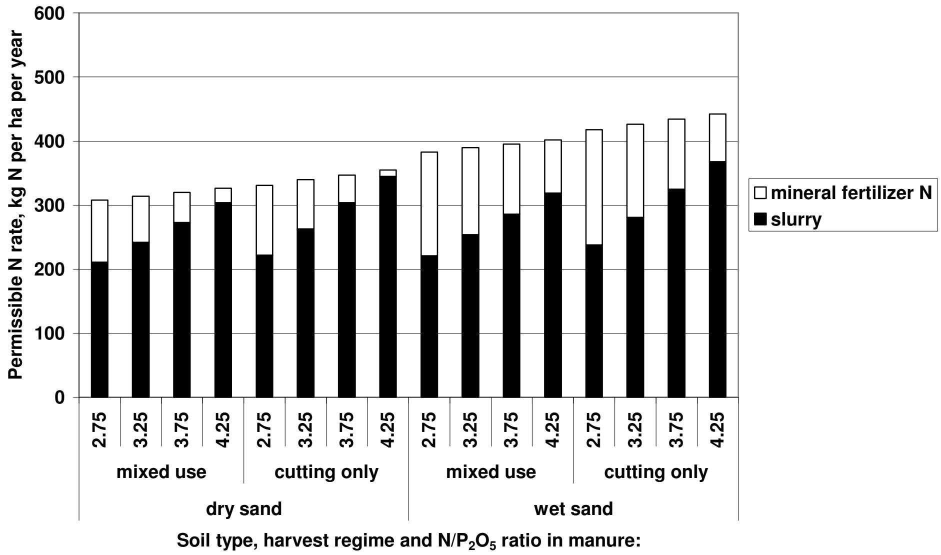

FIGURE 2 **Simulated cattle slurry and mineral fertilizer rates associated with a N concentration of 11.3 mg nitrate-N per litre upper groundwater and a phosphorus surplus of 0 kg P per ha,** as affected by the soil type, the harvest regime of grassland and slurry separation (reflected in N to P_2O_5 ratio's), on dairy farms growing grass and silage maize in a 66.6 to 33.3 ratio (under average growing conditions, average management quality and average leaching risks, *cf.* Schröder et al., 2009a).

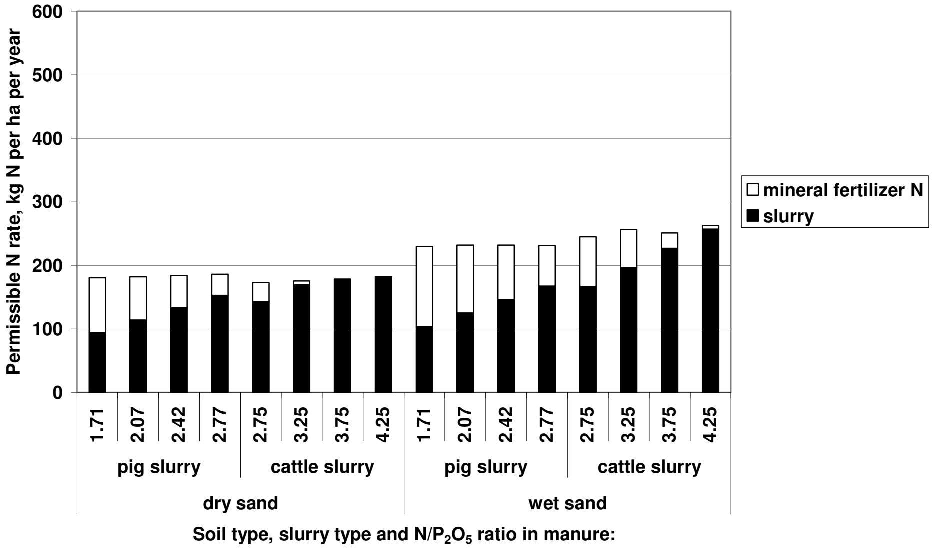

FIGURE 3 **Simulated slurry and mineral fertilizer rates associated with a N concentration of 11.3 mg nitrate-N per litre upper groundwater and a phosphorus surplus of at most 0 kg P per ha**, as affected by the soil type, the slurry type and slurry separation (reflected in N to P_2O_5 ratio's), on farms growing silage maize only (under average growing conditions, average management quality and average leaching risks, *cf.* Schröder et al., 2009a).

4 CONCLUSIONS

The lower N to P ratio in liquid fractions resulting from slurry separation, can justify a much wider use of manure on dairy farms in NVZs, than the current EU threshold of 170 kg N per ha. Separation may help to save mineral fertilizer N and P as well as transport energy within the agricultural sector as a whole.

REFERENCES

Aarts HFM, Daatselaar CHG, Holshof G 2008. Bemesting, mestofbenutting en opbrengst van productiegrasland en snijmaïs op melkveebedrijven (In Dutch). Rapport 208, Plant Research International, Wageningen, 49 pp.

Anonymous 1991. Directive of the Council of December 12, 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC). European Commission, Brussels, 8 pp.

Fraters B, Boumans LJM, Van Leeuwen TC, Reijs JW 2007. De uitspoeling van het stikstofoverschot naar grond- en oppervlaktewater op landbouwbedrijven (in Dutch). RIVM Rapport 680716002/2007, RIVM, Bilthoven, The Netherlands, 83 pp.

Oh I, Burns RT, Moody LB, Lee J 2005. Optimization of phosphorus partitioning in dairy manure using chemical additives wih a mechanical solids separator. Transactions American Society of Agricultural Engeneers 48 (3), 1235-1240.

Schröder JJ, Aarts HFM, Van Middelkoop JC, De Haan MHA, Schils RLM, Velthof GL, Fraters B, Willems WJ 2007. Permissible manure and fertilizer use in dairy farming systems on sandy soils in The Netherlands to comply with the Nitrates Directive target. European Journal of Agronomy 27, 102-114.

Schröder JJ, Aarts HFM, Van Middelkoop JC, Velthof GL, Reijs JW, Fraters B 2009a. *Nitrates Directive requires limited inputs of manure and mineral fertilizer in dairy farming systems*. Report 222. Plant Research International, Wageningen, The Netherlands, 37 pp.

Schröder JJ, De Buisonjé F, Kasper G, Verdoes N, Verloop J 2009b. Mestscheiding: relaties tussen techniek, kosten, milieu en landbouwkundige waarde. Rapport 287 (In Dutch), Plant Research International, Wageningen, 36 pp.

Schröder JJ, Aarts HFM, Verloop J 2010. Model-based estimates of combinations of cattle slurry and mineral fertilizer nitrogen in view of water quality requirements. Tearmann 7 (in press)

Van Dijk W 2003. Adviesbasis voor de bemesting van akkerbouw- en vollegrondsgroentengewassen (In Dutch). PPO-publicatie nr. 307, Praktijkonderzoek Plant & Omgeving, Lelystad, 66 pp.

Vellinga ThV, Van der Putten AHJ, Mooij M 2001. Modelling grassland management and nitrate leaching. Netherlands Journal of Agricultural Science 49: 229-253.