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Managing phosphorus cycling in agriculture

Tentative results from innovation studies in a nutshell

Oscar Schoumans, Oene Oenema, Phillip Ehlert, Marinus van Krimpen, Geert van der Peet, Maikel Timmerman, Nico Verdoes, Koen Meesters, Johan Sanders, Wim Rulkens, Alex Bikker, Harry Kortstee and Jaap Schröder

Introduction

For more than one century, the annual import of phosphate into agriculture via fertilizers and feed has exceeded the annual export of phosphate via crop and animal products in the Netherlands (Table 1). The surplus has resulted in a relatively high mean soil P status and will result also in a 'manure surplus' of about 60 million kg P_2O_5 by 2015.

Table 1 Phosphate balance of the Dutch agriculture in million kg P_2O_5 over the period 1970-2005 (source: CBS)

IN	1970	1986	1995	2000	2005	Out	1970	1986	1995	2000	2005
Concentrated feed	87	179	185	158	135	Animal products	37	60	53	53	66
Feed	48	37	16	11	16	Plant products	23	34	62	89	55
Roughage	2	5	7	7	7	Manure products	-	0	11	14	16
Fertilizer	108	85	62	62	48						
Others	9	11	14	11	14						
						phosphate surplus	195	222	158	94	82
Total	254	316	284	250	220	Total	254	316	284	250	220

Here, we report on possible options to drastically decrease the manure surplus (which basically is a phosphate surplus).

Method

For more than one century, the annual import of phosphate into agriculture via fertilizers and feed has exceeded the annual export of phosphate via crop and animal products in the Netherlands (Table 1). The surplus has resulted in a relatively high mean soil P status and will result also in a 'manure surplus' of about 60 million kg P_2O_5 by 2015.

Results

Figure 1 shows the possible options, together with estimates of the resulting decrease of the phosphate surplus

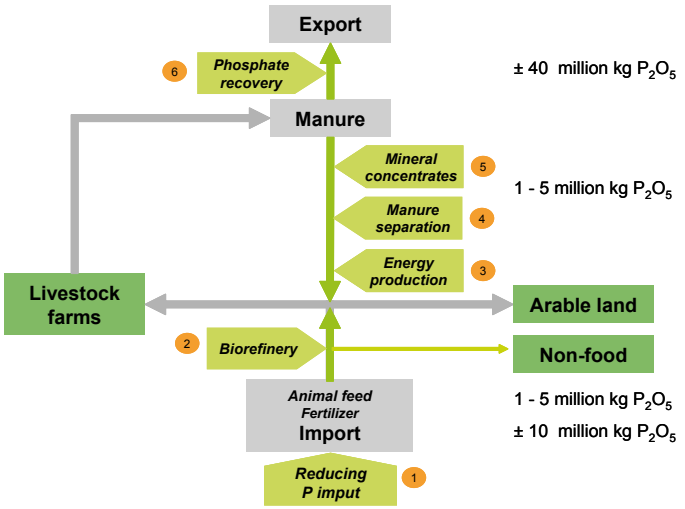

Figure 1 Identification of options to decrease the phosphate surplus, expressed in million kg P_2O_5 per year.

1 P in feed

Phosphorus requirements of livestock vary with animal category. Technically, a further reduction of the P-content of animal feed by 20% is possible at the short term. Reducing the P-content in feed with 20% would reduce the total amount of manure by about 9 million kg of phosphate and will only have a limited impact on the cost of feed.

2. Bio-refinery

Bio-refinery can further optimize the feed-manure-cycle. It allows a better management of the feed, by increasing the amount of easily digestible phosphorus relative to the total amount of phosphorus. It is expected that the total phosphate input into agriculture can be decreased by 1-5 million kg per year. If the removal of phosphorus through bio-refinery is combined with the extraction of other compounds from imported resources for feed, the impact on the price of feed will be limited.

3. Bio-energy

Producing energy from manure through anaerobic digestion does not change the phosphate balance. However, the surplus heat from biogas plants could be used to dry the manure to enhance the export of manure, or to incinerate it for energy production. Pretreatment technologies can enhance the biogas production from manure.

4. Manure separation

Separation techniques can separate the slurry into a liquid fraction and a solid fraction. The solid fraction, rich in P, is less bulky and can be exported at lower costs to arable farmers. The widened N (largely ammonia-N) to P ratio of the remaining liquid fraction matches better with the requirements of forage crops. It is expected that even simple separation techniques can reduce the manure surplus by 1-5 million kg phosphate per year and the cost will be less than 5 € per m^3 manure.

5. Mineral concentrates

By combining manure separation followed by ultra-filtration and reversed osmosis of the liquid fraction, so-called mineral concentrates can be produced. These concentrates may become an alternative for conventional mineral nitrogen and potash fertilizers.

6. Phosphate recovery

Via recovery of phosphate from animal manure as phosphate fertilizer, biochar and elementary phosphorus, the phosphate surplus can further be decreased by about 40 million kg phosphate per year. The net cost range from 23 to 30 € per m^3 pig slurry.

Conclusions

The exploratory studies indicate that the phosphate surplus can decrease by some 60 million kg phosphate through a combination of measures. Some of these measures can be implemented rather easily in the short term, whereas others require significant investments and institutional arrangements. The cheaper options, such as reduction P content in feed and manure separation, can be regarded as 'low-hanging fruit' and should obviously be exploited first.

Information
Project team: Oscar Schoumans, Oene Oenema, and Phillip Ehlert (Alterra), Marinus van Krimpen, Geert van der Peet, Maikel Timmerman, Nico Verdoes (ASG), Koen Meesters (FBR), Johan Sanders (VPP), Wim Rulkens (adv.), Alex Bikker, Harry Kortstee, (LEI) Jaap Schröder (PRI)
Email: Oscar.Schoumans@wur.nl
Website: http://www.mestverwerken.wur.nl

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