RATE OF APPLICATION MANURE ON GRASSLAND

DR IR CH.H. HENKENS

Consulentschap voor Bodemaangelegenheden in de Landbouw, Wageningen (The Netherlands)

In the past in agricultural enterprises animals were fed farm made products. In such enterprises manure was considered a valuable and scarce expedient to maintain soil fertility. This might be evident from the fact that in some leases it was not allowed to sell manure. Keeping a lot of animals was only possible on farms with large acreages in those days.

Nowadays agriculture has to struggle continously for a sufficient income per worker which makes an increase in size of the enterprice necessary. On grassland farms first of all it is tried to intensify exploitation. On farms with a small acreage, however, this doesn't give enough scope to garantee sufficient income. Therefore, it is tried to increase the size of the enterprise by activities not dependent on soil, such as keeping housed stock.

For keeping animals farmers now no longer depend on home produced feedstuffs. So larger concentrations of live stock can be kept on small acreages. In this situation manure presents a problem, which should be solved in the cheapest way possible as it is no longer an expedient which can be used on the own farm. To keep the cost of transport low it would be convenient to have sufficient arable land available in the areas with animal concentrations. In many countries however, the small holdings are concentrated in certain areas, so transporting manure over longer distances will be necessary.

In this connection the question arises what quantity of manure can be used per ha grassland or cropland.
The answer to this question will differ according to the criteria used: plant growth, animal health or environment. If quantities of manure are applied, which are harmfull to plant growth or animal health the term "manuring" should not be used for this activity. Quantics acceptable in terms of plant growth or animal health are not necessarily acceptable for enviroment.

CRITERION: PLANT/ANIMAL

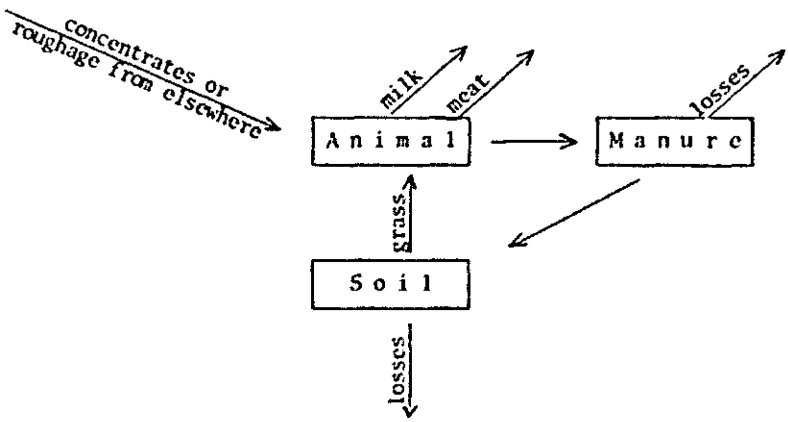
When dressing with a view to plant growth or animal health, a direct positive effect of the application is aimed at. The first question is than always "how little suffices to obtain maximum yield". The aim of dressing is than to annul nutrient shortages in order to obtain maximum yields. It is obvious that the farmer would like to apply maximum permissible amounts if he has to dispose of a lot of manure. On arable land the permissible amount is determined by plant growth and on grassland by animal health, because grass growth is not affected so quickly.

High applications of potassium will increase herbage potassium to a level higher than needed for yield, and decrease magnesium and calcium. This might lead to an insufficient supply of magnesium and/or calcium, especially so if herbage nitrogen is high.
Although deficiencies in magnesium and calcium can be prevented by supplying salts to the animals it is obvious that potassium supply should be taken as a standard for the application of manure on grassland.
The supply should not be based on potassium requirement of grassland, which depends on the potassium level of the soil. Otherwise on soils with a high potassium level only small amounts of manure could be applied, despite the fact that the potassium contained in the manure for the biggest part comes from the own farm. In my opinion it is better, therefore, to start from the potassium export from the soil as a criterion.

The amounts of plant nutrients, which are removed from a grassland farm are rather small. The minerals in the herbage consumed are for the greater part returned in the manure.

During the grazing season they are unevenly deposited on the grassland; during the housed winter period they are collected in the manure. As long as this manure is used on the grassland, there is a recycling of nutrients within the boundaries of the farm. During storage and transport losses may occur however The losses during storage depend mainly on the construction of the storage basins.

Part of the minerals taken up by the animal are excreted in the milk or stored in meat (calf or growth). These minerals are withdrawn from the cycle. The cycling of mineral nutrients may be summarised as follows.



From this scheme it follows that a farm which does not use concentrates or roughage from elsewhere has to apply fertilizers to maintain the nutrient status of the soil. Concentrates can be looked upon as a sort of fertilizer.

Apart from its export in milk and meat potassium disappears from the soil by leaching. Based on a relatively small number of drainage water analyses from grassland leaching on clay grassland can be estimated at 11 kg K (13 kg K_2O)

Table 1. Removal of potassium in kg K ha^{-1} year^{-1} on grassland by milk and meat at different numbers of milking cows per hectare and different milk production per cow

Number of milking cows per ha	Milk production milking cow^{-1} year^{-1}								
	4500 kg			5000 kg			6000 kg		
	Removal of potassium kg K ha^{-1} year^{-1}			Removal of potassium kg K ha^{-1} year^{-1}			Removal of potassium kg K ha^{-1} year^{-1}		
	by milk	by calves	total	by milk	by calves	total	by milk	by calves	total
2.00	13.50	0.16	14	15.00	0.16	15	18.00	0.16	18
2.25	15.18	0.18	15	16.87	0.18	17	20.25	0.18	20
2.50	16.87	0.20	17	18.75	0.20	19	22.50	0.20	23
2.75	18.56	0.22	19	20.62	0.22	21	24.75	0.22	25
3.00	20.25	0.24	21	22.50	0.24	23	27.00	0.24	27
3.25	21.94	0.26	22	24.37	0.26	25	29.25	0.26	30

Table 2. Removal of potassium in kg K ha^{-1} year^{-1} by animal production and leaching on grassland

Number of milking cows per ha	Milk production milking cow^{-1} year^{-1}																	
	4500 kg						5000 kg						6000 kg					
	Removal of potassium kg K ha^{-1} year-1						Removal of potassium kg K ha^{-1} year^{-1}						Removal of potassium kg K ha^{-1} year^{-1}					
	Clay soil			Sandy soil			Clay soil			Sandy soil			Clay soil			Sandy soil		
	by animal	by leaching	total	by animal	by leaching	total	by animal	by leaching	total	by animal	by leaching	total	by animal	by leaching	total	by animal	by leaching	total
2.00	14	6	20	14	52	66	15	6	21	15	52	67	18	6	24	18	52	70
2.25	15	6	21	15	52	67	17	6	23	17	52	69	20	6	26	20	52	72
2.50	17	6	23	17	52	69	19	6	25	19	52	71	23	6	29	23	52	75
2.75	19	6	25	19	52	71	21	6	27	21	52	73	25	6	31	25	52	77
3.00	21	6	27	21	52	73	23	6	29	23	52	75	27	6	33	27	52	79
3.25	22	6	28	22	52	74	25	6	31	25	52	77	30	6	36	30	52	82

per hectare and on sandy grassland at 57 kg K (69 kg K_2O) per hectare. On the other side potassium is supplied by rain (5 kg K/ha). As a result soil potassium is diminished by 6 kg K (7 kg K_2O) per hectare on clay grassland and by 52 kg K (63 kg K_2O) per hectare on sandy grassland (*Henkens, 1976 (3)*).

The removal of the potassium with wilk and meat depends on the milk production per cow and the number of cows per ha, in other words on the milk production per ha. Per 1000 kg of milk 1.5 kg K (1.8 kg K_2O) and per calf of 40 kg 0.08 kg K (0.10 kg K_2O) is removed.
Table 1 shows the removal of potassium per ha by milk and meat at different numbers of cows per ha and different levels of milk production per milking cow.

To maintain the potassium stock of the soil the amounts of potassium exported in milk and meat and lost by leaching should be compensated for. These quantities are given in table 2. On farms where the import of potassium by concentrated feed or roughage is smaller than the total export potassium fertilizers or manure of pigs or other animals should be applied. On farms where the import of potassium is higher than the total export manure should be removed.

As a result of leaching, an overproduction of manure is less likely to occur on sandy than on clay grassland (table 2).

The quantities of concentrates needed per animal depend on the production per animal and the quantity and quality of the roughage. With an increasing number of animals per ha roughage requirements increase more than proportional, because so much grass is used during the grazing period that there is not enough opportunity for mowing to conserve feed as silage or hay.

The Research and Advisory Institute for Cattle Husbandry, Lelystad (Netherlands) calculated how much concentrates and maize silage roughage per ha should be bought with different numbers of milking cows and different grazing systems. To suit our purpose it suffices to use the system of continuous grazing during summer (± 180 days) with changing paddocks every four days (*Wieling, 1977 (3)*). Table 3 and 4 show the amounts needed at different numbers of animals per ha and different milk productions when using 250 or 400 kg N per ha respectively. Besides it is mentioned how much potassium is supplied in this way the concentrates containing 1.24 and maize silage containing 1.49 % K.

In table 5 the potassium supplies mentioned in the tables 3 and 4 are compared with the potassium removal. This table shows that at a nitrogen dressing of 250 kg N ha^{-1} the maximum number of cows on clay grassland is 2.0. On farms with a high milk production per cow the potassium balance is then already positive. At a production of 6000 kg per cow there is already a surplus of 11 kg K (13 kg K_2O). With increasing nitrogen dressing up to 400 kg N ha^{-1} the number of cows may be increased to 2.25 ha^{-1}. More cattle per ha grassland or keeping other animals will cause a manure surplus on clay grassland.
On sandy grassland dressed with 250 kg N ha^{-1} the amounts of potassium added and removed will balance with 2.75 milking cows per ha and a milk production of 4500-5000 kg per animal. With a production of 6000 kg per animal the equilibrium is reached at 2.5 animal ha^{-1}.
Increasing the nitrogen dressing up to 400 kg ha^{-1} allows an increase of the number of cows by 0.25.
Keeping less animals per ha will cause a negative balance. The potassium deficit can made up by potassium fertilizer or by manure of pigs, poultry and fattening calves. Table 6 mentiones the amounts of manure of these animals to be supplied on sandy grassland given 250-400 kg N per ha, in addition to the cattle manure at a production of 5000 kg milk cow^{-1} $year^{-1}$. Moreover the numbers of animals producing this manure are stated.
The number of pig places, etc. in table 6 refers to the number of animals per ha grassland. Table 4 and 5 show that keeping more than 2 cows ha^{-1} is only possible when in addition to the roughage from grassland maize silage is fed.

Table 3. Needed purchases of concentrates and maize silage at different numbers of milking cows per ha, continuous grazing during summer (± 180 days) at nitrogen dressings of <u>250 kg N</u> ha^{-1} and changing paddocks every four days

Number of milking cows per ha	Milk production milking cow^{-1} $year^{-1}$								
	4500 kg			5000 kg			6000 kg		
	concentrates kg	maize silage kg d.m.	potassium[2] supply kg K ha^{-1}	concentrates kg	maize silage kg d.m.	potassium[2] supply kg K ha^{-1}	concentrates kg	maize silage kg d.m.	potassium[2] supply kg K ha^{-1}
2.00	1892	-[1]	23	2179	-[1]	27	2792	0	35
2.25	2098	380	32	2399	720	40	3070	1290	57
2.50	2246	1560	51	2596	1870	60	3280	2570	80
2.75	2399	2710	70	2783	3090	81	3630	3760	101
3.00	2548	3880	89	2974	4240	100	3941	4890	122
3.25	2701	4980	108	3204	5350	119	4296	5900	141

1) Remainder of roughage from own farm; 2) K content concentrates 1.24 %; K content maize silage 1.49 %.

Table 4. Needed purchases of concentrates and maize silage at different numbers of milking cows per ha, continuous grazing during summer (± 180 days) at nitrogen dressings of <u>400 kg N</u> ha^{-1} and changing paddocks every four days

Number of milking cows per ha	Milk production milking cow^{-1} $year^{-1}$								
	4500 kg			5000 kg			6000 kg		
	concentrates kg	maize silage kg d.m.	potassium[2] supply kg K ha^{-1}	concentrates kg	maize silage kg d.m.	potassium[2] supply kg K ha^{-1}	concentrates kg	maize silage kg d.m.	potassium[2] supply kg K ha^{-2}
2.25	2035	-[1]	25	2385	-[1]	30	3060	0	38
2.50	2294	280	33	2624	600	41	3367	1280	61
2.75	2457	1420	52	2835	1790	62	3669	2540	83
3.00	2625	2590	71	3041	2990	82	3989	3680	104
3.25	2792	3730	91	3257	4120	102	4310	4790	125

1) Remainder of roughage from own farm; 2) K content concentrates 1.24 %; K content maize silage 1.49 %.

Table 5. Potassium supply by concentrates and maize silage, respectively potassium removal by animal production and leaching in kg K ha^{-1} at different numbers of milking cows at nitrogen dressings of 250 and 400 kg N ha^{-1}.

Number of milking cows per ha	Milk production milking cow^{-1} year^{-1}											
	4500 kg				5000 kg				6000 kg			
	Removal kg K ha^{-1}		Supply kg K ha^{-1}		Removal kg K ha^{-1}		Supply kg K ha^{-1}		Removal kg K ha^{-1}		Supply kg K ha^{-1}	
	Clay soil	Sandy soil	250 kg N	400 kg N	Clay soil	Sandy soil	250 kg N	400 kg N	Clay soil	Sandy soil	250 kg N	400 kg N
2.00	20	66	23	-	22	68	27	-	24	70	35	-
2.25	21	67	32	25	23	69	40	30	26	72	57	38
2.50	23	69	51	33	25	71	60	41	29	75	80	61
2.75	25	71	70	52	27	73	81	62	31	77	101	83
3.00	27	73	89	71	29	75	100	82	33	79	122	104
3.25	28	74	108	91	31	77	119	102	36	82	141	125

Table 6. Quantity of manure needed to supplu the potassium deficit on sandy grassland given 250-400 kg N/ha to maintain the potassium stock of the soil.

Number of milking cows (5000 kg year^{-1}) per ha	Potassium deficit kg K ha^{-1}	Quantity of manure in tons ha^{-1}							
		fatting calves manure		pig manure		poultry manure		broiler manure	
		tons	year production of	tons	year production of	tons	year production of	tons	year production of
2.00	41	20	9 places[1)]	12	8 places[1)]	5	137 hens	4	512 places[1)]
2.25	34	18	8 places	10	6 places	4	114 hens	3	425 places
2.50	16	9	4 places	5	3 places	2	54 hens	2	200 places
2.75	1	0	0 places	0	0 places	0	0 hens	0	0 places
3.00	-16	0	0 places	0	0 places	0	0 hens	0	0 places

1) 1 fatting calf place = 2,2 delivered calves year^{-1} = 4,40 kg K
1 pig place, = 2,2 delivered pigs year^{-1} = 5,31 kg K
1 broiler place = 5,5 delivered broiler year^{-1} = 0,08 kg K

The dry matter production of maize for silage can be estimated at 12.800 kg ha^{-1}. This means that for a cattle holding of 2.25; 2.50; 2.75 and 3.00 cows per ha grassland, respectively, 0.06; 0.15; 0.24; 0.33 ha silage maize is needed. When this maize is grown on the own farm this acreage can be used for disposal of manure as well. Land supporting maize should be considered arable land and nitrogen used as a standard.

Summarizing we come to the conclusion that using the potassium as a standard on clay grassland, there is no posibility for application of manure of housed stock (pigs, poultry, fattening calves) as contrasted with sandy soils.

CRITERION: ENVIRONMENT

Table 5 shows that the amounts of potassium added by purchased concentrates and maize silage balance with the amounts removed with milk and meat and by leaching on clay grassland with 2.00-2.25 milking cows per ha.
Concentrates containing 0.66 % P and maize silage containing 0.25 % P, however, add 12-20 kg P/ha. Supply by rain (1.47 kg P/ha) exceeds leaching (0.24 kg P/ha) (*Henkens (3)*). The removal with milk and meat by two milking cows with a milk production of 4500-6000 kg milk is 9-13 kg phosphorus per ha. As a result, there is a surplus of 3-7 kg phosphorus (7-16 kg P_2O_5) per ha.

On sandy grassland phosphate is added as concentrates, maize silage and sometimes as manure from housed stock. Table 6 mentiones the amounts of manure from housed stock which can be supplied on sandy grassland in addition to cattle manure at a production of 5000 kg milk cow^{-1} $year^{-1}$.
In table 7 the phosphate surplus by concentrates and maize silage in this case is mentioned. Moreover the amounts of phosphate added by manure from housed stock, as mentioned in table 6, are stated. Table 7 shows that there is already a phosphate surplus of 5 kg P/ha with two milking cows.
Making up the potassium deficit with pig manure will increase the surplus with 26 kg up to 31 kg P (72 kg P_2O_5) per ha. When using poultry manure the phosphate surplus will be even higher.
Keeping 2.75 milking cows per ha gives no potassium deficit, but a phosphate surplus of 14 kg P (32 kg P_2O_5) per ha.

Thise overdose with phosphate will increase phosphate status of soil, but is not harmful for grass growth.
Leaching of phosphate at this moment is negligible. It is not expected that supplying 30 kg P (70 kg P_2O_5) more than is extracted by grass will increase leaching at short notice.

STANDARDS IN OTHER COUNTRIES

As far as I know, there is no country with already existing legislations as to the number of animals per ha grassland. In the fore-mentioned I stated, that on grassland the standard should be the potassium balance.
On this way the cattle number per ha will be independent of the potassium status of soil. The soil type has an influence as far as leaching is concerned. If the potassium balance is poised, but there is a shortage of potassium for optimum growth as a result of a low potassium status of the soil, this should be made up by potassium fertilizers. Low potassium status is temporarily, isn't it ?

In table 8 standards in other countries are mentioned.

Table 7. Surplus of phosphate (kg P/ha) by concentrates and maize silage on sandy grassland given 250-400 kg N/ha at different numbers of milking cows (5000 kg milk $year^{-1}$) and the amount of phosphate (kg P/ha) supplied by the manure of housed stock to make up the deficit of potassium (see table 6).

Number of milking cows per ha	Phosphate surplus by concentrates and maize silage kg P/ha	Phosphate added by manure of:			
		Fattening calves kg P/ha	Pig manure kg P/ha	Poultry manure kg P/ha	Broiler manure kg P/ha
2.00	5	11	26	45	34
2.25	6	10	20	37	28
2.50	8	5	10	18	13
2.75	12	0	0	0	0
3.00	14	0	0	0	0

Table 8. Maximum number of milking cows per ha grassland in different countries

Country	Author	Maximum number of milking cows
Switzerland	2	3.0 - 3.5
West Germany	6 land for grazing	2
	hay fields	4
West Germany	4 land for grazing	1
	hay fields	3.9
Belgium	5	2.5

In Switzerland standards are based on dressing of 220 kg N, 100 kg P_2O_5 and 300 kg K_2O per ha. *Vetter (6)* states that pasture land for grazing should not get more than 100 kg K_2O and that for hay production no more than 300 kg K_2O and 100 kg P_2O_5 per ha.

Rager (4) uses the potassium need of grassland as criterion, i.e. 67 kg K_2O for grazing and 260 kg per ha for hay production. *Verstraete (5)* takes the potassium neeu in mixed exploitation of grassland as a standard.

In Sweden *(1)* the maximum number of milking cows per ha differs from 2.87 - 5 with a winter housed period of 8 months. This number is based on the nitrogen need in crop rotations and not only on grassland.

REFERENCES:

1. Anonymous 1973 Riktlinjer för miljöskyddande atgärder vid animalie produktion. Statens Naturvardsverk; Publikationer 2.

2. Anonymous 1974 Wegleitung zu einer umweltgerechten Anwendung von Düngemitteln. Mitteilungen für die Schweizerische Landwirtschaft, 22(7); 133-149.

3. Henkens, Ch.H. 1976 Voedingsstoffen- en mineralenbalansen. Stikstof, 83/84; 355-362.

4. Rager, K.Th. 1971 Abwassertechnische und Wasserwirtschaftliche Probleme der Massentierhaltung. KTBL Bauschriften, Heft Nr. 11.

5. Verstraete, W. c.s. 1973 Overzicht betreffende de problematiek van de bewerking van dierlijke afvalstoffen in België. Landbouwtijdschrift, 26,6; 1191-1230.

6. Vetter, H. c.s. 1973 Mist und Gülle, Verwertung und Beseitigung von Flüssigmist und Hühnerkot. DLG Verlag, Frankfurt (Main); BLV Verlagsgesellschaft, München.

7. Wieling, H. 1977 The use of planning in grassland management on dairy farms. Proceedings International Meeting on Animal Production from Temporate Grassland, Dublin, June 1977, 109-116.