PERFORMANCE OF DAIRY COWS, FEED QUALITY AND N BALANCE ON PASTURE SYSTEMS WITH OR WITHOUT MINERAL N FERTILIZER

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ABSTRACT
In a 2 year experiment, two levels of mineral N fertilization (nil and 225 kg N/ha) on pasture were checked for their effects on pasture yield and quality as well as for performance of dairy cows. Twenty six cows were used in each treatment and the stocking density was adapted to previous results on pasture growth rates. Cows were kept on pasture during summer and grass silages were harvested from the respective experimental areas for winter feeding periods. Digestibility of organic matter in these silages, determined in wether sheep, was always higher in those silages harvested from pasture without mineral N fertilization, probably due to higher proportions of white clover. Consequently, roughage intake in winter was higher in cows receiving silage from these plots. There was no effect of level of fertilizer on milk yield or fat and protein concentration of the milk. N balance calculated as a difference of N input from concentrates and fertilizer and N output from animal products was 235 and -19 kg N/(ha•y) for the treatments with and without mineral N fertilizer, respectively, when N fixing by legumes and N deposition was not included. Mean nitrate concentration in the soil (0 to 150 cm) was 130 kg N/ha when N fertilizer was applied but only 39 kg N/ha when N fertilizer was omitted.

KEYWORDS
Dairy cows, pasture systems, N fertilzer, feed quality, milk production, white clover, soil nitrate

INTRODUCTION
In intensive west European farming systems, input of N with concentrates and fertilizers very often considerably exceeds N output with farm products (crops, milk, meat, etc.) resulting in long term environmental problems due to nitrate leaching into the ground water or volatilisation of N gases. These problems are exacerbated by increasing uncoupling of animal production from the total area available on the farm. Under the conditions of milk quotas in the EC countries, and in view of governmental initiatives to limit agricultural production by reducing the arable area, approaches are required to produce milk with fewer environmental problems by decreasing the use of fertilizers and stocking density. However, for reasons of economic viability, this must not result in reduced performance of the dairy cows. Many studies have been done on the effects of reducing N fertilization of previously highly intensive pasture, but there are no studies on the long term performance of dairy cows and the N balance of the farm. In a two year experiment we investigated the effects of two levels of N fertilization on pasture growth, feed quality, performance of dairy cows and N balance of the farm.

METHODS
The experiment was performed at Haus Riswick experimental station of the chamber of agriculture Rhineland, Kleve, Germany, on fertile soils and a mean yearly rainfall of 760 mm. The two experimental treatments differed solely in the amount of N fertilizer used on pasture, which was nil in the treatment 'without' and 225 kg N/(ha•y) in treatment 'with', divided in 7 portions distributed over the growing season (Table 1). Two groups of 26 dairy cows were used, selected to equalize the proportion of heifers (1/3), the number of lactations and the pretreatment milking performance of cows in both groups. The stocking density was adopted according to results from previous experiments aiming at about equal amounts of herbage and grass silage available per cow in both treatments. Thus, the area of treatment 'with' amounted to 9.5 ha and that of treatment 'without' to 15.5 ha. Correspondingly, the amount of N spread with manure per ha was different because the total amount of manure from 26 cows was the same in both treatments. Most of the pasture used in this experiment had been treated according to the respective system for at least five previous years.

Mean proportion of white clover in pasture without mineral N fertilizer was about 35%, with extreme values ranging from 15 to 69% depending on the year, the season and on rainfall periods. On pasture receiving mineral N fertilizer, almost no clover was established and grass made up more than 90% of the species. Mean concentration of crude protein (CP) determined in material grown under cages was 233 and 206 g/kg dry matter on pasture with or without mineral fertilizer, respectively.

Cows were kept on pasture during summer and predried grass silages were harvested from rotating parts of the pasture areas for winter feeding periods. Three cuts were done per year, each cut at the same time for both treatments (with the exception of the second cut in the second year) aiming at equal harvesting conditions. In winter, a mixture of grass silage and corn silage (3:1, on dry matter basis) was fed ad libitum and a low protein concentrate (containing 6% CP and 7.4 MJ net energy for lactation (NEL)/kg) was given to balance protein and energy supply and to provide minerals, trace elements, and vitamins according to the recommendations (GEH 1986). A commercial concentrate (19% CP, 6.9 MJ NEL/kg) was given individually according to amount of milk exceeding that produced from the balanced roughage diet. In summer, 3 kg dry matter of corn silage were given per head in the animal house in addition to free pasture grazing. Intake of grass silage and corn silage was determined groupwise in winter but pasture intake could not be measured in summer. Concentrate intake was determined individually as they were provided by a computer controlled self demand feeder. Groups were kept separately in an animal house on perforated floors during all the winter times (~180 d/y) and for milking and feeding of corn silage and concentrates in summer. They were milked twice daily at about 5.30 and 15.30 h. Digestibilities of organic matter (OM) and crude nutrients for grass silages were determined separately using wether sheep according to the suggestions of the GFE (1991), and subsequently, NEL concentrations were calculated using digestible crude nutrients according to GEH (1986) and GFE (1995).

RESULTS AND DISCUSSION
Pasture yield and digestibilities of organic matter. Amount of dry matter grown on pasture was determined at 6 consecutive dates during the growing season using cages placed at several places over the total area. The mean dry matter yields were 12.7 and 10.8 t/(ha•y) for pasture with and without mineral N fertilizer, respectively, this difference being less than expected from results in previous years. As a consequence, total dry matter available for each cow grazing on pasture was higher in treatment 'without' than in treatment 'with', however, there was no indication at any time that feed intake was limited in cows grazing on pasture with mineral N fertilizer. OM digestibilities were significantly higher at all times for grass silages harvested from pasture without mineral N fertilizer than for those grown with mineral N fertilizer (Table 1). This might be due to the differences in the proportion of clover and the fact that we used equal

cutting times for both treatments. The mean concentration of NEL in grass silages was 5.4 and 6.0 g/kg dry matter for treatments with and without, respectively. Correspondingly, roughage intake in winter was remarkably higher in cows receiving the grass silages from the pasture without N fertilizer (Table 1).

Milk production of the cows and N balance in the farming systems. As shown in Table 2, mean daily amount of milk was about 22 kg/cow. It was not significantly different between treatments, neither were concentrations of fat and protein in milk. There were also no significant differences in performance in individual summer and winter feeding periods. Concentration of urea was significantly ($p \leq 0.05$) higher in milk of cows from treatment 'with' than from treatment 'without' (280±21 vs. 242±18 mg/L) although total protein intake was not different. No significant differences could be detected in health and fertility parameters, however, number of cows used here is too low and experimental duration too low to obtain reliable results with regard to these parameters. Total amount of concentrates used in the experiment was about 2 t/cow with no significant differences between treatments. Total amount of N imported with concentrates together with N contained in corn silage and in mineral fertilizer forms the total input of N in the system. It can be balanced against the total amount of N leaving the farm with milk, calves and some feed residues (Table 2). Results show that the N balance of a dairy farm can be almost equalized by completely omitting mineral N fertilizer without influencing the performance of cows as long as sufficient pasture area is available around the farm. As the amount of N fixed by the legumes is difficult to estimate, no attempt was made to include this amount in the calculation. However it must be born in mind, that legumes can bind considerable quantities of N.

Concentration of nitrate N in the ground (0-150 cm), determined once in early spring, summer and autumn, was considerably higher at each time under areas fertilized with mineral N compared with ëwithoutítreatment. As a mean of both years, concentrations were 130 and 39 kg NO3-N/ha in treatments 'with' and 'without', respectively, indicating the differences in nitrate leaching capacity of both treatments.

Table 1
Experimental design, digestibilities of organic matter (OM) in grass silages and mean roughage intake of cows during winter

Treatment	With	Without
No of cows	26	26
Pasture area[1], ha	9.5	15.5
kg N/(ha•y):		
from manure[2]	95	65
from fertilizer	225	-
Digestibility of OM3 in grass silages harvested from pasture areas, %		
Year 1, 1st cut	75	78
2nd cut	70	73
3rd cut	67	69
Year 2, 1st cut	72	78
2nd cut	65	71
3rd cut	68	78
Mean daily roughage intake in winter (kg DM/cow)	12.8	14.0

[1]Stocking density adapted to results from previous experiments. [2]According to difference in stocking density. [3]Values were significantly different for each cut at p(0.05.

Table 2
Mean daily milk yield of cows, concentrations of fat and proteinin milk, intake of concentrates and N balance (n=26, mean(SD)

Treatment	With	Without
Milk, kg/d	21.7 ± 2.4	22.1 ± 3.3
Fat, %	4.00 ± 0.31	4.05 ± 0.36
Protein, %	3.24 ± 0.13	3.26 ± 0.17
Total amount of concentrates[1], kg/cow	2058 ± 406	1965 ±451
Total N input1,2 (kg)	6100	1561
Total N output1 (kg)	1632	2136
N balance1 (kg)	4468	-575
(kg/ha(y)	235	-19

[1]Values given are for the entire experimental period. [2]Ignoring the N fixing by legumes and N deposition from precipitation.

REFERENCES

GEH (Gesellschaft fuer Ernaehrungsphysiologie der Haustiere). 1986. Energie- und Naehrstoffbedarf landwirtschaftlicher Nutztiere. Nr. 3: Milchkuehe und Aufzuchtrinder. DLG-Verlag, Frankfurt, Germany

GFE (Gesellschaft fuer Ernaehrungsphysiologie). 1991. Leitlinien zur Bestimmung der Verdaulichkeit von Rohnaehrstoffen an Wiederkaeuern. J. Anim. Physiol. Anim. Nutr. **65**: 229-234.

GFE (Gesellschaft fuer Ernaehrungsphysiologie). 1995. Zur Energiebewertung beim Wiederkauer. Proc. Soc. Nutr. Physiol. **4**, 121-123.