*Netherlands Journal of Agricultural Science 48 (2000) 291-303*

# The performance of a white clover based dairy system in comparison with a grass/fertiliser-N system. I. Botanical composition and sward utilisation

R.L.M. SCHILS[1,*], TJ. BOXEM[1], K. SIKKEMA[1] AND G. ANDRÉ[1]

[1] Research Institute for Animal Husbandry, P.O. Box 2176, 8203 AD Lelystad, The Netherlands

* Corresponding author (fax: +32-320-241584; e-mail: r.l.m.schils@pv.agro.nl)

Received 18 April 2000; accepted 22 October 2000

## Abstract

The performance of a white clover based dairy system in comparison with a grass/fertiliser-N system was studied during three years. Mixed swards of perennial ryegrass and white clover were established successfully through reseeding or sodseeding. Both systems had 59 dairy cows and a milk quota of 450 tonnes per year. The allocated areas of 41 ha for the grass/clover system and 34 ha for the grass/fertiliser-N system were based on an expected yield difference of 15 to 20% in favour of the grass/fertiliser-N swards. The grassland management consisted of a rotational grazing system with one to three silage cuts per paddock, depending on herbage growth.

The average white clover ground cover was 31, 30 and 26% in the three subsequent years, but with a large variation between seasons and paddocks. Season, clover variety and sward age × clover variety explained 28% of the variance in clover cover, but 72% remained unexplained.

Grass/clover and grass/fertiliser-N swards received 69 and 275 kg N $ha^{-1}$ $year^{-1}$, respectively, including the inorganic N from applied cattle slurry, but excluding animal excreta during grazing. The average annual net DM yield from grass/fertiliser-N swards was 10.8 t $ha^{-1}$ and from grass/clover swards 10.1 t $ha^{-1}$. The yield difference occurred mainly in spring, but was smaller than expected, causing a relative silage surplus for the grass/clover system. The OMD of grass/clover was slightly, but consistently, higher than that of grass-only, while the CP concentration of grass/clover was consistently higher from July onwards. It is concluded that mixed swards of perennial ryegrass and white clover can function as a sound basis to produce good quality herbage for a dairy system.

*Keywords:* white clover, perennial ryegrass, dairy system, nitrogen, botanical composition, sward utilisation

## Introduction

From the 1950's onwards, dairy production systems in the Netherlands have become increasingly dependent on imports of fertilisers and concentrates (Van der Meer, 1994). Concurrently, until the early 1980's interest in white clover disappeared, both in farm practice and, to a large extent, also in research. Since the middle of the 1980's developments such as the introduction of milk quota, a growing interest in organic farming and concern about nitrogen (N) losses (Aarts *et al.*, 1992) have caused a gradual decrease in the use of fertiliser N (Bussink & Oenema, 1998). In 1997, the average amount of fertiliser N applied to grassland on specialised dairy farms was 252 kg $ha^{-1}$ $year^{-1}$ (Anonymous, 1999a). To reduce the N losses, government policies aim to reduce the annual N surpluses of dairy farms, according to the Mineral Accounting System (MINAS), to a level of 180 kg $ha^{-1}$ for grassland by the year 2003 (Anonymous, 1997a; Anonymous, 1999b ). As the use of fertiliser N will gradually be reduced, a greater reliance on white clover may be expected, especially since N fixation by legumes does not have to be accounted for in MINAS so far.

Many studies with mixtures of perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.) concentrated on agronomic aspects (e.g. Frame & Newbould, 1986; Baker & Williams, 1987), animal nutritional aspects (e.g. Thomson, 1984; Beever & Thorp, 1996) or environmental aspects (Jarvis, 1992). Studies on the entire white clover-based dairy system are scarce. System studies in the Netherlands have been restricted to organic farm types (Van Der Meer & Baan Hofman, 1989) and integrated farms (Lantinga & Van Bruchem, 1998). In other countries in Northwest Europe, white clover-based systems have been compared to fertiliser N based systems (Ryan, 1989; Weissbach & Ernst, 1994; Leach *et al.*, 2000). The white clover-based systems in these three studies carried 21 to 40% fewer cows per ha and produced 16 to 40% less milk per ha than the fertiliser N based systems. However, some aspects in these comparisons are not applicable to the Dutch situation, for instance the use of a two-sward system, a set-stocking grazing system or relatively low yielding dairy cows.

The present experiment studied the performance of white clover in a conventional Dutch dairy system, i.e. non-organic, with rotational grazing and cutting and a high yielding dairy herd. The objectives were (i) to compare the agronomic, environmental and economic performance of a white clover-based dairy system with a moderately intensive grass/fertiliser-N system, (ii) to identify potential problems in the utilisation of white clover in dairying, and (iii) to design an agronomically, environmentally and economically sound white clover-based dairy system.

This experiment is presented in two parts. This first paper focuses on sward utilisation and botanical composition, while a second paper (Schils *et al.*, 2000) deals with animal production and the overall system performance.

## Materials and methods

### *Site*

The experiment was conducted at the Waiboerhoeve experimental station at Lelystad (52° N, 5° E). The soil was a young calcareous marine light clay, reclaimed from the sea in 1957 and under grass since 1971. Until the start of the experiment, in 1990, the site had been used for intensive dairying on perennial ryegrass dominated swards

Table 1. Soil characteristics of grass and grass/clover paddocks, determined in spring to a depth of 5 cm, before the start and at the end of the experiment.

| | Grass/fertiliser-N | | Grass/clover | |
|---|---|---|---|---|
| | 1989 | 1993 | 1989 | 1993 |
| Sampled paddocks (n) | 25 | 27 | 18 | 33 |
| pH-KCl | 7.0 | 7.0 | 7.1 | 7.0 |
| Organic matter (%) | 7.7 | 9.5 | 6.3 | 7.4 |
| P-AL (mg $P_2O_5$ 100 $g^{-1}$ soil) | 28 | 57 | 28 | 40 |
| K-HCl (mg $K_2O$ 100 $g^{-1}$ soil) | 46 | 55 | 48 | 55 |

with N application rates of 300 to 500 kg $ha^{-1}$ $year^{-1}$, including inorganic N from slurry. Soil samples taken in 1989 (Table 1), showed that the top soil (0–5 cm) had a sufficient phosphate status and a high potassium status (Anonymous, 1998b).

During the three experimental years, the April-September periods were generally warmer and drier than average (Table 2). From October to March, temperatures were higher as well, with the total precipitation surpluses ranging from 233 to 412 mm.

*Sward establishment*

On a total area of 40.6 ha, 33 paddocks were established with mixed swards of perennial ryegrass and white clover between August 1988 and June 1991, with 7, 15, 10 and 1 paddocks being sown in 1988, 1989, 1990 and 1991, respectively (Table 3). Approximately two thirds of the paddocks were ploughed, cultivated and sown successfully with a seed mixture of 20 kg (diploid) or 30 kg (tetraploid) perennial ryegrass and 5 kg white clover per ha. The other paddocks were direct-drilled, using a disc type drill (Vredo), with 5 kg white clover seed per ha. The results of direct drilling were very variable due to problems with drought, the high density of the old sward and machine calibration. Therefore, paddocks had to direct-drilled 2.4 times on average to obtain a satisfactory clover establishment. The composition of seed mixtures of the old swards, sown around 1980, into which clover was direct-drilled

Table 2. Mean values of daily minimum, mean and maximum temperatures at De Bilt and total precipitation surplus (precipitation – reference evaporation) at Swifterbant per period of six months (Anonymous, 1990–1993).

| | April – September | | | | October – March | | | |
|---|---|---|---|---|---|---|---|---|
| | Temperature (°C) | | | Surplus (mm) | Temperature (°C) | | | Surplus (mm) |
| | Min | Mean | Max | | Min | Mean | Max | |
| Average[1] | 9.0 | 13.6 | 18.6 | −35 | 1.7 | 4.9 | 8.1 | 282 |
| 1990/1991 | 9.0 | 14.4 | 19.4 | −111 | 2.2 | 5.7 | 9.0 | 259 |
| 1991/1992 | 8.9 | 13.9 | 18.5 | −41 | 2.5 | 5.7 | 8.7 | 233 |
| 1992/1993 | 10.5 | 15.2 | 20.1 | −21 | 2.4 | 5.4 | 8.7 | 412 |

[1] Average = 30 year mean 1961–1990

Table 3. Number of paddocks (n) per sowing date, sowing method, perennial ryegrass varieties and white clover varieties in the grass/clover system.

| Sowing date | n | Sowing method | n | Perennial ryegrass varieties | n | White clover varieties | n |
|---|---|---|---|---|---|---|---|
| Aug 1988 | 7 | Cultivated | 21 | Profit, Magella | 11 | Retor | 21 |
| Apr 1989 | 1 | Direct drill | 12 | Trani, Barlet | 2 | Alice | 5 |
| Jun 1989 | 4 | | | Tresor, Parcour, Kerdion, Magella, Edgar | 2 | Milkanova | 2 |
| Aug 1989 | 10 | | | Texas, Heraut, Magella | 2 | Menna | 1 |
| Mar 1990 | 1 | | | Profit, Phoenix | 2 | Retor, Alice, Pertina, Merwi, Milkanova* | 1 |
| Apr 1990 | 3 | | | Condesa, Madera | 2 | Alice, Pertina, Menna, Retor* | 3 |
| Jun1990 | 2 | | | Unknown | 12 | | |
| Jul 1990 | 2 | | | | | | |
| Sep 1990 | 2 | | | | | | |
| Jun 1991 | 1 | | | | | | |

* Paddocks were drilled two to three times with different clover mixtures

is unknown, but perennial ryegrass was the dominant component. This practice resulted in a series of paddocks with a wide variation in sward age, sward composition, perennial ryegrass variety and white clover variety at the start of the study.

In order to have similar sward ages in both systems, an approximately equivalent proportion of the area was renewed on the grass/fertiliser-N farm. A total of 4, 7 and 4 paddocks were reseeded in 1988, 1989 and 1990, respectively. These paddocks were ploughed and sown with 25 kg (diploid) or 40 kg (tetraploid) perennial ryegrass of the same varieties as in the mixed swards.

*Systems layout*

The experiment consisted of a comparison between a grass/clover and grass/fertiliser-N dairy system, from May 1990 until April 1993 (Table 4). One farm manager ran both herds, which were housed under one roof, but in independent units with separated silage clamps and slurry storage facilities, cubicles, feeding passages and milk tanks. A more extensive description of the farm buildings was given earlier (Schils *et al.*, 1995). Both systems had milk quota of 450 tonnes and were planned to be self-supporting in silage production. As the dry matter (DM) yield of grass/clover swards was expected to be 15 to 20% lower than that of grass fertilised with 300 kg N $ha^{-1}$ $year^{-1}$, 41 and 34 ha were allocated to grass/clover and grass/fertiliser-N, respectively. The grassland area was divided into 33 grass/clover and 27 grass/fertiliser-N paddocks with an average area of 1.25 ha.

Each spring, cattle slurry was applied with a shallow disk injector at a rate of 20 $m^3$ $ha^{-1}$. Some paddocks received a second application during summer. On grass/clover swards, fertiliser N was only applied in spring at a rate of 20 kg $ha^{-1}$ in 1990 and 1991 on all paddocks, and in 1992 only on the paddocks planned to be cut for silage. Grass/fertiliser-N swards received fertiliser N in 5 to 7 dressings, depend-

Table 4. System layout of grass/fertiliser-N and grass/clover dairy systems.

| | Grass/fertiliser-N | Grass/clover |
|---|---|---|
| Milk quota (kg) | 450,000 | 450,000 |
| Pasture area (ha) | 34.4 | 40.6 |
| Dairy cows | 59 | 59 |
| Stocking rate[1] (LU $ha^{-1}$) | 2.2 | 1.9 |
| Milk ($10^3$ ton $ha^{-1}$) | 13.1 | 11.1 |
| Nitrogen application[2] (kg $ha^{-1}$) | 300 | < 100 |

[1] LU = Livestock Unit: 0-1 year = 0.3, 1–2 year = 0.6 and cow = 1.0
[2] including inorganic N from slurry

ing on the number of grazings and silage cuts. All paddocks received additional fertiliser $P_2O_5$ depending on available $P_2O_5$ in the soil and the number of silage cuts. Additional fertiliser $K_2O$ was not necessary because of the high $K_2O$ status of the soil (Anonymous, 1998b).

A rotational grazing system was applied with planned grazing periods of two days by dairy cows, followed by two days by young stock together with dry cows. Ideally, dairy cows were turned into a paddock at a DM yield of approximately 1700 kg $ha^{-1}$ above 5 cm. On many occasions throughout the experiment, target yields could not be achieved, due to differences in expected and realised herbage growth. The first priority was to have enough herbage for grazing, whilst surplus herbage was cut for silage. Silage cuts were planned to be taken at a DM yield of 3500 kg $ha^{-1}$ above 5 cm, and silage was wilted for about 24 hours to obtain a DM content of approximately 35 to 40%. Calves grazed on the aftermath of silage cuts.

*Measurements and data analysis*

Each year between January and March, soil samples were taken to a depth of 5 cm and analysed for organic matter, pH-KCl, P-AL and K-HCl.

Between autumn 1990 and spring 1993, the botanical composition of the swards was determined on eight occasions by a visual estimation of the ground cover of all plant species in the whole field. Throughout the experiment, these observations were carried out by the same person. A Residual Maximum Likelihood (REML) analysis (Anonymous, 1998a) was carried out on the white clover ground cover, after logit transformation (Log (X / (100 – X)).

A farm management system was used to record all events occurring on the paddocks, i.e. fertiliser use, grazing management, silage production and miscellaneous. Slurry was sampled at the time of application, and subsequently analysed for DM, $NH_3$-N, total-N, $P_2O_5$ and $K_2O$. Each silage clamp was sampled and analysed for DM, crude ash, crude fibre, crude protein and $NH_3$, from which the organic matter digestibility (OMD) was calculated (Anonymous, 1992). Prior to each grazing, the herbage of five randomly selected paddocks per system was sampled by taking approximately 40 clippings per paddock at a stubble height of 4 to 5 cm, randomly distributed across the field. The 40 clippings were bulked into one sample of 500 to 750 g fresh weight. The sample was split into two fractions. The first fraction was analysed on DM, crude ash, crude fibre, crude protein, in vitro organic matter digestibility (IVOMD), sodium, potassium, magnesium, calcium and phosphorus. The second fraction was separated into white clover and other species. The separated fractions were dried and the white clover content in the dry matter was assessed.

The net DM silage yield was determined by weighing and sampling every silage load. The net DM yield under grazing was calculated from the number of grazing days per ha, assuming that one grazing day equals a net DM yield of 14, 7 or 3.5 kg for dairy cows, heifers or calves, respectively (Hijink & Meijer, 1987; Anonymous, 1997b).

## Results

*Sward composition*

The average white clover ground cover of the grass/clover swards, determined in the autumn of 1990, 1991 and 1992 was 31, 30 and 26%, respectively (Figure 1). The white clover ground cover tended to be lowest in spring and highest in summer. The perennial ryegrass ground cover decreased from 51% in the autumn of 1990 to 37% in the autumn of 1992. Meanwhile the ground cover of other species, such as rough-stalked meadowgrass (*Poa trivialis*), annual meadowgrass (*Poa annua*) and dandelion (*Taraxacum officinale* Web. s.l.) increased slightly. Although the average ground cover of these species generally remained below 10%, some paddocks had a ground cover of up to 30% of rough-stalked meadowgrass or annual meadowgrass, or up to 10% of dandelion.

The species ground cover showed a wide variation between paddocks. Variance components analysis of the white clover ground cover showed that 28% of the variation could be explained by clover variety ($P<0.01$), season ($P<0.05$) and sward age ×

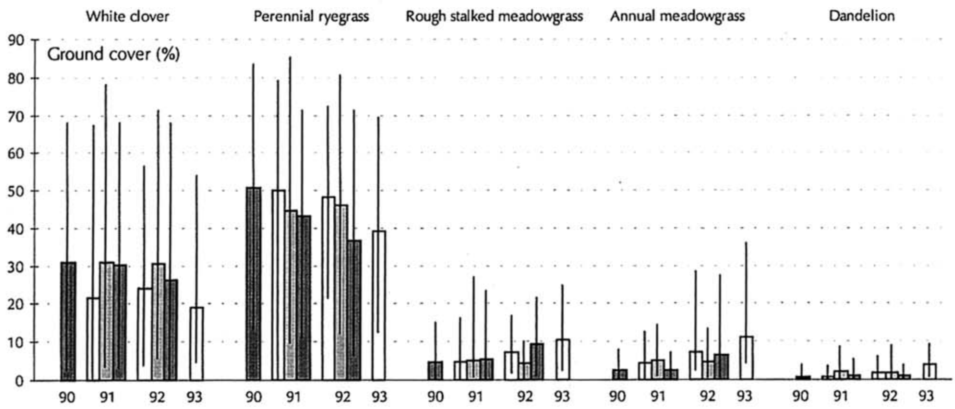


Figure 1. Mean ground cover of the most important species, determined on the grass/clover swards in spring (□), summer (■) or autumn (■); vertical line indicates range between minimum and maximum cover.

clover variety ($P<0.001$). The observed white clover ground cover of the paddocks sown with variety Alice was 42, 51 and 52% in the autumn of the three subsequent years, compared to 32, 27 and 25% for paddocks sown with Retor. Further attempts to explain the variance by soil nutrient status, fertiliser applications, grass varieties and grassland management were unsuccessful.

The swards on the grass/fertiliser-N farm were dominated by perennial ryegrass (71%), with rough-stalked meadow grass (6%) and annual meadowgrass (4%) as the main other species. The average perennial ryegrass ground cover decreased from 75% in the autumn of 1990 to 66% in the autumn of 1992.

*Sward utilisation*

Swards in the grass/fertiliser-N system received 275 kg N $ha^{-1}$ $year^{-1}$ (Table 5), of which 67 kg originated from slurry. Swards in the grass/clover system received 69 kg N $ha^{-1}$ $year^{-1}$, of which 52 kg came from slurry. There were no major differences in slurry composition between the two systems and the average concentrations per $m^3$ slurry were 2.8 kg organic N, 2.1 kg inorganic N, 1.6 kg $P_2O_5$ and 7.8 kg $K_2O$. In 1990, newly sown grass/clover swards (autumn 1989 / spring 1990) received no N, neither from inorganic fertiliser nor from slurry. Therefore, the annual N application in 1990 was only 43 kg $ha^{-1}$. The slurry surplus of 1990 was carried over to 1991, resulting into an annual application of 91 kg $ha^{-1}$ in that year. In order to improve the low phosphate status (Table 1), the phosphate application was relatively high in the first year. As there was no need for potassium fertiliser, the potassium application reflects the amounts of slurry given each year. During the experiment, the phosphate, potassium and organic matter contents of the soil increased in both systems.

In each year, the dairy cows of both systems were turned out on the same day, in the second week of April (Figure 2). In August of the first year and September and October of the second year, a drought period caused a shortage of grass in the grass/fertiliser-N system, during which the dairy cows were kept indoors at night and supplemented with silage. Due to excessive rainfall in the third year, the cows in both systems were kept indoors at night from September onwards, and again, were supplemented with silage. The dairy cows were housed permanently in the last week of October of the first and third year, and in the second week of November in the second year. These events resulted in fewer grazing days (Table 5) and a higher silage supplementation (Schils *et al.*, 2000) in the grass/fertiliser-N system, especially in the summer and autumn of the first and second year.

Each grass/fertiliser-N paddock was grazed on average 4.9 times and each grass/clover paddock 4.5 times a year, with an average grazing time for the dairy cows of 1.6 and 1.4 days, respectively. The difference in grazing time is reflected in the DM yield at grazing of the sampled paddocks, which was 0.2 t $ha^{-1}$ higher on the grass/fertiliser-N swards. During the grazing season, the DM yield at which cows were turned in decreased from 2.3 to 1.5 t $ha^{-1}$. The sampled paddocks showed a higher crude protein concentration and IVOMD for herbage from grass/clover swards than from grass/fertiliser-N swards. The crude protein concentrations were mainly higher from July onwards, whilst the difference in IVOMD was consistent throughout the grazing season. There were no major differences between herbage

Table 5. Fertiliser application, sward utilisation and herbage quality of grass/fertiliser-N and grass/clover swards, averaged over year and season.

| | Mean | | Grass/Fertiliser-N | | | Grass/Clover | | | Grass/Fertiliser-N | | | Grass/Clover | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grass / Fertil-iser-N | Grass / Clover | '90/ '91 | '91/ '92 | '92/ '93 | '90/ '91 | '91/ '92 | '92/ '93 | Start-Jun | July-Aug | Sep-End | Start-Jun | July-Aug | Sep-End |
| *Fertiliser and slurry application (kg ha$^{-1}$)* | | | | | | | | | | | | | | |
| $N_{inorganic}$ | 275 | 69 | 279 | 268 | 277 | 43 | 91 | 74 | 203 | 62 | 10 | 66 | 2 | 1 |
| $P_2O_5$ | 116 | 112 | 137 | 109 | 102 | 138 | 98 | 100 | 91 | 17 | 8 | 85 | 22 | 5 |
| $K_2O$ | 250 | 193 | 227 | 237 | 287 | 93 | 253 | 233 | 230 | 13 | 7 | 184 | 7 | 2 |
| *Sward utilisation* | | | | | | | | | | | | | | |
| Grazings per paddock | 4.9 | 4.5 | 4.9 | 4.6 | 5.1 | 4.5 | 4.3 | 4.7 | 1.5 | 1.4 | 2 | 1.7 | 1.2 | 1.6 |
| Total grazing days ($10^3$ LU) | 14.75 | 15.34 | 14.17 | 15.09 | 14.99 | 15.32 | 15.76 | 14.95 | 5.72 | 4.95 | 4.07 | 5.8 | 5.23 | 4.31 |
| Silage cuts per paddock | 1.9 | 2.4 | 2.0 | 1.7 | 2.1 | 2.3 | 2.2 | 2.6 | 1.3 | 0.5 | 0.1 | 1.4 | 0.7 | 0.3 |
| Total silage yield ($10^3$ kg DM) | 196 | 226 | 196 | 179 | 213 | 195 | 211 | 272 | 145 | 46 | 5 | 150 | 59 | 17 |
| *Herbage at grazing* | | | | | | | | | | | | | | |
| DM yield at grazing (t ha$^{-1}$) | 2.00 | 1.82 | 2.02 | 2.00 | 1.99 | 1.60 | 1.99 | 1.86 | 2.38 | 2.12 | 1.72 | 2.28 | 2.00 | 1.2 |
| Crude protein (g kg$^{-1}$ DM) | 187 | 198 | 182 | 177 | 203 | 201 | 174 | 219 | 190 | 174 | 197 | 192 | 188 | 222 |
| IVOMD (g kg$^{-1}$ OM) | 766 | 785 | 751 | 767 | 780 | 773 | 791 | 791 | 797 | 750 | 738 | 814 | 775 | 760 |
| *Herbage at cutting* | | | | | | | | | | | | | | |
| DM yield at cutting (t ha$^{-1}$) | 2.9 | 2.4 | 2.9 | 3.1 | 3.0 | 2.1 | 2.4 | 2.6 | 3.2 | 2.7 | 1.5 | 2.6 | 2.1 | 1.4 |
| Dry matter (g kg$^{-1}$) | 434 | 434 | 452 | 414 | 435 | 465 | 409 | 429 | 400 | 527 | 573 | 411 | 499 | 417 |
| Crude protein (g kg$^{-1}$ DM) | 168 | 178 | 175 | 157 | 171 | 172 | 177 | 186 | 169 | 162 | 185 | 170 | 192 | 201 |
| OMD (g kg$^{-1}$ OM) | 733 | 750 | 698 | 757 | 745 | 721 | 770 | 758 | 748 | 705 | 584 | 760 | 743 | 692 |

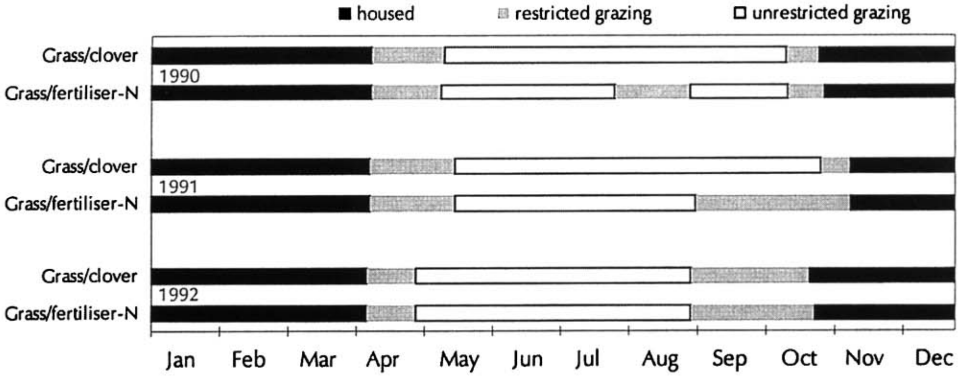


Figure 2. Overview of periods during which the dairy cows were housed, grazed day and night-time without supplementation of silage (unrestricted grazing) or grazed day-time with supplementation of silage (restricted grazing).

from grass/fertiliser-N or grass/clover swards in the concentrations of sodium (1.0 g kg $DM^{-1}$), potassium (33.3 g kg $DM^{-1}$), magnesium (1.7 g kg $DM^{-1}$) and phosphorus (4.2 g kg $DM^{-1}$). The calcium concentration in grass/clover herbage was 9.2 g kg $DM^{-1}$, compared to 6.4 g kg $DM^{-1}$ in grass/fertiliser-N herbage.

The shortage of grass in the grass/fertiliser-N system is also reflected in the mean lower total silage yield than in the grass/clover system, 196 compared to 226 t DM $year^{-1}$, respectively. The differences occurred in the second and third year, and mainly from July onwards. Grass/clover paddocks were cut 0.3 to 0.5 times per year more often than grass/fertiliser-N paddocks. This was not only a result of the total higher silage yield of grass/clover, but also of the lower DM yield per cut for grass/clover. Although not planned, grass/clover paddocks were cut for silage at 2.4 t $ha^{-1}$, compared to 2.9 t $ha^{-1}$ for grass/fertiliser-N paddocks. Similar to the trend at grazing, the DM yield at cutting decreased during the season. The average DM content of silages was 43% in both systems. The average crude protein concentration and OMD of grass/clover were higher than those of grass/fertiliser-N. The difference in crude protein concentration occurred from July onwards. The OMD of silage decreased considerably during the season. Especially the silage in September had a poor quality.

The average annual net DM yield on grass/fertiliser-N was 10.6, 10.5 and 11.4 t $ha^{-1}$ in the three subsequent years, compared to 9.3, 9.9 and 11.1 t $ha^{-1}$ on grass/clover. The average yield deficit of 0.7 t DM $ha^{-1}$ $year^{-1}$ on grass/clover swards occurred completely in the first part of the grazing season (Figure 3). From July onwards, grass/fertiliser-N and grass/clover swards showed similar DM yields.

The more frequent cutting of grass/clover resulted in a higher proportion of aftermath grazing for cows in the grass/clover system. Between July and October, 19% of the grazings on grass/fertiliser-N was on aftermath compared to 37% on grass/clover swards. Therefore, in that period grass/fertiliser-N paddocks had to be topped more often to clean areas with rejected herbage, i.e. 1.1 times per paddock compared to 0.6 times per paddock in the grass/clover system.

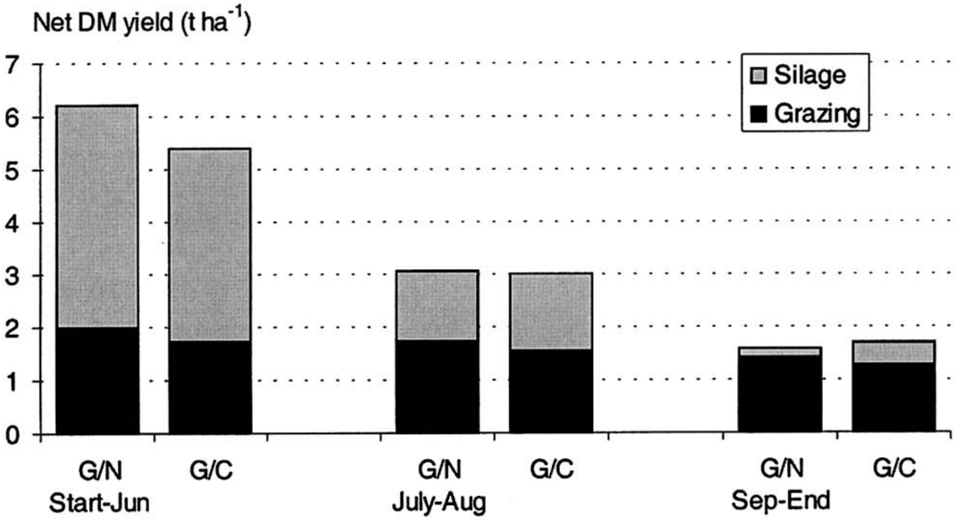


Figure 3. Average seasonal net DM yield during grazing (intake) and cutting (silage) for grass/fertiliser-N (G/N) and grass/clover (G/C).

In both systems, young stock and dry cows grazed day and night from the last week of April to the second or last week of November, while calves grazed from between the third week of May or second week of June until the third week of September or the third week of October.

## Discussion

As biologically fixed N is the driving force for a clover-based system, the white clover content in the sward has to be maintained at an appropriate level. Based on four criteria, i.e. herbage yield, animal performance, bloat risk and N losses, Pflimlin (1993) suggested an optimal annual clover content between 25 and 50%, for rotational grazing systems without supplementation of dry forages. Although the average white clover ground cover was generally within these target values, there was a substantial range between the lowest and highest values of clover ground cover. Although some variation between years and seasons is inevitable, the variation between paddocks could have been reduced by a more uniform variety choice. The poorer performance of clover variety Retor compared to Alice, as shown in cutting experiments by Elgersma & Schlepers (1997) and Baars *et al.* (1995), was confirmed by the present experiment for a practical dairy husbandry situation. Experiences with clover-based dairy systems in United Kingdom (Leach *et al.*, 2000; Bax & Browne, 1995) and more recently in the Netherlands (Lantinga & Van Bruchem, 1998) suggest that it is easier to maintain a more stable clover content in set-stocked grazing systems than in rotational grazing systems.

Strategic N fertilisation in spring is essential to achieve early herbage growth

(Frame & Boyd, 1987; Schils, 1997) and thus an early turn-out date for the dairy cows. In the grass/clover system the bulk of inorganic N was applied through slurry, and only 17 kg N $ha^{-1}$ $year^{-1}$ was applied by inorganic fertiliser.

Despite the relatively low sugar and high protein concentrations of grass/clover (Frame & Newbould, 1986), there was no evidence of a poor fermentation of grass/clover silages. The silage DM content of 43% has probably caused higher field losses in the grass/clover system. Experiments on the same site (Corporaal, 1993) have shown that the average DM field losses were 8.8% for grass/clover silages and 3.9% for grass-only silages. Furthermore the losses of grass/clover increased from 2.9% at DM contents below 35% to 15.2% at DM contents higher than 50%, whilst the losses of grass-only silages were almost unrelated to the DM content.

The results showed that the overall herbage quality of the grass/clover system resembled that of the grass/fertiliser-N system. The crude protein concentration of fresh and ensiled herbage was 6% higher in the grass/clover system and OMD was 2% higher. It is unclear whether the higher nutritive value can be attributed to clover alone or whether it is also an effect of a lower DM yield per cut. The average DM yields per cut were 9 and 17% lower in the grass/clover system for grazing and cutting, respectively. Søegaard (1993) reported no difference in IVOMD when comparing grass and white clover, cut at the same DM yield.

The applied stocking rate in the systems was based on the assumption that the grass/clover swards would yield 15 to 20% less than the grass/fertiliser-N swards. However, the realised DM yields of the grass/clover swards were only approximately 7% lower. Therefore, it can be put forward that the grass/clover system has been relatively understocked in comparison to the grass/fertiliser-N system. Obviously, a direct result was the silage shortage in the grass/fertiliser-N system and the silage surplus in the grass/clover system. Less obvious, but perhaps more important are the implications with respect to grassland management. In the understocked grass/clover system, it was possible to achieve 2.4 silage cuts on a total of 6.9 cuts, while in the overstocked grass/fertiliser-N system only 1.9 silage cuts were achieved on a total of 6.8 cuts. The higher cutting ratio might have stimulated clover content (Schils *et al.*, 1999) and increased the proportion of aftermath grazing. If the grass/clover system had been stocked to capacity, the performance of the system might have been poorer. The grassland management on the grass/clover swards was not very different from the grass/fertiliser-N swards. In both systems, the same principles were applied regarding grazing and cutting strategy, phosphate and potassium fertilisation and slurry application. This similar approach makes it easier for farmers to adopt a grass/clover system in phases, because there needs to be no difference in grassland management on the existing grass-only swards and the newly established grass/clover swards.

## *Conclusions*

In a dairy farm system, mixed swards of perennial ryegrass and white clover had satisfactory but highly variable clover contents in the swards. The variation in clover was partly explained by season, clover variety and sward age × clover variety, but

72% of the variation remained unexplained. The mixed swards, fertilised with 69 kg inorganic N $ha^{-1}$ $year^{-1}$, produced 90 to 95% of the DM yield on grass-only swards, fertilised with 275 kg inorganic N $ha^{-1}$ $year^{-1}$. The OMD of grass/clover was marginally, but consistently, higher than that of grass-only, whilst the CP concentration of grass/clover was consistently higher than of grass-only from July onwards. Overall, the experiment demonstrated that mixed swards of perennial ryegrass and white clover can function as a sound basis to produce good quality herbage for a dairy system.

## Acknowledgements

The authors wish to thank the staff of the Waiboerhoeve experimental farm for their technical assistance. Also we would like to thank Professor Dr. P.C. Struik and Dr. A. Elgersma for their comments on earlier versions of the manuscript.

## References

Aarts, H.F.M., E.E. Biewinga & H. Van Keulen, 1992. Dairy farming systems based on efficient nutrient management. *Netherlands Journal of Agricultural Science* 40: 285–299.
Anonymous, 1990–1993. Monthly Weather Surveys of the Netherlands (In Dutch). Royal Dutch Meteorological Institute (KNMI), De Bilt.
Anonymous, 1992 Handbook nutritional value roughage (In Dutch). Central Bureau for Livestock Feeding (CVB). Lelystad.
Anonymous, 1997a. Policy document on manure and ammonia. Ministry of Agriculture, Nature Management and Fisheries. The Hague, 38 pp.
Anonymous, 1997b. Handbook Dairy Husbandry (In Dutch). Research Station for Cattle, Sheep and Horse Husbandry (PR), Lelystad, 519 pp.
Anonymous, 1998a. Genstat 5, Release 4.1, 4th edition, Laws Agricultural Trust, Rothamsted, 229 pp.
Anonymous, 1998b. Fertiliser Recommendations for grassland and fodder crops (In Dutch). Research Station for Cattle, Sheep and Horse Husbandry (PR), Lelystad, 53 pp.
Anonymous, 1999a. Farm Information Net (In Dutch), Agricultural Economics Research Institute (LEI), The Hague.
Anonymous, 1999b. Integrated approach manure problem (In Dutch). Ministry of Agriculture, Nature Management and Fisheries & Ministery of Housing, Physical Planning and Environment, The Hague, 20 pp.
Baars , T., M. Van Dongen & L. Brands, 1995. Early crop growth, yield and clover development in cut and grazed grass/clover mixtures under organic conditions. In: Frame J. (Ed.) Recent research and development on white clover in Europe. REUR Technical Series 42, pp. 122–125.
Baker, M.J. & W.M. Williams (Eds.), 1987. White clover. CAB International, Wallingford, 534 pp.
Bax, J & I. Browne, 1995. The use of clover on dairy farms. Milk Marketing Board, Dumfries. 20 pp.
Beever, D.E. & C. Thorp, 1996. Advances in the understanding of factors influencing the nutritive value of legumes. In: D. Younie (Ed.) Legumes in Sustainable Farming Systems. Occasional Symposium No. 30. British Grassland Society, Reading. pp. 194–207.
Bussink, D.W. & O. Oenema, 1998. Ammonia volatilization from dairy farming systems in temperate areas: a review. *Nutrient Cycling in Agroecosystems* 51: 19–33.
Corporaal, J., 1993. Grass conditioning gives losses (In Dutch). *Landbouwmechanisatie* Nr. 4: 26–27.
Elgersma, A. & H. Schlepers, 1997. Performance of white clover/perennial ryegrass mixtures under cutting. *Grass and Forage Science* 52: 134–146.
Frame, J. & P. Newbould, 1986. Agronomy of white clover. *Advances in Agronomy* 40: 1–88.

Frame, J. & A.G. Boyd, 1987. The effect of strategic use of fertiliser nitrogen in spring and/or autumn on the productivity of a perennial ryegrass/white clover sward. *Grass and Forage Science* 42: 429–438.

Hijink, J.W.F. & A.B. Meijer, 1987. The cow model (In Dutch). Publication Nr. 50. Research Station for Cattle, Sheep and Horse Husbandry (PR), Lelystad, 52 pp.

Jarvis, S.C., 1992. Nitrogen cycling and losses in clover based pastures. *Herba* 5: 56–59.

Lantinga, E.A. & J. van Bruchem, 1998. Management and output of grass/clover swards in mixed farming systems. In: H. van Keulen, E.A. Lantinga & H.H. van Laar (Eds.), Mixed Farming Systems in Europe. LUW, Wageningen, pp. 191–196.

Leach, K.A., J.A. Bax, D.J. Roberts & C. Thomas, 2000. The establishment and performance of a dairy system based on perennial ryegrass-white clover swards compared with a system based on nitrogen fertilized grass. *Biological Agriculture and Horticulture* 17: 207–227.

Pflimlin, A., 1993. Conduite et utilisation des associations graminée – trèfle blanc. *Fourrages* 135: 407–428.

Ryan, M., 1989. Development of a legume-based dairy system. In: P. Plancquaert & R. Haggar (Eds.), Legumes in farming systems. EEC, Brussels, pp. 159–167.

Schils, R.L.M., M.C. Verboon, Tj. Boxem & S.J.F. Antuma, 1995. Reduction nitrogen fertilisation and introduction white clover (In Dutch). Publication Nr. 106. Research Station for Cattle, Sheep and Horse Husbandry (PR), Lelystad, 58 pp.

Schils, R.L.M., 1997. Effect of a spring application of nitrogen on the performance of perennial ryegrass-white clover swards at two sites in the Netherlands. *Netherlands Journal of Agricultural Science* 45: 263–275.

Schils, R.L.M., Th.V. Vellinga & T. Kraak, 1999. Dry-matter yield and herbage quality of a perennial ryegrass/white clover swards in a rotational grazing and cutting system. *Grass and Forage Science* 54: 19–29.

Schils, R.L.M., TJ. Boxem, C.J. Jagtenberg & M.C. Verboon, 2000. The performance of a white clover-based dairy system in comparison with a grass/fertiliser-N system. II. Animal performance, economics and environment. *Netherlands Journal of Agricultural Science*, this volume.

Søegaard K., 1993. Nutritive value of white clover. In: Frame J. (Ed.), White clover in Europe: state of the art. REUR Technical Series 29, pp. 17–23.

Thomson, D.J., 1984. The nutritive value of white clover. In: D.J. Thomson (Ed.) Forage Legumes. Occasional Symposium No. 16. British Grassland Society, Hurley, pp. 78–92.

Van Der Meer, H.G. & T. Baan Hofman, 1989. Contribution of legumes to yield and nitrogen economy of leys on a biodynamic farm. In: P. Plancquaert & R. Haggar (Eds.), Legumes in farming systems. EEC, Brussels, pp. 25–36.

Van Der Meer, H.G., 1994. Grassland and society. In: L. 't Mannetje & J. Frame (Eds.), Grassland and Society. Proceedings of the 15th General Meeting of the European Grassland Federation, Wageningen, pp. 19–32.

Weissbach, F. & P. Ernst, 1994. Nutrient budgets and farm management to reduce nutrient emissions. In: L. 't Mannetje & J. Frame (Eds.), Grassland and Society. Proceedings of the 15th General Meeting of the European Grassland Federation, Wageningen, pp. 343–360.