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The management and utilisation of white clover/perennial ryegrass and perennial ryegrass swards in relation to milk production and behaviour of dairy cattle.

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THE MANAGEMENT AND UTILISATION OF WHITE CLOVER/PERENNIAL RYEGRASS AND PERENNIAL RYEGRASS SWARDS IN RELATION TO MILK PRODUCTION AND BEHAVIOUR OF DAIRY CATTLE.

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SUMMARY.

The literature concerning the nutritional content of white clover as a grazed herbage or conserved crop offered to dairy cattle and aspects of frothy bloat are reviewed.

In the first nine week change-over design experiment the effect on milk production and behaviour of spring calving dairy cows grazing white clover/grass swards at contrasting sward heights were examined. Grazing the clover/perennial ryegrass sward to a height of 4 cm increased clover content, but reduced milk production. The 8 cm sward increased milk yields by 15.8%. This was accompanied by an increase in fat and protein yields. Grazing time and biting rate were increased on the 4 cm sward. Cows offered choice between sward types produced intermediate milk production values.

A second change-over design experiment conducted over 12 weeks examined milk production and behaviour of spring calving dairy cows in early lactation grazing perennial ryegrass or white clover/perennial ryegrass swards alone or offered a choice between the two sward types or grazed on clover/perennial ryegrass during the day and perennial ryegrass at night. The inclusion of clover in the diet of the dairy cows significantly increased milk production, but reduced fat content. Protein content, fat and protein yields were increased. Cows offered a choice or mixed day and night grazing regime produced similar results, which were intermediate between the clover/ryegrass and perennial ryegrass treatments. Grazing time was increased on clover/perennial ryegrass swards. This experiment also

demonstrated the ability of cows to adjust their grazing time to maximise herbage intake.

The third experiment compared the value in relation to milk production of three different buffer forages fed to spring calving dairy cows in late lactation grazing either clover/ryegrass or ryegrass swards. The forages were ryegrass and ryegrass/clover silages and ryegrass hay. Milk yield and composition were not affected by forage type, but intakes were higher for grass silage for cows grazing clover/ryegrass swards and visa versa. Hay DM intake was low.

The final experiment conducted over the first 15 weeks of the grazing season studied the effect of energy:protein concentration of strawmix supplements on the productivity of spring calving dairy cows grazing a high white clover sward. Milk yields were increased by the provision of a strawmix supplement. The energy:protein ratio had a significant effect on milk composition except fat content. The high energy:high protein supplement tended to precipitate ruminal tympany (bloat), while the low energy:high protein supplement tended to reduce ruminal tympany on this clover based sward.

These experiments have given some insight into the use of clover and stimulated questions which require further investigation to enable the farmer to safely incorporate clover into dairy farming systems.

CHAPTER ONE
WHITE CLOVER POTENTIAL AS GRAZED HERBAGE

1.1 NUTRITIVE VALUE

The nutritive value and the potential for animal production of white clover based systems has been the subject of many reviews during the 1980's (Thomson,1982; Greenhalgh,1981; Thomson,1984), reflecting the interest in the use of clover.

1.1.1 Chemical composition

White clover differs chemically in several respects from perennial ryegrass of equivalent digestibility. The most notable differences are that white clover has a higher protein, pectin, lignin and mineral content, but lower total cell wall (structural fibre) content compared with perennial ryegrass as shown in Table (1.1).

Table 1.1 Chemical composition of perennial ryegrass (cv.Melle) and white clover (cv. Blanca) harvested at similar digestibility throughout the growing season.

	White clover	Perennial ryegrass
Nitrogen	44	28
Total cell wall content	216	427
Cellulose	173	240
Hemi-cellulose	8	161
Lignin	38	27
Pectin	40	8

all values in g/Kg DM

Source Thomson (1984)

White clover cell wall content is approximately half the value of the perennial ryegrass while the protein value is 50% greater than the perennial ryegrass.

1.1.2 Voluntary intake

It has been accepted for some time that ruminants consume more white clover than perennial ryegrass of the same digestibility. Thomson, (1984) summarised intake data of sheep, cattle and dairy cow experimentation and found an increase of approximately 20% for all three categories of animal considered.

1.1.3 Digestibility and digestion

In the primary phase of growth the digestibility of white clover declines more slowly with advancing maturity than perennial ryegrass (Spedding and Diekmahns,1972). White clover contains less structural carbohydrate, therefore the rate of organic matter and cell wall breakdown is more rapid and the retention time is reduced compared to grass (Thomson,1984). Work by Moseley (1981) indicated that large particles break down to smaller particles more quickly and that these small particles leave the rumen more rapidly for white clover compared to grass. A net result of this shown by a number of authors and stated by Thomson (1984) is that organic matter leaves the rumen both more rapidly and in greater amounts in cattle fed white clover compared with grass.

Additionally, for immature white clover the total viable bacterial population in the rumen pre-feeding is 23 times that of perennial ryegrass (Theodorou et al,1984). Ingested protein is also rapidly degraded in the rumen (Losada,1983). A consequence of this rapid digestion of protein and cell walls of white clover in the rumen can be the occurrence of tympany

(Fay et al, 1980 a and b; Lees et al, 1981).

1.1.4 Nutrient supply and value

The supply of apparently absorbed amino-acids per megajoule of metabolisable energy (ME) is on average 35% greater for clover compared to grass. The efficiency of utilisation of ME for growth and fattening (k_f) was 0.51 (clover) and 0.33 (grass) when measured with sheep and similar values were shown in cattle, but cattle fed clover tended to retain more protein for use as an energy source. On average liveweight gain was 65% greater for sheep and 18% greater for cattle fed clover ad-libitum, compared to grass (Thomson,1984).

1.1.5 Milk production

1.1.5.1 Stall fed herbage

Rogers et al, (1979) studied the effect of clover or perennial ryegrass as sole diets on milk production of dairy cows. They used thirty-two Friesian cross-bred cows in early lactation. The animals were housed and individually fed a mixed herbage for ten days prior to the experiment. They were then offered pure diets of either perennial ryegrass or white clover *ad libitum* or at 60% *ad libitum*.

When fed to appetite, cows offered the clover diet consumed 33% more DM and produced 25% more milk and also 33% and 38% more fat and protein respectively than cows offered a ryegrass diet (Table 1.2). The fat and protein concentration in the milk was unaltered but chemical analysis of the milk fat of cows fed clover contained a greater proportion of short chain fatty-acids (Rogers et al 1979).

Regression analysis carried out on this experiment showed that at the same level of dry matter intake milk production was significantly higher for clover, indicating that the clover diet was more efficiently converted to milk than the grass diet.

Table 1.2 Effect of diet and feeding level on intake and milk production

Diet	P.Ryegrass		White clover		L.S.D
Feeding level	100%	60%	100%	60%	(P=0.05)
Intake (Kg/DM)	12.0	8.0	15.9	8.6	0.7
Milk yield (l/d)	13.06	11.1c	16.2a	12.5b	1.2
Fat yield (g/d)	506bc	459c	674a	514b	53
Protein yield (g/d)	381b	311c	524a	357b	39
Milk fat %	3.92b	4.22a	3.94b	4.13ab	0.25
Milk protein %	2.99ab	2.84c	3.05a	2.88bc	0.11

Means not followed by common letters differ significantly ($p<0.05$)

Source: Rogers et al, (1979).

1.1.5.2 Grazed herbage

A comparison of the nutritive value and production potential of pure perennial ryegrass and white clover swards for milk production was conducted by Thomson et al,(1983). The pure swards of either white clover cv. Blanca or perennial ryegrass cv. Melle were pre-trimmed to provide herbage of intended equivalent digestibility to both a production group of cows and to a group of lactating cows prepared with both rumen and duodenal cannulae. The cows were offered *ad libitum* herbage.

Milk yield results were analysed on a lactation day basis for both production groups. It was found that during the changeover period and for the first 35 days of lactation, cows grazing white clover increased their milk yield at a greater rate (0.18 Kg/d) compared with perennial ryegrass (0.08Kg/d). Also cows grazing pure white clover swards obtained a mean peak yield of 27.6 Kg/d on day 35, whereas cows grazing the perennial ryegrass sward had a peak value of 25.2 Kg/d on day 50. Mean milk yield was on average 2.8 Kg/d greater on the clover diet. The solids-corrected milk yield was 24.4 and 22.1 Kg/cow/d for the white clover and perennial ryegrass swards respectively. Also the clover diet produced higher milk protein content, but lower fat contents. Lactose values were similar (Table 1.3).

Table 1.3. Milk composition of lactating Friesian cows grazing perennial ryegrass or white clover *ad libitum*.

	Perennial ryegrass	White clover
Protein g/Kg	30.3	31.8
Fat g/Kg	42.2	38.7
Lactose g/Kg	49.4	49.4

Source Thomson et al (1983)

These results were further supported by a subsequent experiment by Thomson (1984). Where cows grazing pure white clover swards produced 300 litres more milk than cows grazing pure perennial ryegrass swards during the first 18 weeks of lactation.

1.1.5.2.1 Mixed swards

There are difficulties in conducting and fully interpreting work with grazing animals on grass/clover mixed swards, but several lactation studies have been conducted. Gibb and

Treacher (1983) studied ewe lactation in which the liveweight gain of twin lambs from ewes fed 2.5 Kg dry matter from either all grass or varying mixtures of the two, demonstrated a linear response to successive increments of white clover.

Rogers et al (1980) fed lactating cows at both *ad libitum* and restricted (60% *ad libitum*) levels of feeding,all grass, all white clover or a 50:50 mixture as fresh forage. Cows fed clover consumed 15% more herbage dry matter and produced 22% more milk (Table 1.4).

A review of 13 experiments conducted over six years at the Ellinbank Dairy Research Institute has shown the nutritional superiority for milk production of white clover over perennial ryegrass, with values of milk yield response of about a 20% increase when grazing clover to appetite. This value is reduced to 10% increase at 65% *ad libitum* diets of equal rations of clover compared to perennial ryegrass (O'Brian,1989)

Table 1.4 Effect of diet and feeding level on intake and subsequent milk production

Diet	PRG		PRG/WC		WC		L.S.D
Feed level (%)	100	60	100	60	100	60	P=0.05
Intake (Kg/DM)	16.5a	10.8	18.4b	11.1	18.9b	10.6	1.44
Milk yield (l)	16.7a	15.2a	18.9c	15.9b	20.3d	15.4b	1.45
Fat yield (g/d)	585a	565a	705b	580a	690b	565a	80
Protein yield g/d	505a	428b	587c	460b	616c	426b	43
Milk fat (%)	3.66ab	3.75a	3.73a	3.70a	3.48b	3.48b	0.25
Milk protein (%)	2.97a	2.80b	3.09a	2.89b	3.18c	2.79b	0.14

Means not followed by common letters differ significantly ($P<0.05$)

Source Rogers et al, (1980)

1.1.6 Conclusions

From the experiments described and reviews of work on clover, two principal features contribute to the superior feeding value of white clover compared to that of perennial ryegrass; firstly the higher voluntary food intake of clover, and secondly the higher net supply of apparently absorbed amino-acids per MJ of ME. This leads to an increased yield and protein, total casein and altered casein content in milk, but reduced milk fat content, in particular long chain fatty acids.

1.2 HERBAGE PRODUCTION

White clover is primarily a grazing legume grown in association with grass. Through the process of fixation of atmospheric nitrogen (N) by rhizobia in root nodules, white clover obtains sufficient N for it's own needs. The associated grass obtains N from the clover by decay of nodules and of leaf and root tissue in the soil. N is also recycled by the grazing animal through faeces and urine. Therefore the production potential of the clover sward is determined by the amount of clover present. The theoretical annual dry matter (DM) potential production of grass/clover swards in the UK is 18.5 to 22.5 t/ha and 16 t/ha for pure sown white clover (Frame and Newbould, 1984). They also noted that 15.5 t/ha was the highest recorded DM output for a grass/clover sward and 10.3 t/ha for a pure sown clover sward; these levels were achieved under cutting experimentation without irrigation. Many authors have put forward values for actual DM production of clover/grass swards in the UK. Frame (1990) suggested that average annual DM production on farms would be 7-10 t/ha, which is circa 70% of the production from ryegrass swards given 300-400 Kg N/ha annually. Morrison et al. (1985) had previously stated a similar value.

The seasonal growth patterns of grass and white clover differ. Grass grows more rapidly in the spring and peak growth occurs in May. White clover requires higher temperatures than grass, therefore generally starts growth one to two weeks after the grass in spring and peak production occurs in June and July. White clover also stops growing earlier in the season than grass, consequently apart from less growth in spring, the seasonal production of a grass/white clover sward is more uniform than grass receiving fertiliser.

1.2.1 Varietal differences

Assessment of varieties is based on seasonal and annual DM production, quality (digestibility and crude protein content),persistence, winter hardiness and resistance to pests and diseases. Assessment under grazing is limited, but interactions between varieties and grazing systems have emerged,smaller leaved varieties are best under frequent/severe grazing such as by sheep, while larger-leaved varieties are more suitable to cattle grazing i.e infrequent/lax or cutting.

1.2.2 Compatibility of grass and clover

Grass species differ in their compatibility with clover such as meadow fescue (*Festuca pratensis*) is highly compatible, but Cocksfoot (*Dactylis glomerata*) is incompatible. Perennial ryegrass (*Lolium perenne*) is the major grass species sown with clover.

Work carried out at Auchincruive (Frame and Boyd, 1986) has shown that ryegrass ear emergence type did not have a marked effect on compatibility, but tetraploids allowed better clover growth with the following DM production per hectare and associated clover percentage:- diploid ryegrass produced 3.4t/ha white clover with a sward composition of 40% clover compared to 3.9 t/ha and 46% respectively for the tetraploid ryegrass (Frame and Boyd,1986).

The co-adaption concept (Burden,1983) developed at Aberystwyth whereby both clover and compatible grass species are selected from co-existing genotypes has shown high production values. This is seen in work carried out by Evans et al (1985) (Table 1.5).

Table 1.5 Effect of co-adaption on annual grass/white clover dry matter productivity

Perennial ryegrass companion grass	Total herbage (t DM/ha)	White clover (t DM /ha)	White clover (%)
Aberystwyth S23	7.4	5.1	69
Co-adapted	10.3	7.1	69

Source Evans et al. (1985)

1.2.3 Seed rate

Frame and Boyd (1986) found that at a constant clover seed rate (3Kg/ha), grass seed rate (10-30 Kg/ha) did not influence total herbage or white clover performance, but it did affect the establishment and presence of clover initially.

1.2.4 Application of nitrogen fertiliser

Clover based swards have similar fertiliser requirements to a well managed grass sward in relation to P and K. Repeated application of fertiliser-N to a clover based sward will progressively reduce clover production and content, but will increase total mean herbage production as demonstrated by results published by Frame and Boyd (1987a) Table 1.6.

Table 1.6 Effect of fertiliser N rates evenly distributed in six dressings on annual grass/white clover DM productivity

N (Kg/ha/year)	Total herbage (t DM/ha)	White clover (t DM /ha)	clover (%)
0	7.8	4.1	53
120	8.7	2.4	28
240	10.0	1.1	11
360	11.7	0.5	4

Source Frame and Boyd (1987a)

Frame and Newbould (1986) demonstrated a mean herbage increase of 8 to 9 Kg DM per Kg N applied to clover/perennial ryegrass swards, which is approximately half the increase expected on an all grass sward. At low to moderate N rates a negative response can occur in that the loss in clover production is not compensated by the gain in grass production (Frame,1990).

Frame and Boyd (1987b) and Purvis and Younger (1984) found that Spring-applied N improved total herbage production in early season, but adversely affected clover performance in mid season. Later application reduces the harmful effect on the clover component. An experiment conducted by Frame,(1987) showed an increase in clover productivity with N application. An Autumn fertilizer application reduced clover content to 45%, but maintained clover contribution at 3.4 t DM/ha compared to the control and also increased total herbage production (Table 1.7).

Table 1.7 Effect of Spring, Autumn or Spring plus Autumn fertiliser N application on the productivity of a perennial ryegrass white clover sward

Fertilizer N (Kg/ha/yr) Spring	Autumn	DM (t/ha/yr) Total herbage	White clover	White clover (%)
0	0	7.1	3.4	48
75	0	8.1	2.7	33
0	75	7.6	3.4	45
75	75	8.2	2.2	27
25	50	7.4	3.0	41

adapted from Frame and Boyd, (1987b)

1.2.5 Grass/clover relationship in cut and grazed swards

During the 1980's a number of experiments were carried out on the productivity and relationship between grass and clover in mixed swards under cutting or grazing regimes. Briseno de la Hoz and Wilman (1981) investigated plant morphology under these regimes and found that the selective grazing of sheep led to a large reduction in the amount of stolon, shorter internodes, petioles and leaflets and thinner stolons closer to the ground. Reducing the height of defoliation from 8 to 4 cm above ground level also reduced the dimensions of the white clover. Cattle grazing had a similar effect on clover as comparable cutting treatments, but did reduce the number of tillers and increased the proportion of bare ground. General observations of the experiment were that grazing rather than cutting tended to encourage perennial ryegrass and to discourage Holcus, and that cutting for hay encouraged *Bromus mollis*. Reducing the height of defoliation reduced leaf sheath and blade and the rate of production of new blade per tiller in perennial ryegrass, but increased the total number of grass tillers present.

Purvis and Younger (1984) looked at the relationship between grass and clover yields in mixed swards which had been subjected to either a continuous grazing management by cattle or a monthly cutting regime. A constant grazing pressure was maintained. Results showed that increasing fertilizer N increased grass productivity by substitution of the clover (as shown by Frame and Newbould, 1986 and Frame and Boyd, 1987 a and b) and the rate of substitution, especially within each season was very similar between the cut or grazed sward. However at any grass yield, clover content was higher on the grazed sward compared to the cut swards. Total nitrogen yield was greater for the grazed sward than for the cut sward, reflecting the greater proportion of clover in the sward and the return of nutrients via the grazing animal.

Newton et al. (1985) found that continuous heavy stocking with sheep had a detrimental effect on white clover persistence and production compared with rotational grazing, but sward height guidelines were not used to determine grazing pressure. Parsons, (1987) showed that where controlled continous sheep grazing is practised, clover can be less adversely affected. A possible explanation of the greater depression of clover by sheep than cattle grazing put forward by Parsons (1987), is that the excretal N return pattern is more uniform from sheep than cattle and that sheep selectively graze clover more than cattle.

Therefore in summary the proportion of white clover in a mixed sward is lowered by sheep grazing compared to cutting which is clearly shown in the results of Frame (1976) (Table 1.8). Cattle grazing effects are less severe than sheep grazing and more akin to a cutting situation (Briseno de la Hoz and Wilmen,1981). Clover production, in terms of DM production and nitrogen yield, are greater on a grazed sward compared to cutting (Purvis and Younger,1984).

Table 1.8 Effect of cutting versus rotational sheep grazing on annual grass/white clover DM production

System	N applied (Kg/ha/yr)	Total herbage (t/ha)	White clover (t/ha)	White clover (%)
cutting	0	6.4	2.4	38
	120	7.3	1.5	21
sheep grazing	0	7.1	0.8	11
	120	8.9	0.4	4

Source Frame (1976)

1.3 MILK PRODUCTION ON CLOVER BASED SWARDS

1.3.1 *Ad libitum* versus restricted grazing

The results of an experiment conducted by Santamaria and Rogers (1980) on the efficiency and milk production of dairy cows offered either *ad libitum* (100%) or restricted grazing (60%) on pure white clover or pure perennial ryegrass swards are given in Table 1.9. Their results show that the utilisation of the clover sward was much higher than that of the ryegrass sward, particularly when grazing access is restricted, but the daily pasture allowance in Kg of DM was greater on the clover swards.

Table 1.9 Pre-grazing and post-grazing herbage yields, pasture allowance and utilisation percentage

	Clover		Ryegrass		L.S.D	
Feed level(%)	60	100	60	100	P=0.05	P=0.01
Pre-grazing yld (Kg DM/ha)	2925	2992	1789	1736	206.1	275.2
Pasture allowance (Kg DM/cow/day)	15.0	56.4	14.1	50.3	3.3	4.5
Post-grazing yld (Kg DM/ha)	650	2195	1325	1485	159.1	212.5
% utilisation	77.7	26.7	28.8	14.4	2.9	3.8

where yld = yield

Source: Santamaria and Rogers (1980)

Increasing the pasture allowance of either diet increased both milk yield and protein content (Table 1.10).

Table 1.10 Effect of diet and feeding level on milk production

	Clover		Ryegrass		L.S.D
Feeding level (%)	100	60	100	60	P=0.05
Milk yld (l/d)	15.8a	13.3b	14.0b	11.8c	0.83
Milk fat (g/Kg)	39.4	42.0a	41.9a	41.0b	2.3
Milk fat yld (g/d)	619a	546b	560b	477c	36
Milk protein (g/Kg)	33.4a	31.4b	33.5a	31.4b	0.9
Milk protein yld (g/d)	528a	417c	470b	362d	27

where yld = yield

Means not containing common letters differ significantly ($P<0.05$)

Source: Santamaria and Rogers (1980).

On the *ad libitum* diet, the cows on clover produced 1.8 litres more milk than those fed ryegrass, but their milk fat content was lower. However, the milk fat yield of clover fed cows was increased. Protein content was not affected by the diet, but milk protein yield was higher for cows grazing clover. Therefore, restricting the diet increases the utilisation percentage of the herbage available, but reduces milk yield.

1.3.2 Continuous

Grass/clover swards can be grazed continuously or rotationally. An experiment conducted at Hurley 1981/1982, indicated a slight advantage of continuously grazed swards over rotational grazing (Morrison et al,1985) (Table 1.11).

Table 1.11 A comparison of continuous and rotational grazing by cattle of a grass/clover sward

Management	Herbage yld tDM/ha (% clover)	Grazing days* per ha	Gain Kg/ha/d	Gain Kg/ha	UME GJ/ha
Rotational**	6.4 (46)	910	0.83	755	75
Continuous	7.4 (46)	911	0.90	820	83

* (Steers of 450 and 250 Kg at turn out in 1981 and 1982 respectively

** (28 day recovery interval)

Source Morrison et al (1985)

Under continuous grazing optimum sward and animal performance was obtained at a grazing intensity which maintained a sward surface height of about 8 cm, (this value will vary with cattle productivity) equivalent to a compressed depth of 5-6cm, measured with a rising plate sward meter

(Morrison et al,1985).

1.3.3 Rotational grazing

Little benefit has been found from offering first grazing in a paddock to high yielding cows i.e the leader follower system (Jahn et al, 1983).

1.3.3.1 Grazing intensity

Work carried out by Michell et al (1987) on the effect of grazing intensity of clover rich pastures on milk production by dairy cows showed that increasing the grazing intensity in the spring, above normally accepted levels, increases pasture utilisation in spring and summer and also increased milk production. In detail, a high grazing intensity produced less milk fat (0.79 versus 0.81 Kg/cow/day) than a low grazing intensity in the spring, but produced significantly more milk fat (0.63 versus 0.59 Kg/cow/day) and milk protein (0.44 versus 0.42 Kg/cow/day) during the summer. The authors also noted that in spring despite the higher grazing intensity, there were no differences in the intake of pasture or in the digestibility of herbage selected by the cows.

1.3.3.2 Comparison with grass based systems supplied with Fertilizer N

In a five year summer grazing trial in Eire (Ryan,1989) cows were rotationally grazed on grass/clover, with no fertilizer N (stocking rate 2.52 cows/ha), or grass plus fertilizer N at 361 Kg N/ha/year at 2.46 or 3.2 cows/ha. A grass silage area which received 122 KgN/ha complemented the grass/clover sward. The high N-based, high stocking rate grass system achieved the greatest milk yield per hectare, but due to a higher milk yield per cow, the grass/clover system was able to produce 84% of the milk of that system during the summer (Table 1.12). The high N-based, high stocking system had an increased gross margin compared with the clover system, which in turn produced a better gross margin than the high N-based low stocking rate system.

Table 1.12. Stocking rate, summer milk yield and composition for three grassland systems in Eire

	Cows/ha		Milk yield (Kg)		Milk quality (g/Kg)	
	Turn-out	Overall	per cow	per ha	fat	protein
Grass/clover	3.78	2.52	2738	6900	38.1	36.0
Grass/N(low)	4.92	2.46	2740	6740	38.7	36.3
Grass/N(high)	6.40	3.20	2578	8250	37.8	36.2

Adapted from Ryan (1989)

1.3.4 Strip-grazing

King and Stockdale (1984) studied the effects of pasture allowance on the production of strip-grazed dairy cows in late lactation (Autumn). The cows were strip-grazed ryegrass/white clover or paspalum dominant perennial pastures for 60 days. Mean pasture allowances were 23.2, 13.3 or 6.9 Kg digestible DM/cow/day. It was found that reducing the pasture allowance during late lactation reduced milk yield and body condition (Table 1.13).

Table 1.13. Effect of grazing management and pasture type on milk production and pasture intake

Variable	Pasture Allowance						Difference
	Ryegrass/clover			Paspalum			between
	high	medium	low	high	medium	low	pasture type
4% fat corrected milk (Kg/cow)	10.4a	10.7a	6.1b	9.5x	9.0x	5.0y	NS
Pasture intake Kg DM/cow	9.5a	9.4a	7.3b	10.4x	9.3x	6.5y	NS

For each pasture type, values within rows not followed by a common letter differ significantly ($P<0.05$)

Source: King and Stockdale (1984)

These results are explained by pasture intake being positively related to pasture allowance. Each additional kilogramme of DM eaten produced 0.93 Kg milk and 0.45 Kg milk fat. Cows grazing ryegrass/white clover pastures produced more milk and milk solids at equivalent DM intakes and were in better condition. This was accounted for by King and Stockdale to be due to herbage quality i.e. cows grazing the ryegrass/white clover pasture were able to select higher quality diets than cows grazing the paspalum dominant pasture.

1.4 CONCLUSIONS

The relationship between white clover performance in grazed swards, the proportion grazed and resultant animal production require further investigation to be fully understood. Although a number of experiments have been conducted to determine the optimum grazing system for dairy cattle on ryegrass swards, on white clover/grass swards it is still not clearly defined, but it has been demonstrated that dairy farming on clover swards can give satisfactory and reliable outputs despite some fluctuations in clover contribution from year to year.

1.5 BEHAVIOUR CHARACTERISTICS

1.5.1. Herbage allowance

The majority of work carried out on grazing behaviour characteristics has been conducted on predominantly grass swards and demonstrates that as herbage allowance declines grazing time and rate of biting tend to increase to compensate for reduction in bite size (Jamieson and Hodgson,1979; Le Du et al,1979). When comparing rotationally or continuously grazed cows it has been observed that rotationally grazed cows do not increase their grazing time at low herbage allowances to the same extent as continuously grazed cows (Jamieson and Hodgson,1979). On temperate pasture cows normally graze up to 10 hours/day (Waite et al,1951; Meijs,1981), although grazing times in excess of 12 hours a day have been recorded on tropical pastures (Smith,1955;Stobbs,1974). To sustain maximum herbage intake even at a high herbage allowance a high yielding cow must graze for 9 hours a day or more and there would appear to be little opportunity to increase grazing time when herbage availability is inadequate. Brumby (1959) found that grazing time is significantly related to milk yield.

Herbage intake may be regarded as the product of grazing time, bite size and biting rate (Jamieson,1975). If one parameter is restricted eg.bite size with low density pastures or grazing time with high intake potential dairy cows, the animal attempts to compensate by increasing one or both of the other parameters. It is however essential to examine the relationship between these characteristics for cows grazing high white clover swards (clover content > 50%) and whether the relationships are the same.

1.5.2. Social dominance of cows in a grazing herd

Social interactions exist among cows in a herd structure, therefore one cow can influence the behaviour of another cow. Herbage intake is determined by the time a cow spends grazing, the rate of biting and the size of each bite (Jamieson,1975) and subsequent productivity of the cow. Stakelum et al. (1987) looked in detail at the relationship between the social dominance of cows in a grazing herd and the effect on their milk production, herbage intake and grazing behaviour. The authors found no relationship between herbage intake or any ingestive or grazing behaviour activities and dominance values, but age, body weight and daily milk yield were significantly correlated with dominance (0.50, 0.66 and 0.47 respectively). The authors concluded that under the strip grazing system used in the experiment, social interactions between cows are unlikely to affect herbage intake or grazing behaviour, but the results do show that milk yield was positively correlated with social dominance.

1.5.3. Effect of supplementary feeding on grazing behaviour

Experimentation on the effect of supplementary feeding of hay to dairy cows grazing perennial ryegrass and clover swards at high and low stocking rates, indicated that grazing time was decreased by offering hay, especially at high stocking rates. The relationship between grazing time and milk yield approached significance in early and mid season and was significant at P<0.05 for the late season (Phillips,1983).

Experiments involving supplementary feeding of silage in early and late season to cows set-stocked on a perennial ryegrass/white clover sward, indicated that grazing time was decreased by offering silage both in early and late season. Ruminating time was increased by offering silage, but there were no significant effects on biting rate at pasture. It was noted that as the season progressed idling time declined as grazing and ruminating time increased (Phillips,1983).

1.6 WHITE CLOVER POTENTIAL AS A FORAGE CROP - SILAGE

1.6.1 Nutritive quality

The nutritive quality of the cut crop depends on the stage of growth of the grass and the proportion of white clover. White clover herbage which is almost entirely leaf has a higher D value than grass and falls in quality more slowly over the grazing season. The D-value (%) of the white clover herbage in a conservation crop is between 67 and 70 whereas that of the grass component is 63 to 65 at the same cutting frequency (Morrison et al,1985).

Herbage production and quality from a grass/clover sward (with no fertilizer N) and a grass sward (320-340 Kg N/ha/year) under a silage cutting regime were compared by Roberts et al (1989). They found that the DM yield of the grass/clover sward as a proportion of the grass sward varied between 65 and 78% (overall mean 71%) over 3 full harvest years. The mean values for chemical composition are given in

Table 1.14. This indicates that the grass/clover herbage (mean clover content of 43% DM basis) ensiled was higher in estimated ME, crude protein and mineral contents than the herbage ensiled from the N-fertilised grass sward.

Table 1.14. Chemical composition of ensiled herbage (g/Kg DM).

	Sward type	
	grass/clover	grass + N
OMD	715	688
CP	156	149
P	3.9	3.5
K	25.7	19.4
Ca	10.1	6.0
Mg	2.9	2.5

Source: Roberts et al (1989)

1.6.2. Aspects of ensiling clover from pure and mixed swards, in relation to productivity and quality.

1.6.2.1 Cutting

Infrequent defoliation of high white clover swards reduces the clover content of the sward but, although total herbage DM increases with a rest interval between defoliation, white clover performance is not markedly affected. The following experiments conducted in this field demonstrate how clover can be used successfully as a forage crop.

Increasing the cutting interval from 3-6 weeks increased total herbage production by 1.7 t/ha, but marginally reduced the clover content (50 to 48%). When 108 KgN/ha was applied along with an increased cutting interval the clover content and contribution to total herbage was reduced. Delaying the date of cutting the primary harvest increased total herbage production, but reduced clover content and productivity (Frame, 1990)(Table 1.15).

Results of experimentation carried out by Roberts et al (1989) indicated that grass/clover swards could be ensiled in successive years without detriment to clover contribution. Yields were about 70% of those from grass swards given 300-350 Kg N/ha/year (Table 1.16).

Table 1.15. Effect of delaying primary harvest on annual grass/white clover DM productivity.

Date of primary harvest	Total herbage (t/ha)	White clover (t/ha)	White clover (%)
8 May	8.8	5.6	64
5 May	9.7	5.7	59
19 May	10.1	5.4	53
3 July	10.8	4.2	44

Adapted from: Frame (1990)

Table 1.16. Annual DM production (t/ha) from grass/clover and heavily N-fertilised grass swards

Harvest year	grass/clover	grass/Nitrogen*
1**	3.7	4.8
2	9.4	12.6
3	7.0	10.9
4	8.5	11.6

* 320-340 Kg N/ha/year ** Establishment year

Source: Roberts et al. (1989).

1.6.2.2. Monoculture versus mixed swards

Table 1.17. Annual DM production of white clover monocultures cut for silage

	Total herbage (t/ha)	White clover (t/ha)	White clover (%)
Frame (1986)	8.1	6.3	78
Frame and Harkess (1987)	6.8	5.1	75
Castle et al (1983)	7.0	5.2	76

Source: Frame (1990)

White clover monocultures are less suitable for silage since yields are lower than those produced by a grass/clover sward and it is also difficult to prevent invasion of unsown species (Frame,1990)(Table 1.17).

1.6.2.3. Wilting

White clover herbage has a higher water content and a greater buffering capacity than grass herbage. This initiated work on the effect of wilting on subsequent DM intake and milk production of silage fed to cows.

Wilting to 32% DM compared to unwilted 18 % DM was found to increase the average daily *ad libitum* DM intake from 9.4 to 12.1 Kg/cow (Carruthers,1985). Similar increases were recorded by Rogers et al. (1987), where an increase in intake was marginally reflected by an increase in milk yield from 7.9 to 8.3 Kg/day. Restricting the intake of wilted silage did not affect milk yield but offering unwilted silage at the same rate decreased the mean milk yield to 7.3 Kg/cow (Carruthers,1985). Rogers et al (1987) found wilting had little effect on milk yield and liveweight gain, but did decrease milk protein content by 4 g/Kg.

Carruthers (1985) found that precision chopping/ chopping increased DM intake without affecting milk yield or composition, whereas Rogers et al (1987) concluded that length of chop had no effect on intake or milk production and composition. From the results of these two authors, it would appear that wilted rather than unwilted clover herbage does have some beneficial effects on milk yield, but it can reduce milk protein content.

Morrison et al. (1985) stated that over wilting, i.e to over 35% DM, can have detrimental effects since DM may be lost via clover leaf blades in the field. This was confirmed by work conducted by Skouborg et al. (1988) on the degree of wilting. They found that a further increase in wilting to 50-55% DM did not significantly improve silage quality, DM intake or milk production.

1.6.2.4. Additives.

Due to the higher water content of clover herbage it is standard practice to use an acid additive to aid stable fermentation of the ensiled herbage. The amount of additive required depends upon the water content and the proportion of clover in the crop to be ensiled (Table 1.18).

Table 1.18. Guide to additive use for grass/clover silage.

	Clover content		
	low (up to 15%)	moderate (15-40%)	high (over 40%)
DM content (%)			
less than 20	3	3	3
20-25	2	2	3
over 25	1	1	2

where, 1- low rate of additive, insurance only
2- recommended rate
3- high rate, consult manufacturer

Source: Morrison et al (1985).

1.7 PRODUCTION POTENTIAL IN DAIRY SYSTEMS.

Experimental feeding of grass/clover silage repeatedly demonstrated the quality and production potential of clover compared to grass. An experiment conducted by Roberts and Kelly (1987) showed growth rates of 0.72 and 0.48 for calves and 0.76 and 0.53 (Kg/day) for bulling heifers on grass/clover and grass silage respectively.

Castle et al. (1983) studied the effect of manipulating the amount of white clover silage in the diet (Table 1.19).

Table 1.19. Effect on milk production of manipulating the amount of clover silage in the diet.

Proportion of silage GRASS	CLOVER	Milk yield (Kg/day)	Fat (g/Kg)	Protein (g/Kg)
100	0	19.0	39.1	30.0
75	25	20.6	39.8	30.1
50	50	20.3	40.5	31.1
0	100	21.0	41.8	31.0

Source: Castle et al. (1983)

A direct comparison between grass and clover silage illustrated that the clover silage produced an increase in milk production as the proportion of clover in the silage increased. This trend was also apparent in milk fat and protein contents.

A major farmlet study was initiated in 1988 at the West of Scotland College of Agriculture (Crichton Royal Farm,Dumfries) to compare the performance and profitability of a dairy herd based on a grass/clover sward (no fertilizer N) with a high nitrogen grass system (350Kg N/ha/year) (Frame 1990). Although quantities of clover seed sown were given (4Kg/ha), actual clover content of the established swards that were grazed or ensiled were not given. The results are therefore recorded as a direct comparison of a grass/clover and grass plus high nitrogen system. The results show that the grass plus nitrogen system achieved a greater harvested yield of silage compared to the grass/clover system (230 and 170 t DM respectively). Values of silage composition were similar for the first cut and are given in Table 1.20. High clover silage achieved higher ME and DM contents, but the grass plus N system had a higher crude protein value (i.e. associated with the high nitrogen rate applied to the sward).

Table 1.20.First cut Silage quality from the dairy farmlet comparison at the West of Scotland College of Agriculture in1988-1989 Year 1.

	grass/clover	grass + N
ME (MJ/Kg DM)	11.2	10.9
CP (g/Kg DM)	126	160
DM (g/Kg)	183	177

Source: Frame (1990)

Feed intakes of silage were similar on a dry matter basis (grass/clover 1923.3 and grass+ N 1973.2 Kg DM/ cow), but in the grass/clover system cows were additionally fed 202 Kg fresh weight straw/ cow and 1709 compared to 1413 concentrates/cow (Kg) in the grass + N system. This gave a value of 0.3 compared to 0.24 (Kg) concentrates/litre for the grass/clover, grass + N system respectively. Milk composition is given in Table 1.21.

Table 1.21. Milk composition and Scottish Milk Marketing price for dairy systems comparison at West College in 1988-1989 Year 1.

	grass/clover	grass + N
Milk fat (g/Kg)	40.0	39.5
Milk protein (g/Kg)	31.9	31.8
Milk Price (pence/litre)	18.13	18.03

Source: Frame (1990).

The marginally higher values of milk fat and protein content were reflected by the higher price/litre achieved on the grass/clover system (Table 1.21). Total output data of the two systems is given in Table 1.22.

Table 1.22. Output data from dairy systems comparison at West College in 1988-1989 - Year 1.

	grass/clover	grass + N
Milk sales/year (l/cow)	5658	5764
Concentrates (Kg/cow)	1709	1412
Margin over concs (£/cow)	827	872
Gross margin (pence/litre)	14.55	14.68
Total gross margin (£/ha)*	1804	1856
Fixed costs (£/ha)	1102	1107
Total farm surplus (£)	25261	26956

*- Dairy cows, young stock and over-wintered sheep

Source: Frame (1990)

When all the results are considered, it would appear that a grass clover system could be viable for dairy cows, but feed and fertilizer prices exert a strong influence.

1.7.1 Unsupplemented grass and grass/clover silage.

Reeve, (1989) stated that grass silage has the theoretical potential to support maintenance and the production of 13-25 Kg milk/day from daily intakes of 14-16 Kg DM, based upon observed performance of grazing dairy cows or predictions of dry matter intake limits. In trials where high-quality grass silage has been offered as the sole feed to cows in mid-lactation, intakes of 11-13 Kg DM/day and milk yields of 13-16 Kg/day were achieved. In longer trials , where cows were offered only grass silage from calving to turn-out intakes of 11-14 Kg DM and milk yields of 16-21 Kg milk/day were achieved. Trials conducted on white clover and Lucerne silages have achieved higher DM intakes with values ranging from 15-19 Kg/day and recorded milk yields of 14-26 Kg/day.

Therefore grass silage can approach intake and production potential, but clover and Lucerne silages tend to approach their potential more consistently.

1.7.2. Supplementation of clover silage.

Castle et al. (1984) found similar milk yields were achieved for cows given either barley or soya bean supplements with white clover silage, (28.0 and 28.6 Kg milk/cow respectively), but offering a mixture of barley and soya bean marginally reduced milk yield (27.6 Kg/cow). The authors concluded that the white clover silage used (cv. Blanca) had an excellent fermentation and a large potential for milk production as previously shown by Castle et al (1983).

1.7.3. Buffer feeding.

Matching the herbage production to the requirements of grazing dairy cows is difficult due to the unpredictability of herbage production throughout the season. This can reduce the efficiency of the system in relation to production/hectare by low stocking rates. Conversely too high a stocking rate leads to under feeding during certain periods in the grazing season. Conserved forage can be used as a supplement for grazing dairy cows to reduce the variability in forage intake by the cow and allow an increase in pasture stocking rate to improve land use efficiency (Phillips, 1988). This is carried out by offering a buffer feed, a homegrown or purchased feed, available *ad libitum*, when nutrient intake from the basal forage is restricted (Greenhalgh,1975). The amount of buffer feed required is determined by the variation in herbage intake and quality. A review by Phillips (1988) indicated that buffer feeding reduced total nutrient intakes and milk fat and protein yields when compared to cows offered *ad libitum* herbage only, but these variables are increased when a buffer feed is offered to cows on a restricted herbage level. The author proposed that increasing pasture stocking rates may allow increases in utilised metabolisable energy levels from grassland, but that further research is needed. Both grass and maize silage supplements offer potential for increasing the efficiency of land use, but in the case of grass based silage this is only achieved in the best management practises.

1.7.4 Strawmix supplements.

The high fibre and low protein content of straw led to its use as a supplement to intensively fertilised pasture with a low fibre and high protein content. It has mainly been offered with *ad libitum* rather than restricted herbage and has been fed either alone, or mixed with a high energy,low protein supplement such as molasses (Hildebrandt,1958) or potato flakes (Sjolemma,1950). Recently there has been renewed interest in straw fed as a strawmix containing a high energy and high protein content via addition of molasses and barley or soya respectively for use in step-feeding or as a buffer feed.

1.7.4.1 Use in a partial storage feeding system.

Roberts and Kelly,(1990) conducted an experiment to compare the feeding value of silage with a straw/concentrate mixture when both were fed as supplements to set-stocked dairy cows on a partial storage feeding system. Three groups of cows were either grazed conventionally (G) or grazed between morning and afternoon milkings and housed overnight and offered grass silage (Si) or a straw/concentrate mixture (St) *ad libitum*.

The straw/concentrate mixture contained proportionately :- 0.33 long barley straw, 0.28 ground barley, 0.12 soya bean meal, 0.25 molasses and 0.02 minerals.

The chemical composition of the feeds is given in Table 1.23. They found that cows ate more of the straw/concentrate mixture than silage, with a corresponding reduction in herbage intake (Table 1.24).

Feeding the straw/concentrate mixture increased total DM intake, but the estimated total ME intake was similar for cows solely on grass and cows receiving the straw/concentrate mixture *ad libitum*. The provision of silage during the night reduced milk yield compared to cows continuously grazed. Whereas the straw/concentrate mixture overall achieved similar results to G, when broken down by periods through the trial, the cows on the straw/concentrate mixture produced more milk during the latter part of the season than cows continuously grazed.

Table 1.23. Chemical composition of feeds.

	Straw/concentrate	Silage week 1-8	Silage week 9-24
ME (MJKg/DM)	10.1	9.5	10.6
CP (g/Kg/DM)	134	160	191
Oven DM (g/Kg)	826	162	156

adapted from: Roberts and Kelly (1990).

Table 1.24. Estimated herbage and buffer feed intake (KgDM/d) and ME intake(MJ/d).

	G	Si	St
Herbage	11.7	6.8	4.1
Silage/strawmix		5.1	9.1
Total	13.5	13.6	15.0
Total ME	163	155	163

Source: Roberts and Kelly (1990).

Feeding silage improved milk fat content by 2.3 g/Kg, but was not statistically significant (Table 1.25). The authors proposed that the lack of response to storage feeding could be due to the low level of concentrate in the mixture (0.67 of the total DM).

Protein content and yield were decreased by housing the cows overnight, especially when they were fed silage. Finally no significant differences were found in liveweight change between treatments. This experiment demonstrated that although the two feeds used had similar ME contents, animal productivity was different. Therefore physical characteristics and the nutrient intake from the feeds are important criteria when considering the potential of a buffer feed, (Roberts and Kelly, 1990).

Table 1.25. Milk yield (Kg/d) and milk composition (g/Kg)

	T R E A T M E N T S			
	G	Si	St	S.E.D
Milk yield	19.2	17.5	19.1	0.87
Milk composition				
Fat	36.9	37.6	37.1	1.22
Protein	35.3	32.9	33.4	0.76
Lactose	45.9	46.4	46.9	0.42

Source: Roberts and Kelly (1990).

1.7.4.2. Variation in ME values.

The latter experiment prompted further work by Roberts (1990) on the effect of varying the ME content of the straw/concentrate mixture on animal productivity. It was found that as the ME value of the straw/concentrate mixture increased the intakes also increased. This was associated with a decline in estimated herbage intake. Grazing time was reduced by as much as 1.4 h/day for cows on a high ME (154 MJ/d) compared to cows on the low ME (141 MJ/d) straw/concentrate mixture. Milk yield was reduced by offering the low ME straw/concentrate mixture. There was no difference between the continuously grazed or the high ME straw/concentrate treatments.

It was concluded that the use of partial storage feeding system with a low ME straw/concentrate mixture led to a reduced total ME intake and animal performance, but an increased stocking rate. When a high ME straw/concentrate mixture was used there was an indication that the supplement did not act as a buffer but substituted for grass. Therefore the ideal chemical composition of a buffer feed (which can be easily produced in a straw/concentrate mixture) will depend on the milk yield of the cow, physical characteristics of the buffer feed, herbage availability and finally the desired stocking rate.

All the experimentation to date has been related to grass swards, but the versatility of the straw/concentrate mixture, with prospects of increasing stocking rates could be beneficial in high white clover based systems and additionally the presence of a high fibre content in the straw/concentrate could reduce the problem of bloating associated with clover.

1.8. BLOAT.

Scientific interest in pasture bloat began in the 1940's, when experiments were carried out to determine the possible cause and prevention of bloat. The foam hypothesis was firmly established as the cause of bloat for many years (Howarth,1975). Unequivocal evidence to support this hypothesis at the time was that surface active agents, such as oils,fats and detergents were used to prevent and treat bloat. These allow the coalescence of the small gas bubbles distributed throughout the rumen during the occurrence of bloat. Bloat results from a failure in eructation of these gases produced by microbial fermentation in the rumen. There are two major types:-

(1) frothy or foamy bloat, where the gas remains trapped as tiny bubbles in the rumen ingesta. This occurs on legume based diets.

(2) free gas bloat, where the gas separates from the rumen contents, but eructation does not occur.

1.8.1. Legume pasture bloat.

Cattle appear to be at risk of frothy bloat when the content of certain legumes in the pasture exceeds 50%. Bloating would normally occur within two to three hours after being offered the bloat provoking forage although it may occur as early as 20 minutes. Many factors contribute to bloat, a correlation of outbreaks and associated factors by Howarth (1975) led to a generalisation of the possible causes such as, the occurrence of bloat increases during the pre bloom stage of legume growth and where field conditions allow a rapid vegetative growth. Also cool nights, which may result in heavy dew, have been associated with bloat. Reid, (1973) reported that bloat does not occur during dry weather and may return 3-7 days after rain. Since the review of bloat in cattle by Howarth (1975) many workers have experimentally studied the possible causes of bloat, looking at cell structure and components of bloat-causing and bloat-safe legumes, and also animal characteristics such as breed susceptibility and rumen microbiological components.

1.8.2. Role of the forage legume in bloat.

Ruminant animals may bloat when they graze certain leguminous crops. Howarth et al. (1978) put forward a possible explanation as to why particular legumes cause bloat, while others do not. This was the cell rupture hypothesis, which states that leaf cell rupture, either mechanical or enzymatic and the ensuing release of intercellular constituents are important events affecting the bloat potency of fresh herbage. Cheng et al. (1980) working on the sequence of events in the digestion of fresh legume leaves by rumen bacteria found that damage to leaf tissue via chewing provides sites for invasion by these bacteria and also mechanical rupture of leaf mesophyll cells immediately releases cellular constituents for fermentation (Reid et al,1962). Therefore considering previous work, it was suggested by a number of authors (Fay et al. (1980) that the chewing action of ruminants disrupts the cells of bloat-causing legumes to a greater extent than bloat-safe legumes. In the latter a reduced rate of the digestion of the leaves by the rumen microorganisms and increased mechanical strength of the leaf epidermal layers and mesophyll cell walls are important in resisting this type of damage.

1.8.2.1.Mechanical damage and the cell wall.

Early work by Reid et al (1962) on red clover showed that chewing damaged 60% of cells and Fay et al (1980a) using chewed herbage from rumen fistulated cattle demonstrated that in vitro digestion of bloat-causing legumes was faster and produced more foam in the digestion flasks than bloat-safe legumes, indicating greater cell rupture.

Lees et al (1981) looked at the effect of mechanical disruption of leaf tissue and cells of three bloat-safe and three bloat-causing forage legumes to identify characteristics which might contribute in resisting cell and tissue rupture during chewing. The leaves were either shaken with glass beads, homogenised by a ground glass tissue grinder or sonicated. Cell disruption in alfalfa and white clover (bloat-causing) as attributed to weak cell walls and low tissue strength, while in the bloat-safe legumes, bird's foot trefoil, *sainfoin* and *cicer vetch* cell walls were moderately strong combined with a high degree of tissue strength. The authors, concluded that their results could be extrapolated to the events preceeding bloat in the ruminant animal. This work gives a greater insight into the differences between bloat-safe and bloat-causing legumes. When whole leaves were crushed by shaking with glass beads to mimic cell disruption of some leaves due to chewing, cell disruption was determined by cell wall strength alone or in connection with tissue strength and cell to cell adhesion, thus influencing the bloat potential of the legume. This prompted further work by Lees (1984) on cuticle and cell wall thickness in relation to mechanical strength of whole and isolated cells from bloat-safe and bloat-causing legumes. The role of the cuticle in resistance to mechanical damage was not clearly shown, but it was stated that among the species studied mean cuticle thickness had the largest variation coefficient, which is reflected in the distinct separation of the species based on cuticle thickness in Table 1.26. Additionally *sainfoin* had the thickest cuticle in both epidermal layers and showed greatest resistance to leaf disruption by sonication. Conversely red clover leaflets had the lowest proportion of cuticle in both epidermal layers and were damaged easily by sonication, but it must also be mentioned that alfalfa showed 45% disruption with a relatively high mean cuticle thickness.

The results of this study show that all three layers i.e. cuticle, epidermal and mesophyll cell wall were thicker in the bloat-safe legumes, which also exhibited greater resistance to epidermis or cell rupture. This demonstrated that cell wall and cuticle thickness i.e. leaf morphological characters are related to the mechanical strength of whole leaves and isolated cells, which in turn contribute to the non-bloating nature of the bloat-safe legumes. This relationship could be used in future breeding programmes to select for bloat-safe strains of leguminous plants.

Table 1.26. Mean cell wall and cuticle measurements (nm) from the adacial and abaxial epidermis of seven forage legume species compared to the percent leaf disruption by sonication.

Species	Cell wall + cuticle	cell wall	Cuticle	Percent disruption
Red clover	997*	958a	38a	42ab
White clover	1149ab	1055ab	93b	32b
Alfalfa	1229abc	1120abc	109b	45a
Arrowleaf clover	1333bc	1248bc	85b	36ab
Birdsfoot trefoil	1335c	1185abc	150c	35ab
Cicer milkvetch	1474c	1325c	149c	21c
Sainfoin	1976d	1734d	242d	17c
SE**	+93	+87	+12	+4

where
* Means with the same letter are not significantly different (P=0.05) using Duncan's multiple range. n=20.
** Pooled standard error of the means of seven species.

Adapted from: Lees (1984).

1.8.2.2. Rumen micro-organisms.

Cell sap nutrient fermentation is a major source of initial gas production in the rumen, this is important in legume pasture bloat, since the gas produced from microbiological digestion of forage remains dispersed throughout the rumen ingesta giving rise to the frothy appearance of the rumen contents. Bloat-causing legumes are prone to leaf disruption by chewing therefore allowing rapid access to cell contents to the rumen micro-organisms. Cheng et al (1980) described the sequence of events during invasion and digestion of fresh legume leaves by rumen bacteria . They found that the time required for bacterial penetration through leaf tissue was greater in bloat-safe legumes. Fay et al (1980a), studying the in vitro digestion of bloat-safe and bloat-causing legumes, found that gas production from whole or chewed leaves was greater in the bloat-causing legumes in the relative order *alfalfa* > white clover > red clover > *cicer vetch* > bird's foot trefoil and finally *sainfoin*. The authors believe that once the variability in the measurement of gas production is reduced this technique could be useful as a bioassay to differentiate between bloat-safe and bloat-causing lines in a plant breeding programme. Further work by Fay et al. (1980b) involved scanning electron microscopy, a new technique of using ruthenium red to detect foci of bacterial digestion in mounts of whole leaflets that have been incubated with rumen bacteria. This technique showed rapid breakdown of the bloat-causing legume, alfalfa, where massive bacterial adhesion and proliferation were noted at the stomata and sloughing of the epidermis, after 6 hours of incubation, whereas only a few isolated bacteria adhered near the stomata of the sainfoin leaflets (bloat-safe legume). Dry matter loss due to leaching or bacterial digestion when whole leaflets of legume were suspended in an artificial rumen medium, alone or with rumen bacteria was significantly higher in the bloat- causing legume. It was found that values of leaching and bacterial digestion were positively correlated. The authors suggested that the extent of leaching of leaflet constituents is a determinant on the extent of subsequent bacterial digestion of the leaflet. The lower rate of bacterial colonisation of sainfoin leaflets may be a result of reduced DM loss by leaching, but also the epicuticular wax of sainfoin contains a high content of anti-microbial substances i.e. tannins, which reduce the proliferation of bacteria on the leaf.

This rapid release of nutrients from bloat-causing legumes by leaching and by early stages of microbial digestion may explain the rapid onset of frothy bloat after the ingestion of fresh forage.

Theodorou, Austin and Hitching (1984) used fistulated steers fed on grass or either mature or immature clover to compare microbiological aspects of bloat. Previous work in this field had been conducted under laboratory conditions. An anaerobic glove box and agar plate tehnique were used to determine the viable bacterial population of the rumen prior to feeding. The results show that rumen fluids from animals fed on clover contained up to 23 times more viable bacteria prior to feeding, than samples from the same animals fed on grass. The highest viable cell counts were obtained from animals fed on bloat-causing immature white clover. Enrichment culture demonstrated differences between the microbial population of animals fed grass or clover. Animals receiving clover diets produced predominantly *Lachnospira* species, which were identified by reference to a type culture. These were not found in cultures from grass fed animals. In cultures where this bacteria species predominated, filamentous mats were produced which had the ability to trap particulate material. other micro-organisms and gas. Animals fed immature white clover produced extremely high values of the inoculum in the rumen and appeared to correlate with the incidence of bloat. The high inoculum potential within the rumen on clover based diets could explain why bloat is such a rapidly occurring condition.

1.8.3. Factors in animal susceptibility to bloat.

1.8.3.1. Variation between breeds.

Susceptibility to frothy bloat varies among cattle. Carruthers et al. (1987) found from a survey of 312 dairy farms in New Zealand in 1986 that death rates were higher in Jerseys (1.42%) than in Friesians (0.88%), Friesian x Jersey (0.72%) or Ayrshires (0.84%) and also death rates were greater in milking cows (0.83%) compared to young stock (0.23%). Howarth (1975) had previously estimated that approximately 30% of cattle are susceptible to bloat under conditions normally encountered in practice.

1.8.3.2 Genetic variation.

Evidence that susceptibility to bloat is a heritable trait is provided by greater incidence of bloat in progeny of certain sires (Howarth,1975).

1.8.4. Agents which reduce bloat.

1.8.4.1. Anti-foaming compounds.

Anti-foaming compounds such as salivary mucin, promote coalescence of the bubbles of gas produced and trapped in frothy bloat. The rate of salivation is decreased by consumption of succulent forage, since the chewing action is reduced thus promoting bloat, as seen by the increased occurrence of bloat for cattle fed immature clover (Theodorou et al, 1984).

Tannins (flavins) found in the epicuticular wax are thought to be anti-foaming compounds which reduce bloat (Fay et al, 1980a). Further evidence to support this is that bloat-safe legumes such as sainfoin are rich in tannins.

Barry and Reid (1985) looked at the nutritional effects attributable to condensed tannins, cyanogenic glycosides and oestrogenic compounds in leguminous plants. High concentrations of low weight tannins were found to reduce plant protein degradation and increase amino-acid supply to the animal; legumes containing high concentrations of the condensed tannins in stem and leaf tissue do not cause bloat. These tannins are present in the flowers of white clover, but this species still causes bloat, because the tannins separate from the soluble leaf protein. Therefore introducing these condensed tannins into other portions of the herbage would reduce the bloating potency of white clover.

1.8.4.2. Bentonite.

Carruthers (1985) found that dusting the bloat-causing pasture with sodium bentonite at a rate of 600g/cow daily significantly reduced the incidence of bloat. ($P<0.1$). In a second trial where dairy cows in late lactation were fed cut Lucerne and ryegrass/white clover at 80% ad-libitum, with bentonite added at 0, 3 or 6% DM in a Latin square design. Bloat was again significantly reduced. In the latter trial bloat was decreased as the level of bentonite increased. Milk yield and composition were not affected by the addition of bentonite in the diet. Moate et al (1985) also achieved similar results, but attributed reduced bloat to a reduction in DM intake, which was accompanied by a decrease in milk yield.

1.8.5. Treatment.

Frothy bloat can be treated with anti-foaming agents. Commercial preparations contain detergents and other anti-foaming substances which provide rapid dispersion of the foam. Mineral and vegetable oils are also effective. The only problem with the latter is that they are rapidly degraded in the rumen therefore reducing the period of effectiveness. In mild cases of bloat briskly walking the animal around for 20-30 minutes will stimulate gas eructation and alleviate the bloat. In severe cases the animals rumen has to be cannulated.

CHAPTER TWO

EXPERIMENT 1. THE EFFECT ON MILK PRODUCTION AND COW BEHAVIOUR OF COWS GRAZING WHITE CLOVER/GRASS SWARDS AT CONTRASTING HEIGHTS.

2.1 INTRODUCTION.

White clover is mainly grown with grass in mixed swards in Britain. The root nodules of white clover fix atmospheric nitrogen by rhizobium bacteria, thereby supplying sufficient N for it's own needs. The grass component in the sward also receives nitrogen from decaying clover root nodules, leaf and root tissue in the soil. Grazing activity on clover/perennial ryegrass swards also leads to return of nitrogen via urine and faeces. Grazing pressure also has an effect on plant morphology, reducing the height of defoliation from 8 to 4 cm above ground level has produced a reduction in the dimensions of white clover. Cattle grazing was found to have a similar effect to cutting, but reduced the number of grass tillers and increased the proportion of bare ground,(Briseno de la Hoz and Wilman 1981).

Grazing high clover swards has led to increased milk yields, (Santamaria and Rogers, 1980), but the majority of work has been with cut or grazed pure clover swards. Studies on grazing behaviour of dairy cows has indicated that cows are able to manipulate grazing behaviour via bite size, biting rate while grazing and duration in respect to herbage allowance,(Jamieson et al,1979; Le Du et al,1979).

The aim of this experiment was to study the effect on milk production and behaviour of dairy cows grazing a clover/perennial ryegrass sward at two contrasting heights and the effect on the pasture in relation to the grazing pressure. A choice treatment was implemented to see if the cows could maintain a selection of low and high herbage or would they graze one sward excessively to the detriment of the other sward.

2.2 MATERIALS AND METHOD.

The trial was performed at the University college farm at Aber, Gwynedd (Lat 652,Long 727, sheet 115, scale 1:50,000). The nine week change-over design trial was undertaken during the late grazing season of 1988, using 12 spring calving British Friesian dairy cows. Prior to the trial the cows were grazed on predominantly perennial ryegrass swards with limited access to the high white clover/perennial ryegrass (clover/prg) sward used in this trial. From the commencement of the trail on August 2nd the cows were grazed entirely on a high white clover/perennial ryegrass sward. Milk production data, behaviour studies and sward measurements were recorded throughout the trial.

2.2.1 Cow management.

Twelve British Freisian/Holstein cows from second to fourth lactation were allocated to a three treatment, three period change-over design using completely balanced Latin squares with three week periods. The cows were ranked in relation to milk yield, calving date and age to give four blocks,defined as follows,very high (VH), high (H), medium (M) and low (L) yielders. Each cow was then given a cow number (1-3, 4-6, 7-9 and 10-12 respectively). This was used to determine the treatment allocation to each cow within a period. (Table 2.1).

Each period lasted three weeks to allow the cows time to adapt to the new sward height and grazing regime before milk production and behaviour studies were recorded. The treatments were as follows:-

1- grazing 4cm high white clover/prg sward (4)

2- grazing 8 cm high white clover/prg sward (8)

3- choice of grazing the 4 or 8 cm high white clover/prg sward (choice).

Table 2.1 Change-over design used in Experiment 1.

	Block 1 (VH)			Block 2 (H)			Block 3 (M)			Block 4 (L)		
	1	2	3	4	5	6	7	8	9	10	11	12
	TREATMENTS											
Period 1	1	2	3	1	2	3	1	2	3	1	2	3
Period 2	2	3	1	3	1	2	2	3	1	3	1	2
Period 3	3	1	2	2	3	1	3	1	2	2	3	1

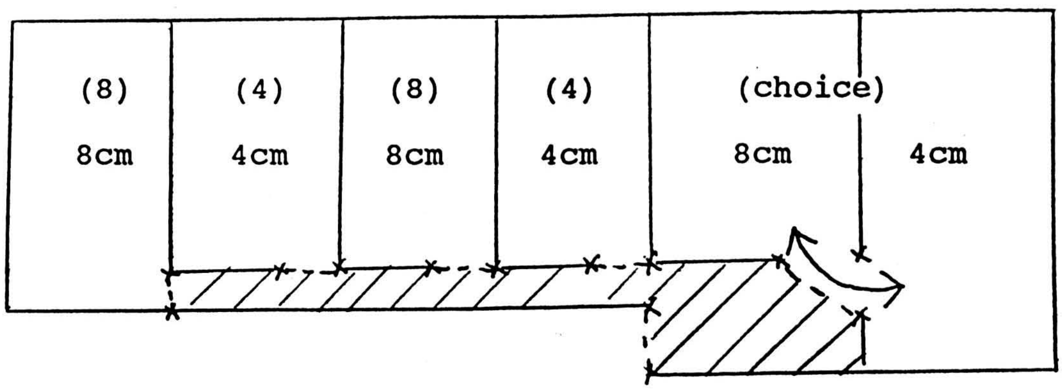
where Treatment 1- 4cm sward
2- 8cm sward
3- choice between 4 and 8 cm sward.

The cows were milked at 05.45 hrs and 14.30 hrs and then returned to the treatment paddocks. The cows had coloured plastic tape attached to their tail to help distinguish cows in each treatment and allocation to the various paddocks.

2.2.2 Pasture.

The experimental pasture consisted of one white clover/prg sward, which had been reseeded in 1986 with perennial ryegrass and white clover c.v. Blanca. The field was divided up into six equally sized electrically fenced paddocks which had been grazed by dairy cattle under trial throughout the spring and summer up to the commencement of this trial. During the previous trial carried out by Murray Evans, the paddocks had been grazed to maintain a sward height of either 4 or 8 cms. An electric fence at the bottom of each paddock was moved up to twice a week when necessary to adjust the area available for the cows to maintain a constant sward height. The 4 and 8 cm paddocks alternated along the field to reduce bias in relation to soil type, drainage and weather conditions. Each paddock was supplied with fresh running water (Diagram 2.1). In the 4 and 8 cm treatments the cows were divided into two groups per treatment and grazed on separate paddocks to reduce group grazing behaviour. In the choice treatment the cows were given a choice of grazing either the 4 or 8 cm high swards. The cows were turned out to a small enclosed area in front of the paddocks so that they had to actively choose which paddock to graze. Fertilizer was not applied to the experimental field during the trial.

Diagram 2.1 Paddock distribution within experimental field.



where

( ) treatment
4 and 8 cm herbage height

gate
passage way and sorting area

2.2.3 Sward measurements.

The sward height in each paddock was recorded twice weekly, using a rising plate meter produced by the MMB (Baker,1980). Sward height was taken as the mean value of 20 measurements taken randomly along a set `W' shaped course in each paddock.

Sward composition was determined by cutting fresh sward samples from each paddock and sorting into the various sward components every 3 weeks throughout the trial. Four identical quadrats (1m x 0.1m) were laid on the ground, their position pre-determined by set random co-ordinates. These were then ranked in relation to visual clover content, low (L), medium (M), high (H) and very high (VH) and only one sample was cut each time the quadrats were set out. Initially the L quadrat was cut and the sample obtained was kept in a separate sealed plastic bag. This procedure was continued until three samples of each rank L,M,H and VH were obtained from each plot. The samples were kept in cold storage (to reduce respiration and weight loss) until they could be sorted into the various sward components and oven dried at $80^{0}C$ until there was no further change in weight on two subsequent weighings. This weight was used to calculate clover percentage and other sward component relationships on a DM basis. The samples were then milled using a 2mm sieve and placed in a sealed plastic bag, so that chemical analysis of crude protein, ash and modified acid detergent fibre (MADF) could be carried out at a later date using two procedures of MAFF (1985).

2.2.4 Animal measurements.

2.2.4.1 Milk yield.

Milk yield was recorded in Kg/day on four consecutive days at the end of the last week of every three week period throughout the trial. The daily value was taken to be the sum of the evening and following morning milk yield and was defined as the visible line below the froth, in all cases 0.2 Kg was added to compensate for the froth.

2.2.4.2 Milk sampling and chemical analysis.

Individual whole milk samples were taken on four consecutive days at the end of the last week of the three week period. A sample was taken at an afternoon milking (14.30 hrs) and the following morning milking (5.45 hrs) from the milk storage jar as recommended by the Milk Marketing Board (MMB) and preserved with potassium dichromate tablets (Lactotabs Mark 3) which contain 30 mg potassium dichromate and 20 mg salt . The samples were then stored in cold storage at -4^{o}C for up to seven days until analysis for crude protein and butterfat content by the Kjeldahl and Gerber methods were determined respectively (MAFF,1985). The mean value of the 4 days were used for data analysis of the period and for individual cows in the trial.

2.2.4.3 Cow behaviour.

Cow behaviour characteristics were recorded for one 24 hour period at the end of the second week of every three week period, during which time grazing, ruminating either while standing or lying, lying, walking and sleeping time and biting rate were recorded. To facilitate observation the cows had large conspicuous numbers painted on both sides of their bodies in a white emulsion paint. These numbers were picked up at night using a portable re-chargeable 12 volt torch.

Grazing behaviour was recorded every 5 minutes during the day light and every 15 minutes at night. If all the cows were clearly visible, time between observations was reduced to achieve more accurate values for time spent at various activities. Grazing time was also split up into day time (5.45-14.30 hrs) and night time (14.30-5.45 hrs) to analyse any grazing periodicity.

Biting rate was defined as the total number of bites taken on the pasture in 90 seconds without a break of more than 10-15 seconds and was recorded every 30 minutes for each cow.

Ruminating behaviour was recorded every 5 minutes in the field during day light hours and every 15 minutes at night. If a cow was observed to be ruminating i.e. regurgitating and chewing a bolus and subsequently swallowing it then it was assumed that the cow had been ruminating for the whole of the 5 or 15 minutes. Ruminating behaviour was also recorded during milking and time spent in the collecting yard prior to milking. The remainder of the time spent milking was classified as milking on the record sheet.

Sleeping was defined as, if the cow appeared to be asleep with her head tucked in to her side and subsequently shining a torch towards her face did not disturb or make her move in any way. This was recorded every 5 or 15 minutes.

Walking was defined as periods greater than two minutes walking at any one time. Walking for milking purposes was recorded under milking.

2.2.5 Statistical analysis.

Milk production and behaviour parameters were analysed using the Latin square analysis (Genstat 4 copywright,1984) available on the U.C.N.W. Bangor vax cluster. Sward botanical content and chemical composition were analysed using two way analysis of variance (Copyright 1989) available in the Minitab statistical package. Herbage height was analysed using oneway analysis of variance in Minitab.

2.3 RESULTS.

2.3.1 Herbage Height.

Results of analysis of variance of sward height indicated that the 4 cm swards in the 4 and choice treatments were similar, 3.5 (S.D 0.3) and 3.6 (S.D 0.2) cm respectively, but variation between swards and within swards were greater in the 8 cm swards of treatment 8 and choice, 6.4 (S.D 0.5) and 5.8 (S.D 0.5) cm respectively. Mean herbage height of the choice treatment was 4.7 compared to 5.0 cm of the treatment 4 and 8 combined.

2.3.2 Stocking rate.

Stocking rates declined with time. A mean value of 0.39 ha/cow was recorded for the choice treatment while mean value for treatments 4 and 8 combined was 0.37 ha/cow. Table 2.2.

Table 2.2 Stocking rates on the experimental swards.

	Stocking rate (hectare/cow)			
	PERIOD			
Treatment	1	2	3	Mean
8	0.41	0.45	0.50	0.45
4	0.23	0.29	0.36	0.29
mean 8 and 4	0.32	0.37	0.43	0.37
choice 8cm	0.37	0.41	0.41	0.40
choice 4cm	0.32	0.39	0.46	0.39
mean choice	0.34	0.40	0.43	0.39

2.3.3 Pasture data.

The botanical content of both swards studied are given in Table 2.3 and the chemical analysis of crude protein, MADF and ash of the clover and grass in each sward type are given in Table 2.4.

The seasonal growth of the clover component in each sward varied between paddocks. The mean clover content for the experimental period was greater for the 4 cm paddocks but were not statistically significant (Table 2.3). Clover content of all the experimental paddocks peaked during the second period in the trial. The weed content of the paddocks tended to increase with time associated with a corresponding decline in grass.

Mean clover crude protein value was 90 and 78% greater than the grass component for the 8 and 4 cm swards respectively. Clover crude protein was significantly higher than values obtained for grass,(P=0%) with the highest crude protein values recorded for the 4 cm swards. Mean crude protein contents of the swards in respect to clover and grass were significantly higher on the 4 cm swards. Grass MADfibre values were significantly higher on the 8 cm swards. The mean ash content of the 4 cm sward was significantly higher than the 8 cm swards. Clover ash content tended to be higher than the grass component on the 8 cm swards, but grass ash content was greater than the clover on the 4 cm swards. Ash content of the sward components increased with time.

Dry matter content of all sward components declined with time (Table 2.5). Clover DM content was consistently lower than grass, but was comparable with the values obtained for the weeds present in the sward. Variation in DM content was not significantly different between the 4 and 8 cm swards.

Table 2.3 Botanical composition of the experimental sward.

		SWARD TYPE				
		8 cm	4 cm	Probability %		(SED) g/kg
Period	Species			sward	rank	period
1	clover	250	283			
	grass	729	694			
	weed	21	23			
2	clover	260	308			
	grass	719	673			
	weed	21	19			
3	clover	255	268			
	grass	712	706			
	weed	33	26			
MEAN	clover	255	286	13 (2.0)	0 (2.9)	NS (2.5)
	grass	720	691	16 (2.1)	0 (2.9)	NS (2.5)
	weed	25	23	NS (0.6)	NS(0.8)	NS (0.7)

where NS is not significant P> 25%
all values in g/Kg DM

Table 2.4 Chemical content of sward components.

		PERIOD 1		PERIOD 2		PERIOD 3		MEAN	
		clover	grass	clover	grass	clover	grass	clover	grass
crude protein (g/Kg)	SWARD								
	8 cm	224	116	224	112	262	138	237	125
	4 cm	232	123	235	136	272	156	246	138

	Probability (%)	(SED)
sward	P= 0	3.17
species	P= 0	3.17
period	P= 0	3.88

		PERIOD 1		PERIOD 2		PERIOD 3		MEAN	
		clover	grass	clover	grass	clover	grass	clover	grass
Madfibre (g/Kg)	SWARD								
	8 cm	NA	259	NA	238	NA	251	NA	249
	4 cm	NA	232	NA	217	NA	223	NA	224

	Probability (%)	(SED)
sward	P= 0	3.68
period	P= 1	4.12

		PERIOD 1		PERIOD 2		PERIOD 3		MEAN	
		clover	grass	clover	grass	clover	grass	clover	grass
Ash (g/Kg)	SWARD								
	8 cm	83	72	93	85	96	83	91	80
	4 cm	90	87	93	99	98	101	94	96

	Probability (%)	(SED)
sward	0	2.12
species	<10	2.12
period	0	3.72

Table 2.5 Dry matter content of sward components

Dry matter (g/Kg)	Sward	PERIOD 1 clover	PERIOD 1 grass	PERIOD 1 weed	PERIOD 2 clover	PERIOD 2 grass	PERIOD 2 weed	PERIOD 3 clover	PERIOD 3 grass	PERIOD 3 weed
	8 cm	215	330	161	197	276	210	167	241	152
	4 cm	219	320	196	203	279	213	162	242	161

Mean value	SWARD 8 cm	SWARD 4 cm	Probability (%) (S.E.D) sward	period	sward x period
clover	193	195	>25 (5.22)	0 (6.39)	>25 (10.44)
grass	279	280	>25 (8.26)	0 (10.12)	>25 (14.32)
weed	174	190	>25 (4.55)	9 (5.24)	>25 (9.56)

2.3.4 Milk production.

The production parameters of milk yield, fat, protein contents and fat and protein yields are given in Table 2.6.

Table 2.6 Mean milk production parameters for animals within each treatment group.

	TREATMENTS				
	(4)	(8)	(choice)	SED	Prob (%)
Milk yield (Kg/d)	15.22	17.63	16.08	0.86	< 0.1
Fat (g/Kg)	41.76	39.74	42.75	1.35	< 0.5
Protein (g/Kg)	36.76	37.45	36.72	0.69	< 10
Fat yield (g)	624.5	699.0	675.4	39.8	< 0.5
Protein yield (g)	555.1	657.3	585.5	36.1	< 0.1

Grazing an 8 cm high sward produced the highest mean milk yield per treatment, followed by the choice treatment. There was a mean difference of 2.4 Kg milk/cow /day between the 4 and 8 treatments.

Fat content was significantly increased on the choice treatment. The highest fat yield was recorded for the 8 cm treatment and followed the same trend as milk yield. There were small differences in protein content, with the 8 treatment producing the highest value. Differences between treatments were only statistically significant at the 10% level. Protein yield was significantly greater for the 8 than the 4 or choice treatments.

Table 2.7 Mean diurnal grazing activity for animals within each treatment group (m/day).

		TREATMENTS			Probability % (SED)		
	PERIOD	(4)	(8)	(choice)	Trt	Period	TxP
D	1	298.8	295.0	300.0			
A	2	303.8	197.5	337.5			
Y	3	325.0	278.8	238.8			
	Mean	309.2	257.1	292.0	19.5 (23.42)	>25 (23.42)	3 (40.57)
N	1	300.0	311.3	323.8			
I	2	318.8	337.5	320.0			
G	3	316.3	366.3	383.8			
H	Mean	311.7	338.3	342.5	>25 (24.32)	20 (24.32)	>25 (42.12)
T							

Where Trt = treatment
TxP = treatment x period interaction

2.3.5 Cow Behaviour.

The analysis of the behaviour parameters studied are given in Table 2.8. Grazing time was further analysed into the mean diurnal grazing activity (described in section 2.2.4.2) of cows within the 4 and 8 treatments (Table 2.7) and the mean grazing allocation of the choice treatment for preference of the 4 or 8 cm sward (Table 2.9).

Grazing observation indicated that cows were grazing for a longer period of time in the choice treatment, a mean daily grazing time of 634.6 minutes, which was 39.2 and 13.8 minutes longer than time spent grazing the 8 and 4 treatments respectively.(Table 2.8).

When considering the diurnal allocation of time spent grazing during the day or night by cows in treatments 4 and 8 it was found that cows on treatment 4 cm grazed 52.1 minutes longer during the day (P< 1%) and 26.6 minutes less during the night (P> 25%) than cows on treatment 8. Cows on treatment 4 increased total grazing time by increasing their day time grazing. In both treatments cows spent more time grazing during the night (Table 2.7).

When the time spent grazing on the choice treatment was analysed for time spent grazing each sward (Table 2.9), it was found that cows preferred to graze for a longer period of time on the 4 cm sward (337.5 compared to 297.1 m/d on the 8 cm sward), but this was not statistically significant.

Table 2.8 Mean behaviour parameters for animals within each treatment group.

	TREATMENTS (4)	(8)	(choice)	S.E.D.	Prob (%)
Grazing (m/d)	620.8	595.4	634.6	30.4	< 2.5
Biting rate (bites/90 s)	95.7	91.5	94.8	4.3	< 25
Lying Ruminating (m/d)	292.5	337.9	320.8	41.7	< 2.5
Standing Ruminating (m/d)	30.0	22.1	25.8	12.6	> 25
Total Ruminating (m/d)	322.5	360.0	346.7	38.8	< 10
Lying (m/d)	221.3	243.8	200.4	40.9	< 10
Sleeping (m/d)	55.4	33.8	55.0	18.7	< 2.5
Walking (m/d)	11.67	5.0	30.8	25.8	< 25
Standing (m/d)	37.92	36.25	22.5	17.4	< 25

Table 2.9 Mean grazing time of cows in the choice treatment for the 4 and 8 cm swards.

	SWARD HEIGHT 4 cm	8 cm	S.E.D.	Prob (%)
Grazing (m/d)	337.5	297.1	40.4	>25

	PERIOD 1	2	3	S.E.D.	Prob (%)
Grazing per cow (m/d)	311.9	328.7	311.9	11.5	>25

Biting rate on treatments 4 and choice were similar (95.7 and 94.8 bites/90 seconds respectively) and tended to be higher than values recorded on treatment 8 (Table 2.8)(Prob<0.25). Total ruminating time consisted of ruminating while lying and standing. These were analysed separately. Lying and ruminating produced significant differences between treatments at the 2.5 probability level. The highest value of 337.9 was 45.4

minutes/day greater than the lowest value of 292.5 on the 4cm sward, S.E.D. 41.7 m/cow/d Prob $P < 2.5\%$ (Table 2.8). Standing ruminating was not significantly affected by treatment. Total ruminating time was strongly influenced by lying ruminating with treatment 8 producing the highest value. Cows spent longer lying down in treatment 8, which was 43.3 minutes longer than cows in the choice treatment. This produced a probability value of $P < 10\%$ but S.E.D between treatments was also large.

The difference in sleeping time was minimal between treatments 4 and choice (55.4 and 55.0 m/cow/d respectively), and was up to 22 minutes more than sleeping values obtained for cows in treatment 8.

Grazing to a particular sward height did not affect standing time or time spent walking, but cows in the choice treatment did walk up to 25 and 19 minutes more than cows in treatment 8 and 4 respectively.

2.4 DISCUSSION

2.4.1.1 Effect of grazing height on sward characteristics

2.4.1.1 Botanical content.

Grazing the clover based sward to maintain a constant sward height of 4 or 8 cm affected clover content and chemical composition. This field had been maintained at these sward heights throughout 1988, therefore allowing sufficient time for grazing effects to produce changes in the sward. A low sward height of 4 cm was tended to increase clover content with values of 286 and 255 g/Kg for the 4 and 8 cm swards respectively. A possible explanation for this increase in clover content is that a sward maintained at 4 cms reduces grass competition for light, therefore allowing vigorous clover growth. Briseno de la Hoz and Wilman (1981) found similar results, reducing defoliation height from 8 to 4 cm above ground reduced the dimensions of the clover but, cattle grazing tended to reduce the number of tillers and increase the proportion of bare ground. This was also observed in this experiment but was not quantitatively analysed.

Botanical composition varied throughout the experiment, clover content peaked during period two in both swards. Weather data was not available for analysis and could have possibly explained why the clover peaked at this time. In this experiment the grass component in the swards was not competitive with either the clover or weeds. Fertilizer was not applied to the sward and would therefore affect grass growth. The clover was supplying sufficient nitrogen for it's own growth requirements. Botanical content of the sward was determined on a DM basis and did not demonstrate differences in weed content between the experimental paddocks, but observation of the field revealed that thistles were a major problem particularly on the 8 cm swards. Rank sampling did not affect weed content in the samples obtained (Appendix 1).

2.4.1.2 Sward height and stocking rate.

As the season progressed herbage availability declined and stocking rates were relaxed to maintain herbage heights. This was not achieved on the 8 cm swards because there was insufficient land to increase the area available to the cows. Results of herbage height indicate that the 4 cm swards in both treatments were maintained at a constant value, but variation between the herbage height of the 8 cm swards was greater (standard deviation value of 0.5 cm).

Mean stocking rate was lower on the choice swards compared to values recorded for treatments 8 and 4 combined. Individual values for the 4 and 8 cm swards in the choice treatment indicated that the stocking rate was higher for the choice 8cm compared to treatment 8 and that the stocking rate for the choice 4 cm sward was lower than treatment 4. Although the mean stocking rate was higher on 8 and 4 combined, these swards produced a higher mean herbage height. This was possibly influenced by the high herbage height recorded for treatment 8 compared to the choice 8 cm sward. The herbage heights of the 4 and 8 cm swards in the choice treatment were relatively stable over the nine week trial, this indicates that although the cows could select which sward to graze they did not reduce the herbage height of the 8 cm sward by overgrazing the sward but chose to also graze the 4 cm sward which contained a higher clover percentage. Behaviour studies indicated that the cows spent on average 40 minutes longer on the 4 cm swards.

2.4.1.3 Herbage composition.

The crude protein content of both sward components increased with time. Clover crude protein was consistently higher than grass,(clover 4 cm 246 and 8 cm 237 and grass 4 cm 138 and 8 cm 125 g/Kg). This trend agrees with nitrogen values obtained by Thomson (1984).

Crude protein content of clover obtained from the 4 and 8 cm sward types also varied. The 4 cm sward had higher crude protein values compared to the 8 cm sward. In the latter, cut herbage for chemical analysis probably contained a large proportion of long petiole compared to herbage cut from the 4 cm sward which contained a higher proportion of leaf blade (rich in nutrients) compared to petiole. Although the 4 cm sward was richer in nutrients (CP) this was not reflected in animal production possibly because this sward overall did not provide an adequate herbage allowance to maximise animal intake and utilisation of the sward.

Grass MADfibre values of the 8 cm sward were significantly higher than the 4 cm sward. This difference could again be due to the nature of the cut sample in each sward.

Clover ash content was higher on the 4 cm sward compared to the 8 cm sward again demonstrating physiological differences in the cut herbage from the swards. Grass ash content was higher on the 4 cm sward possibly because the reduced herbage height increased the proportion of the grass sheaths/stem to blade. This would increase the density of the grass compared to the leafy structure of the grass from the 8 cm sward.

2.4.2 Milk production.

Grazing cows at a sward height of 8 rather than 4 cm significantly increased milk production by 15%. Cows offered a choice of grazing either sward produced intermediate values between treatment 4 and 8. This suggests that cows on the choice treatment were able to overcome the reduced herbage allowance on the 4 cm sward by increasing their total grazing time, thus supporting the hypothesis that herbage intake is a product of grazing time, bite size and biting rate put forward by Jamieson (1975). Cows preferred to graze for longer on the 4 cm sward possibly because of it's superior nutritional quality and cows tend to adapt grazing time to compensate for reduced herbage availability.

Fat content was significantly affected by treatment. Cows offered a choice produced the highest fat content of 42.8 g/Kg. Cows in this treatment were able to maximise their fibre intake by grazing both swards as illustrated by longer grazing time and this could account for the increased fat content. These results conflict with work carried out by Thomson (1984) where fat content was higher for cows fed perennial ryegrass compared to white clover. These results suggest that the 8cm sward with the higher grass content would tend to increase fat content compared to the lower grass content of the 4 cm sward. This trend was not apparent because differences in botanical content of the swards were too small. The highest fat yield occurred in treatment 8 where cows were grazing the 8 cm sward, but this yield was primarily due to a high milk yield value.

Protein content, and to a greater extent protein yield, were significantly affected by herbage height. The higher protein content of the 4 cm sward was offset by the increased herbage availability in the 8 cm sward.

These results demonstrate how herbage height has affected the sward composition and milk production of the dairy cows. Although a low sward height of 4 cm increased clover content the advantage of increased crude protein was not reflected in milk yield and composition because the reduced herbage allowance affected the cow's intake and subsequent production capacity.

2.4.3 Cow behaviour.

Grazing time varied between treatments, cows grazed for longer on the choice treatment (10.6 hour/day), followed by treatment 4, cows grazing an 8 cm sward spent the least time grazing (9.9 hours/day). The diurnal grazing pattern indicated that cows in treatment 4 increased their total grazing time by increasing the amount of time spent grazing during the day, by up to 52 minutes. Cows in this treatment also increased their biting rate to compensate for the reduced herbage allowance.

Analysis of ruminating behaviour indicated that cows tended to ruminate more while standing than lying down. Cows on the high herbage height (8) spent more time ruminating than cows in the other treatments. This could explain the increased milk production, since herbage was easily available cows did not need to graze for long periods to fill their gastrointestinal tract. Cows in treatment 4 had to spent longer grazing to obtain the herbage, whereas cows in the choice treatment slightly preferred to graze the 4 cm sward and could account for the time spent grazing in this treatment. This increase in grazing time of the latter treatments would explain the reduced ruminating time by cows in these treatments.

The amount of time spent sleeping was difficult to obtain, due to the observation technique. Cows were only observed every 15 minutes at night, but taking this into consideration cows in treatment 8 still slept for a shorter period of time than cows on the other treatments.

Herbage height and the provision of a choice system influenced the walking habits of the cows. Cows on an 8 cm sward, where herbage was freely available only spent 5 minutes/day walking as defined by walking time in the analysis, because there was no need to walk substantial distances to consume sufficient herbage, whereas cows on the reduced herbage treatment 4 had to spent more time walking (11.7 minutes/day) in order to graze and consume sufficient herbage. Cows offered a choice of swards (choice) spent up to 30.8 minutes/day walking. This was particularly high because cows in this treatment would actively walk from one sward to the other. Another factor which increased this time was the distance between the swards in the choice treatment. This was as short as possible but the cows had to cover a distance of 30m. The variation between cows reduced the significance of the results.

2.5 SUMMARY.

A nine week change-over trial was conducted using 12 spring calving dairy cows in late lactation to determine the effect on milk production and behaviour of cows grazing white clover/prg swards at two contrasting sward heights (4 or 8 cm), or grazing a combination of both swards in a choice system.

Grazing the clover based sward to a height of 4 cm increased clover content.

Milk production was significantly increased by 15.8 % by grazing the 8 compared to the 4 cm sward. Cows offered a choice of swards produced intermediate milk yields, this was achieved by increasing their grazing time.

Fat content was increased by offering the cows a choice of swards. Providing the cows with a high herbage allowance (8) significantly increased fat and protein yields. Protein content was marginally affected.

Reduced herbage allowance in treatment 4 increased grazing time and biting rate. Cows in the choice treatment spent slightly longer grazing the 4 cm sward and increased their walking time.

CHAPTER THREE.

EXPERIMENT 2. A STUDY OF MILK PRODUCTION AND BEHAVIOUR OF FRIESIAN COWS GRAZING WHITE CLOVER/GRASS OR GRASS SWARDS DURING EARLY LACTATION.

3.1 INTRODUCTION.

The nutritional superiority of clover compared to grass has been demonstrated by a number of authors. Clover has a high crude protein concentration and maintains a high digestibility over the grazing season even with increasing maturity and has a higher concentration of calcium, magnesium, iron, cobalt, molybdenum, boron and selenium compared to grass (Frame and Newbould,1986).

Grazing a clover based sward increased milk production in experimentation conducted by Santamaria and Rogers (1980). This is because clover herbage contains a higher crude protein content compared to grass and is rapidly digested in the rumen which increases animal intake. Clover achieves a higher level of animal production compared to grass (Frame,1990). The majority of studies conducted on clover have been direct comparisons with grass, either cut and fed to the cows or grazed pure swards.

Behaviour studies conducted with cows grazing perennial ryegrass swards indicate that as herbage allowance declines grazing time and biting rate increase, but bite size is reduced, (Jamieson and Hodgson,1979: Le Du et al,1979) This indicates that cows can adjust their grazing behaviour to at least partially compensate for reduced herbage allowance. This was to some extent demonstrated in Experiment 1. Grazing behaviour has been widely studied on perennial ryegrass swards, but there is a lack of work on clover.

The aim of this experiment was, primarily, to compare milk production and grazing behaviour of cows grazing either clover/grass or grass swards, and a choice and enforced mixed grazing treatments were implemented to determine practical techniques of grazing high clover/grass swards in conjunction with grass swards.

3.2 MATERIALS AND METHOD.

The trial was performed at the University college farm at Aber, Gwynedd (Lat 652, Long 727, sheet 115, scale 1:50,000). The twelve week change-over trial was carried out from turn out in April 1989, using sixteen spring calving Friesian/Holstein dairy cows from second to sixth lactation. All the experimental cows had a minimum dry period of six weeks prior to calving. The cows calved during February, during which time they were housed and fed a complete diet. The turn out period was gradual; initially cows were turned out to graze prg swards, once turn out to grass was achieved the cows were then introduced gradually over a week to high white clover/prg swards. From the commencement of the trial on the 28th of April to the July 21th the cows were grazed on pure perennial ryegrass (prg) or high white clover/prg swards. Milk production data, behaviour studies and sward measurements were recorded throughout the trial.

3.2.1 Cow management.

The sixteen cows were allocated to a four treatment four period change-over design using orthogonal Latin squares. The cows were ranked in relation to milk yield, calving date and age to give four blocks of cows defined primarily on milk yield as very high (VH), high (H), medium (M) and low (L). The cows were then allocated at random to treatments within each period Table 3.1. Each period lasted three weeks to allow sufficient time for the cows to adjust to the new pasture or grazing regime, before milk production and behaviour characteristics were recorded.

Table 3.1 Change-over design used in Experiment Two.

	BLOCKS															
	VH				H				M				L			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PERIOD	TREATMENTS															
ONE	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
TWO	2	1	4	3	3	4	1	2	4	3	2	1	2	1	4	3
THREE	3	4	1	2	4	3	2	1	2	1	4	3	3	4	1	2
FOUR	4	3	2	1	2	1	4	3	3	4	1	2	4	3	2	1

Where
Treatment 1, grazing clover/prg only (C)
Treatment 2, grazing prg only (R)
Treatment 3, grazing clover/prg during the day, prg at night (C/R)
Treatment 4, choice of grazing clover/prg or prg (choice)

C/R treatment was conducted in this order to reduce the need for bloat detection at night. The cows were milked at 07 00 hrs and 16 00 hrs and then turned out to the various experimental pastures. A rope collar with various coloured tape attached to it was placed around the cows neck to identify the cows in each treatment and facilitate sorting them out into the various experimental paddocks.

3.2.2 Pasture.

The experimental pasture consisted of electrically fenced areas from two permanent fields. The perennial ryegrass sward was a long term ley. The white clover/prg sward had been resown in 1986 with 5Kg/acre Blanca white clover both swards were grazed by cattle during the summer and by sheep throughout the winter. The fenced off areas in each field was further subdivided into three paddocks. The electric fence was used to adjust the area available to the cows in an attempt to maintain a constant sward height of 6 cm. The paddocks were supplied with fresh running water. Paddocks used in the choice treatment were situated as close together as possible (Diagram 3.1).

The paddocks were dusted with calcined magnesite three times a week to prevent the occurrence of hypomagnesaemia. Fertilizer was not applied.

3.2.3 Sward measurements.

The sward height in each paddock was recorded twice weekly, using a rising plate meter produced by the MMB (Baker,1980). Sward height was taken as the mean value of 20 measurements taken randomly along a set `W' shaped course in each paddock.

Sward composition was determined by cutting fresh sward samples from each paddock and sorting into the various sward components every 3 weeks throughout the trial. Four identical quadrats (1m x 0.1m) were laid on the ground, their position pre-determined by set random co-ordinates. These were then ranked in relation to visual clover content, low (L), medium (M), high (H) and very high (VH) and only one sample was cut each time the quadrats were set out. Initially the L quadrat was cut and the sample obtained was kept in a separate sealed plastic bag. This procedure was continued until three samples of each rank L,M,H and VH were obtained per paddock. The samples were kept in cold storage (to reduce respiration and weight loss) until they could be sorted into the various sward components and oven dried at 80°C until there was no further change in weight on two subsequent weighings. This weight was used to calculate clover percentage and other sward component relationships on a DM basis. The samples were then milled using a 2 mm sieve and placed in a sealed plastic bag, so that chemical analysis of crude protein, ash and modified acid detergent fibre (MADF) could be carried out at a later date (MAFF 1985).

Diagram 3.1 Distribution of experimental paddocks.

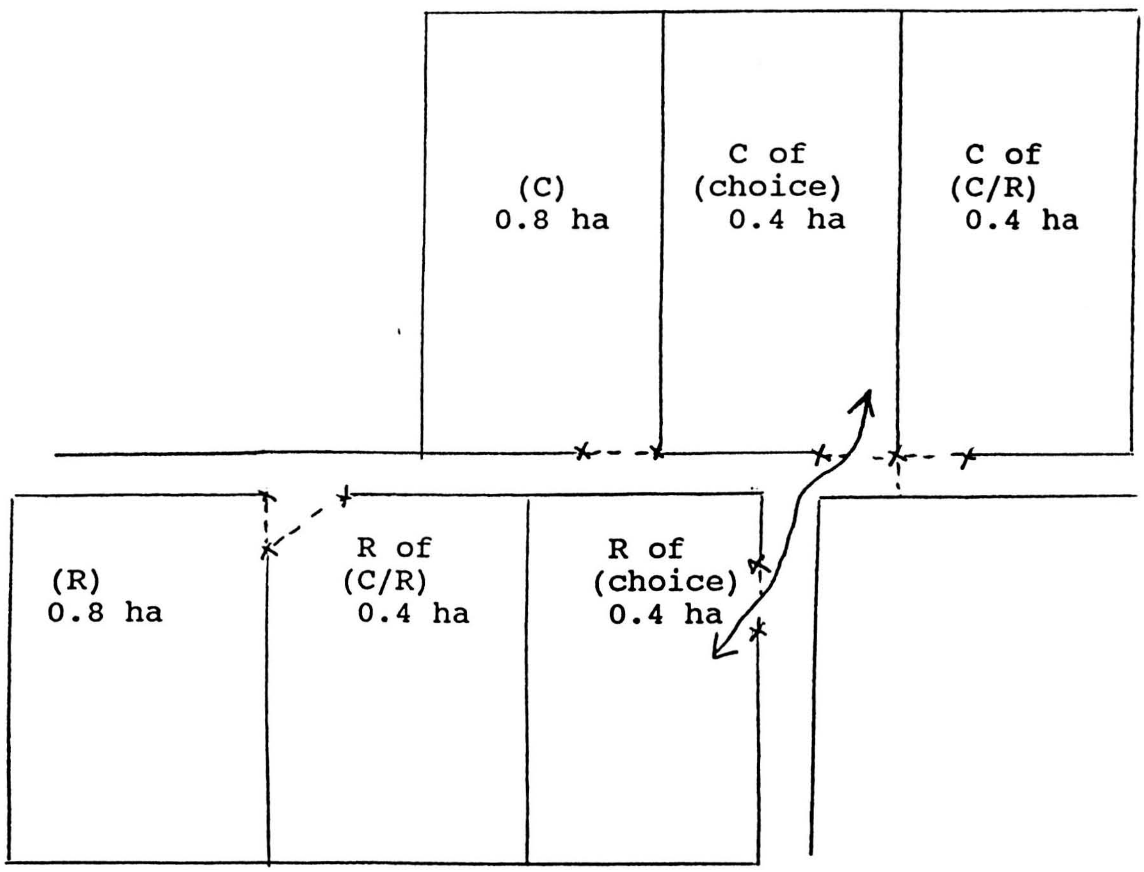


Diagram not to scale.

Where
() = treatments
⟷ = pathway of cows in choice treatment

3.2.4 Animal measurements.

3.2.4.1 Milk yield.

Milk yield was recorded in Kg/day on four consecutive days at the end of the last week of every three week period throughout the trial. The daily value was taken to be the sum of the evening and following morning milk yield and was defined as the visible line below the froth, in all cases 0.2 Kg was added to compensate for the froth.

3.2.4.2 Milk sampling and chemical analysis.

Individual whole milk samples were taken on four consecutive days at the end of the last week of the three week period. A sample was taken at an afternoon milking (16 00 hrs) and the following morning milking (07 00 hrs) from the milk storage jar as recommended by the Milk Marketing Board (MMB) and preserved with potassium dichromate tablets (Lactotabs Mark 3). The samples were then stored in a cold store for up to seven days until crude protein and butterfat content were analysed by the Kjeldahl and Gerber methods respectively (MAFF,1985). The mean value of the 4 days were used for data analysis of the period and for individual cows in the trial.

3.2.4.3 Cow behaviour.

Cow behaviour characteristics were recorded for one 24 hour period at the end of the second week of every three week period, during which time grazing, ruminating either while standing or lying, standing, lying, walking and sleeping time and biting rate were recorded. To facilitate observation the cows had large conspicuous numbers painted on both sides of their bodies in a white emulsion paint. These numbers were picked up at night using a portable re-chargeable 12 volt torch.

Grazing time was recorded every 5 minutes during the day light and every 15 minutes at nigh. If all the cows were clearly visible this observation was reduced to achieve more accurate values for time spent at various activities. Grazing time was also split up into day time (08 00 to 16 00 hrs) and night time (16 00 to 08 00 hrs) to analyse any grazing periodicity.

Ruminating time was recorded every 5 minutes in the field during day light hours and every 15 minutes at night. If a cow was observed to be ruminating i.e. regurgitating and chewing a bolus and subsequently swallowing it then it was assumed that the cow had been ruminating for the whole of the 5 or 15 minutes. Ruminating behaviour was also recorded during milking and time spent in the collecting yard prior to milking. The remainder of the time spent milking was classified as milking on the record sheet.

Cows were considered to be sleeping when shining a torch towards the face of a cow lying down with her head tucked in to her side did not cause movement. This was recorded every 5 or 15 minutes.

Walking was defined as periods greater than two minutes walking at any one time. Walking for milking purposes was recorded under milking.

3.2.5 Statistical analysis

Data analysis was performed using programmes available on the University of Wales, Bangor vax cluster.

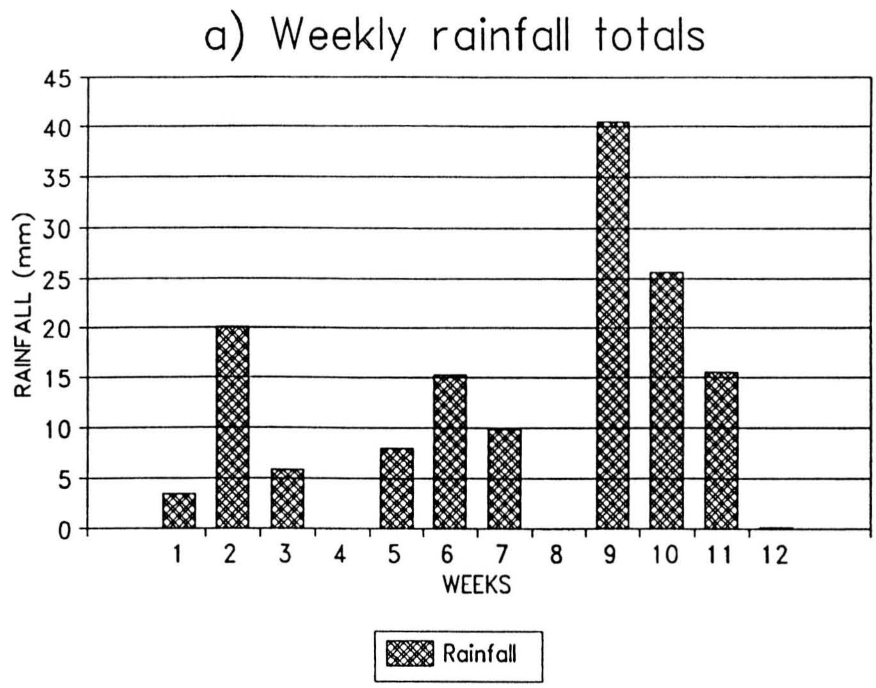
Milk production and behaviour parameters were initially analysed using the Latin square analysis (Genstat 5,1987). The regression equations of milk yield and behaviour parameters were calculated in Minitab (Copyright 1989) by correlation and stepwise regression. Herbage height and stocking rate were analysed by two way analysis of variance in Minitab to determine treatment and period effects. Sward botanical content and chemical composition of the sward components were also analysed by Two way analysis of variance in Minitab.

3.3 RESULTS.

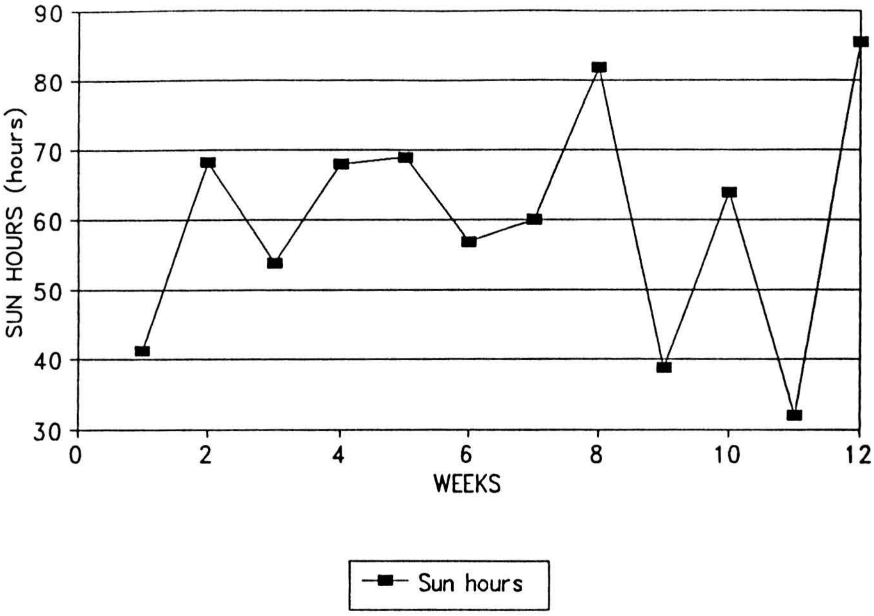
3.3.1 Weather.

Total rainfall for the experimental period was 144.2mm and mean daily sun hours was 8.5 hrs/day (Figure 3.1).

Figure 3.1 Weekly rainfall and sun hour totals.



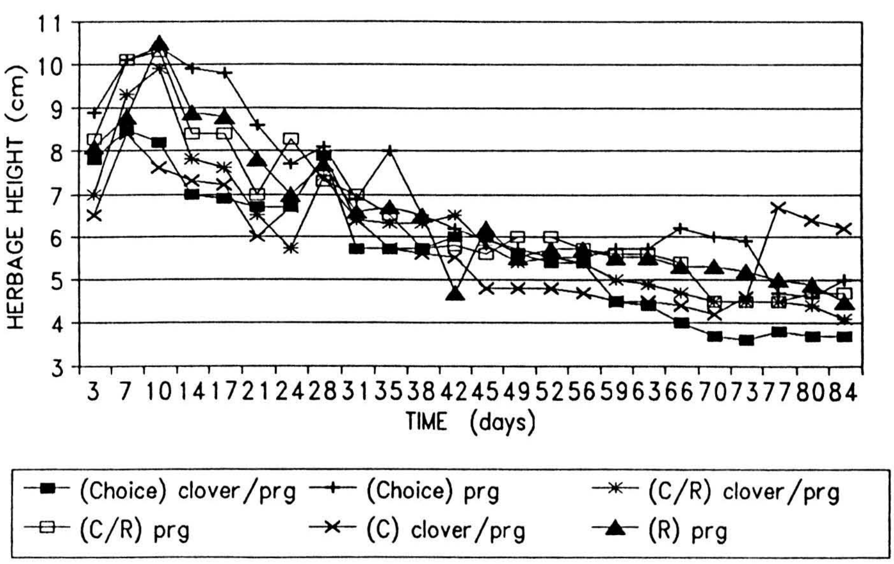
b) Weekly sun hour totals



3.3.2 Herbage height.

Statistical analysis of mean herbage height per period of the individual experimental paddocks is given in Table 3.2 and variation in herbage height on a weekly basis is illustrated in Figure 3.2.

Figure 3.2 Variation of herbage height with time.



Herbage height declined with time on all the experimental swards. Analysis of variance of herbage height of the swards in choice and C/R indicated that the swards in the choice and to a lesser extent the C/R sward the herbage height was higher in the grass than clover areas. There was no significant difference between treatments C and R and the mean of the choice and C/R treatments.

Table 3.2 Herbage height in relation to period.

	SWARD TYPE					
	CLOVER			GRASS		
	TREATMENTS					
Period	C	C/R	choice	choice	C/R	R
1	7.2	8.1	7.6	9.6	9.0	8.8
2	6.5	6.5	6.4	7.5	7.1	6.5
3	4.7	5.4	5.4	5.7	5.8	5.7
4	5.7	4.4	3.7	5.2	4.9	4.9
MEAN	6.0	6.1	5.8	7.0	6.7	6.5

	Probability (%)	(SED)
treatment	0.1	0.291
period	0	0.291
txp	<25	0.491

3.3.3 Stocking rate.

Stocking rates were relaxed with time to attempt to compensate for declining herbage height and maintain the same herbage height for the four treatments over the whole experiment. Differences between C and R were further analysed and the results are given in Table 3.3.

Stocking rates differed significantly between C and R during the latter half of the experiment, but were similar between

C/R and choice. R achieved the highest mean stocking rate followed by C/R and choice 0.22 0.28 and 0.28 hectare/cow respectively.

Table 3.3 Variation in stocking rate with time.

	STOCKING RATE (hectare/cow)			
	TREATMENT			
Period	C	R	C/R	choice
1	0.20	0.10	0.18	0.18
2	0.21	0.20	0.30	0.30
3	0.31	0.24	0.30	0.30
4	0.31	0.24	0.30	0.30
Mean	0.26	0.22	0.28	0.28

Probability (%)	SED
0	0.010

3.3.4 Pasture.

The botanical content of both sward types are given in Table 3.4 and the chemical analysis in Tables 3.5 and 3.6.

The seasonal growth of the clover component varied between paddock and sward type. There was a general decrease in clover content in the clover/prg sward with time. The clover component of the prg sward consisted mainly of wild clover species. Clover content of the prg sward in choice peaked during period three, while clover continued to increase throughout the trial in the prg sward of C/R. Clover content of R remained relatively constant. A subsequent comparison of weed content of the prg and clover/prg sward indicated that the latter sward contained significantly more weeds (clover/prg,23 and prg, 1 SED 3.14g/Kg p=0%) and variation with time remained constant.

Table 3.4 Botanical composition in g/Kg DM of the **experimental** paddocks.

	SWARD					
	white clover/prg			prg		
	TREATMENTS					
Period	C	C/R	choice	choice	C/R	R
O clover	187	168	160	10	5	**17**
N grass	779	827	794	983	995	**983**
E weed	34	5	46	7	0	**0**
T clover	103	82	80	11	2	**15**
W grass	855	915	898	985	998	**985**
O weed	42	3	22	4	0	**0**
T						
H clover	106	86	92	21	16	**18**
R grass	871	914	876	975	984	**982**
E weed	23	0	32	4	0	**0**
E						
F						
O clover	132	78	60	14	23	**20**
U grass	833	919	915	986	977	**980**
R weed	35	3	25	0	0	**0**
Mean value						
clover	132	104	98	14	12	**17**
grass	835	893	871	982	988	**983**
weed	33	3	31	4	0	**0**

	Probability (%)	(SED)	
	sward	period	sward x period
clover	0 (10.16)	0 (8.30)	0 (20.32)
grass	0 (12.13)	0 (9.91)	1 (24.26)
weed	0 (5.31)	>25(4.34)	>25(10.63)

Table 3.5 Chemical analysis of sward components by **period.**

a) Dry matter content (g/Kg DM)

		SWARD TYPE	
		clover/prg	prg
Period			
1	clover	195	197
	grass	181	182
2	clover	199	201
	grass	197	199
3	clover	209	210
	grass	240	235
4	clover	216	220
	grass	250	247

b) Crude protein (g/Kg DM)

Period		SWARD TYPE clover/prg	prg
1	clover	253.4	NA
	grass	133.5	221.5
2	clover	250.9	NA
	grass	98.5	157.4
3	clover	220.1	NA
	grass	91.3	131.5
4	clover	193.9	NA
	grass	87.9	121.5

c) Ash (g/Kg DM)

Period		SWARD TYPE clover/prg	prg
1	clover	82.8	NA
	grass	76.0	68.0
2	clover	97.8	NA
	grass	76.0	71.4
3	clover	87.6	NA
	grass	76.1	68.7
4	clover	78.7	NA
	grass	72.0	60.5

d) MADF (g/Kg DM)

Period		SWARD TYPE clover/prg	prg
1	grass	210.7	203.7
2	grass	227.7	247.1
3	grass	348.2	262.0
4	grass	264.6	263.8

Table 3.6 Mean chemical composition of sward components in g/KgDM.

	SWARD TYPE				
	clover/prg	prg	Probability % (SED)		
			sward	period	s x p
a) Dry matter					
clover	205	207	0 (0.46)	0 (0.66)	>10 (0.93)
grass	217	216	<15 (0.49)	0 (0.67)	0 (0.96)
b) Crude protein					
clover	229.6	NA	0 (2.91)	0 (3.36)	0 (5.82)
grass	102.8	158.0			
c) Ash					
clover	86.7	NA	0 (1.41)	0 (1.63)	0.3 (2.83)
grass	75.0	67.1			
d) MADF					
grass	262.8	244.1	NS(21.29)	10 (30.11)	NS(42.58)

Where NS is P>25%
NA is not available due to inadequate sample size

Clover DM values were consistently lower than the grass component. DM content increased with time (P = 0% for both sward components). Clover crude protein values were significantly higher than the grass component in both sward types. Perennial ryegrass crude protein values were significantly higher on the prg compared to the clover/prg sward. Crude protein content declined with time. There was a mean difference of 126.8 g/Kg between the clover and grass component in the clover/prg sward. The small SED value of 2.91 g/Kg between treatment species indicated that variation was minimal between paddocks of the same sward type. When chemical and botanical content are considered together the high proportion of prg in the prg sward gives the sward a higher total crude protein value.

Clover ash values were significantly higher than the grass component in the clover/prg and prg sward and reached a peak value in period 2. Grass ash content of the clover/prg sward remained constant throughout the trial and consistently higher than the prg grass component. This difference was significant in period 1.

Clover MADF values were not analysed due to insufficient sample size. Differences between sward types were not statistically significant, but the grass component in clover/prg tended to be higher than the grass component of prg sward when taken as a mean value over the trial. MADF values increased with time and approached significance (P=10%)

3.3.5 Milk production.

The production parameters of milk yield, fat and protein contents including fat and protein yields are given in Table 3.7.

Grazing the clover/prg sward in treatment C increased milk production by 17% compared to cows grazing a prg sward in R. Cows grazing a combination of both swards (treatments C/R and choice) produced similar and intermediate results i.e 20.01 and 20.43 Kg/cow/day respectively.

Cows grazing a clover/prg sward only produced the highest protein content followed by the choice treatment, but differences between treatments were not statistically significant. Protein yield was significantly increased by grazing a clover/prg sward only (C) and reduced by grazing a prg sward (R).

The highest fat content was produced by treatment R (prg sward), while C (clover/prg sward) produced the lowest fat content. Fat yield was increased by grazing a clover/prg sward primarily in C and secondly in the choice treatment. Treatment R produced the lowest fat yield. Where cows were grazing a combination of both sward types, milk production parameters except for fat content were marginally increased by offering the cows a choice of grazing regime.

Table 3.7 Mean milk production parameters for animals within each Treatment group.

	TREATMENTS				S.E.D	Prob (%)
	C	R	C/prg	choice		
milk yield (Kg/day)	22.14	18.88	20.01	20.43	1.02	<0.5
Fat content (g/Kg)	34.61	36.97	35.19	34.80	1.25	<0.5
Protein content (g/Kg)	33.44	33.09	32.99	33.14	0.78	>25
Fat yield (g)	760.0	689.0	693.9	704.9	40.9	<1.0
Protein yield (g)	734.1	620.3	653.5	674.9	40.0	<0.5

3.3.6 Cow Behaviour.

The analysis of the behaviour parameters studied are given in Table 3.8. Grazing time was further analysed to show diurnal grazing activity of the cows in the experiment and the results are given in Table 3.9. Preference for sward type by cows in the choice treatment are given in Table 3.10.

Grazing behaviour observations indicated that cows were grazing for increased period of time in the choice treatment. The lowest grazing time was recorded for cows grazing entirely on prg swards (R).

Table 3.8 Mean behaviour parameters for animals within each treatment group (minutes/day).

	TREATMENTS				S.E.D	Prob %
	C	R	C/R	choice		
Grazing	545.3	517.8	523.1	557.8	31.02	<10
Lying ruminating	340.3	365.6	375.5	323.4	37.7	NS
Standing ruminating	59.1	64.7	60.0	65.9	19.6	NS
Total ruminating	399.4	430.3	417.5	389.4	27.9	<5
Lying	244.1	235.6	231.9	230.6	39.3	NS
Sleep	24.4	35.6	39.7	31.9	13.3	NS
Lying+ sleep	268.4	271.2	271.6	262.5	42.0	NS
Standing	79.9	70.9	74.4	76.3	20.6	NS
Walking	9.4	12.2	12.2	16.6	6.0	NS

Where NS - Not statistically significant, P>25%

The grazing time was broken down into two grazing periods: day and night. The mean grazing time for treatments C,R and C/R are given in Table 3.9.

Table 3.9 Mean diurnal grazing activity of animals within each treatment group (minutes/cow/day).

	TREATMENTS				
	C	R	C/R	S.E.D	Prob
Grazing (day)	231.9	226.3	279.7	27.8	< 1
Grazing (night)	313.4	291.6	243.4	29.4	<0.1

Results of diurnal grazing activity of the cows in the experiment indicate significant differences occur between treatments in relation to night grazing. Cows grazing a clover based sward tended to graze for longer during the night. Daytime grazing analysis also demonstrated large differences between the treatments with the enforced split grazing regime producing the longest bout of grazing during the day i.e on prg/clover.

Differences between day and night grazing in each treatment, indicated that cows on treatments C and R tended to graze for longer during the night. Cows in treatment C spent 35% longer grazing during the night than day. Cows on the enforced split regime (C/R) increased the amount of time grazing during the day, by 15% while reducing their night time grazing. Comparing the night and day components of C/R with the relevant corresponding night and day components of treatments C and R indicated that cows in the enforced grazing regime (C/R) increased their daytime grazing period on the clover based sward by 47.8 minutes i.e 20% and reduced their night grazing on the prg sward by 48.2 minutes/cow/day i.e.16.5%.

The analysis of time spent on each sward type in the choice treatment is given in Table 3.10. The cows tended to graze for longer on the clover based sward and observation studies demonstrated that the cows preferred to graze this sward during the day.

Table 3.10 Mean grazing allocation of cows in the choice treatment

	SWARD TYPE clover/prg	prg	Prob (%)	S.E.D
Grazing m/cow/day	351.9	206.5	8	49.89

Differences in time spent standing ruminating were small but the highest value was recorded for the choice treatment.

The differences in lying ruminating were greater between treatments but were not statistically significant. Results of total ruminating time produced significant results, whereby cows in R spent longer ruminating than cows in C, but cows grazing in the latter treatment ruminated for longer than cows offered a choice of swards.

Although differences in time spent lying or sleeping were not statistically significant, cows tended to sleep for longer in C/R, while cows in C tended to spend more time lying down than cows in the other treatments. To eliminate the effects of error in observing sleeping time which occurred for only a small proportion of the day sleep and lying time were combined and analysed, but again differences between treatments were not significant.

Standing and walking times were not significantly influenced by treatment, although walking time was higher in the choice treatment.

3.3.7 Correlation of milk yield and behaviour parameters

The results of correlation of milk yield and behaviour parameters are given in Table 3.11. Regression equations carried out by stepwise regression of relevant parameters are given in Table 3.12 and Table 3.13.

Milk yield was significantly negatively correlated with walking but no other parameters. The regression equation given in Table 3.12 indicates that there is a relationship between milk yield and time spent walking in this experiment, but that the r^2 value of 10.6 was low.

The behaviour parameters were also analysed by regression, Grazing was strongly influenced by lying + sleep, total ruminating time standing and walking. As these parameters increased grazing time was reduced.(Table 3.12).

The adjusted regression equations for total ruminating time i.e where lying and standing ruminating times were not considered, indicated that ruminating time was strongly influenced by time spent lying and standing idling. The adjusted regression equations for standing ruminating and lying ruminating as described in Table 3.13 showed that time spent standing and ruminating by cows was influenced by time spent lying and ruminating and visa versa. They were also strongly influenced by the following order of behaviour parameters; lying+ sleep, grazing, standing and finally walking.

Table 3.11 Correlation of milk yield and behaviour parameters.

	MILK	*GRAZE*	*LYING*	*STAND*	*WALK*	*SLEEP*	*LYRUM*	*SRUM*	*TOTRUM*	*LY+SLP*
GRAZE	-0.266									
LYING	0.295	-0.718								
STAND	-0.009	-0.380	0.181							
WALK	-0.325	0.338	-0.436	0.140						
SLEEP	-0.206	-0.085	-0.110	-0.097	0.132					
LYRUM	-0.026	0.032	-0.482	-0.381	-0.100	0.049				
SRUM	0.041	-0.094	0.068	0.310	0.098	-0.114	-0.573			
TOTRUM	-0.010	-0.010	-0.545	-0.298	-0.070	-0.000	0.906	-0.172		
LU+SLP	0.243	-0.737	0.970	0.157	-0.402	0.136	-0.469	0.040	-0.543	

Table 3.12 Regression equations of milk yield and behaviour parameters

Equation	R^2 (%)	PROB (%)
Milk Yield = 22.1 - 0.0140(-+ 0.052) WALK	10.6	9
GRAZE = 1224 - 0.956 (+-0.033)LY+SLP - 0.848 (+- 0.04)TOTRUM - 0.987(+- 0.070)STAND - 0.771 (+- 0.236)WALK	95.5	0

Where
LY+SLP= LYING + SLEEP COMBINED
TOTRUM= TOTAL RUMINATING TIME
SRUM= STANDING RUMINATING
LYRUM= LYING RUMINATING

Table 3.13 Adjusted regression equations for milk yield and behaviour parameters

Equation	R^2 (%)	Prob (%)
TOTRUM = 1330 - 1.06(+- 0.04)LYING - 1.03 (+-0.05)GRAZE - 1.03(+-0.08)STAND - 0.848(+-0.11)SLEEP - 1.16(+-0.25)WALK	93.4	0
where LYING and STANDING RUMINATING not considered		
SRUM = 984 - 0.731(+- 0.046)LYRUM - 0.762(+- 0.058)LY+SLP - 0.753(+-0.062)GRAZE - 0.0686(+-0.092 STAND - 0.703(+-0.21)WALK	83.5	0
where TOTAL RUMINATING not considered		
LYRUM = 1342 - 1.12(+-0.07)SRUM-1.05(+-0.04)LY+SLP-1.03(+-0.05)GRAZE -1.02(+-0.086)STAND -1.01(+-0.26)WALK	95.3	0
where TOTAL RUMINATING not considered.		

Where LY+SLP= LYING + SLEEP COMBINED
TOTRUM= TOTAL RUMINATING TIME
SRUM= STANDING RUMINATING
LYRUM= LYING RUMINATING

3.4 DISCUSSION.

3.4.1 Herbage height and stocking rate.

Herbage availability declined with time due to a dry experimental period. The area available for experimentation was limited and stocking rates were relaxed primarily by increasing the grazing area per treatment, but as the season progressed cows were removed from the trial. The aim was to maintain a constant herbage height between the treatments but due to a lack of herbage and area adjustments to maintain the constant herbage height were not possible. The prg sward in R maintained cows at a mean stocking rate of 0.22 ha/cow and mean herbage height of 6.5 cm, but cows on the clover/prg sward in C achieved higher milk yields on a 6.0 cm sward with a relaxed stocking rate of 0.26 ha/cow. Clover based swards produce circa 70% of the herbage production of ryegrass swards receiving 300-400 Kg N/year (Frame,1990). Stocking rates are therefore expected to be reduced on clover based swards to produce comparable milk yields. In this trial fertilizer was not applied to the experimental swards and would partially explain the small difference in stocking rates between C and R. The increased milk production from a lower herbage height is probably explained by increased herbage quality on the clover/prg sward.

Stocking rates and mean herbage height of the swards were similar between C/R and choice throughout the trial. Milk production data and herbage heights recorded would suggest that stocking rate of the two treatments would follow the same trend i.e produce intermediate values between C and R, but stocking rates were lower than either of these treatments.

The reason for this is unclear, but difficulties in maintaining a constant herbage heights could have contributed to these results. Detailed examination of herbage height of individual swards within each treatment indicated that cows were grazing the clover/prg sward to a greater extent than the prg sward. This is discussed further in cow behaviour (section 3.2.4). Cows in choice also tended to reduce the herbage height of the clover/prg sward to a greater extent than the prg sward, but over grazing of this sward was not apparent, the cows would also select to graze the prg sward possibly to ensure sufficient herbage intake.

Result obtained in choice and C/R indicate that set stocking regimes or cows given a choice of clover/prg or prg swards does not influence herbage height and stocking rates.

3.4.2 Herbage botanical and chemical composition.

Clover content in the clover/prg sward (primarily in C/R and choice) were reduced by the action of dairy cows grazing the sward which agrees with a comparable grazing versus cutting study conducted by Briseno de la Hoz et al. (1989). Clover content in C was higher initially than C/R and choice and did not follow the same trend, in that clover content did decline during period two and three, but was increased during the final period. A possible explanation for this is that the continuous grazing action of the cows in this treatment did not have such a detrimental affect on clover as the differential grazing regimes in C/R and choice where high clover areas may have been more selectively grazed. Variation in herbage height between the swards was small and therefore probably did not contribute to these results. Work carried out on continuous versus rotational grazing regimes have demonstrated advantages for both clover content and animal productivity for continuously grazed sward (Morrison et al. 1985).

Weed content was significantly higher in the clover/prg sward, highlighting the problem of weed control associated with clover swards. Weed control conducted over many years had been effective in the prg swards at the College farm. Herbicides were used when necessary, but not during this series of experiments. Thistles were removed by topping.

Clover crude protein was considerable higher than the prg grass component, which agrees with Greenhalgh (1981), Thomson (1982) and Thomson (1984). Grass crude protein values were higher for grass obtained from the prg compared to the clover/prg sward suggesting that the grass in the latter sward was not receiving nitrogen to the same extent as the grass in the prg sward.

3.4.3 Animal production.

Grazing white clover/prg swards with a clover content above 10% significantly increased milk production by up to 17% compared to cows grazing prg swards. Rogers et al.(1980) quoted values of 22% increase in production when cows were fed *ad libitum* pure clover compared to ryegrass and a 50:50 mixture of clover:prg produced intermediate values. O'Brian (1989) quoted values of 20% increase in milk production for grazed clover swards and reducing the herbage allowance i.e. herbage intake reduced this value by 10%. The results in this experiment support results obtained by Rogers et al.(1980) and the review by O'Brian in 1989, but the cows in this experiment have produced a higher increase in milk production than expected for clover contents in the region of only 10%.This could be due to the chemical content and herbage available to the cows in this experiment, the work previously mentioned did not give sward chemical composition and therefore makes a direct comparison difficult. Clover species used in the previous experiments were not named and this could also affect the nutrient intake by the animal and affect its subsequent productivity. Cows offered a combination of both sward types produced intermediate milk yield values between C and R.

Fat content was reduced by 6.4% by grazing a clover based sward. Fat yield is not reduced. This is because fat yield is a product of milk yield and fat content and since milk yield is increased by the inclusion of clover in the diet the reduction in fat content is overridden. In this trial fat yield was increased by 10% compared to cows grazed entirely on prg swards and was statistically significant at the 1% probability level. Similar results were obtained by Rogers et al.(1979) and Rogers et al.(1980).

When results of chemical composition and botanical content are combined, the clover based sward with only 10% clover would not be expected to produce a 17% increase in milk yield. This can perhaps be explained by the ability of the cows to select the nutritionally superior clover herbage i.e the cows actively select the clover and are therefore probably ingesting a higher clover percentage than the calculated clover content on a DM basis. These results provide a means for the dairy farmer to safely incorporate clover at low levels which theoretically are easy to maintain and to produce a substantial increase in productivity. It also provides a means to manipulate milk composition to maximise productivity within a quota system. This experiment has also demonstrated that providing a choice or enforced split grazing regime of clover/prg and prg swards will also increase productivity and in the latter treatment could also alleviate problems of bloat detection at night.

3.4.4 Cow behaviour.

Grazing time was increased by the inclusion of clover in the diet of the dairy cattle in this trial, but only approached significance at the 10% probability level. The rapid breakdown and movement of clover through the rumen (Moseley, 1981; Thomson, 1984) allows the cows to graze for longer on the clover based sward because intake is not restricted so much by gut fill. When cows were offered a choice of sward type grazing time was increased by 40 and 13 minutes/cow/day compared to R and C respectively. The diurnal grazing pattern indicated that cows on one sward type in C or R tended to graze for longer during the night, but cows in C/R would actively increase their day time grazing on the clover/prg sward and reduce their night grazing on the prg sward. This enabled the cows to sleep for longer during the night. This selectivity in grazing behaviour by cows in this treatment explains the intermediate milk production produced. Analysis of the grazing behaviour in the choice treatment again demonstrated how cows were actively choosing the clover/prg sward by increasing the grazing time on this sward by up to 70%. The majority of this grazing activity was conducted during the day time. This can explain the milk production obtained in this treatment and can also explain why there were minimal differences between choice and C/R, since cows in these treatments were either actively choosing and grazing for longer or grazing for longer on the clover based sward respectively. The result from analysis of grazing behaviour indicate that cows appear to prefer to graze for longer during the evening/night but they will adjust this grazing behaviour to obtain a nutritionally superior diet.

Due to the expected increase in fibre intake of prg in R the cows tended to spent more time ruminating.

3.5 SUMMARY.

A twelve week change over trial was conducted using 16 spring calving Friesian/Holstein cows in early lactation to determine the effects on milk production and behaviour of dairy cows grazing prg or clover/prg swards alone or combined in a choice system, or grazed on clover/prg during the day and prg at night.

The inclusion of clover in the diet of the dairy cows increased milk yield , but reduced fat content compared to cows grazing pure prg swards. Fat and protein yields were significantly increased by 10 and 18% respectively. Protein content was not affected. Cows offered a choice or enforced mixed grazing regime of clover/prg or prg produced similar results which were intermediate between cows solely on clover/prg or prg.

Grazing behaviour in the choice or enforced grazing regimes demonstrated the ability of cows to select and adjust their grazing behaviour to maximise the amount of clover in their diet, by either selecting to graze for longer on the clover/prg sward in the choice treatment, or by grazing for longer during the day and reducing their night grazing in the enforced grazing regime. Ruminating time was reduced on the clover based sward.

CHAPTER FOUR

EXPERIMENT 3 A COMPARISON OF DIFFERENT FORAGES FED TO DAIRY COWS GRAZING WHITE CLOVER/RYEGRASS OR RYEGRASS SWARDS DURING LATE LACTATION IN RELATION TO MILK PRODUCTION AND BEHAVIOUR.

4.1 INTRODUCTION.

Supplementary forage is frequently fed to grazing cows to overcome pasture shortages during the grazing season. Maintaining a short sward encourages high white clover contents through the season, since at low sward heights clover is highly competitive with the grass as previously demonstrated in Experiment 1. At these low sward heights herbage allowance is reduced, therefore the utilisation of supplementary forage on clover based swards would appear to be particularly important during the latter half of the grazing season when herbage allowance is usually reduced.

The inclusion of clover in the diet of dairy cows can increase milk production as demonstrated in Experiment 2. This has been demonstrated by Santamaria and Rogers (1980) for fresh herbage, and ensiled clover has also increased productivity when fed to cattle (Roberts and Kelly,1987). The incorporation of clover in the diet of dairy cows either as grazed herbage or silage increases milk production and supplying a buffer feed further increases productivity. Previous work in this area did not combine clover swards and buffer feeding clover based forages.

The aim of this experiment was to investigate the differences between high white clover/ryegrass and ryegrass silages and hay as supplements for cows grazing high white clover or ryegrass pastures in relation to animal production during the late grazing season.

4.2 MATERIALS AND METHOD.

The trial was carried out at the University college farm at Aber, Gwynedd(Lat 652, Long 727,sheet 115, 1:50,000). The eight week continuous design trial was undertaken during the late grazing season of 1989 using 36 spring calving British Freisian/Holstien dairy cows. Prior to the experiment the cows were grazed on predominantly ryegrass swards with some access to high white clover/ ryegrass swards. From the commencement of the trial on the 14th of August 1989 the cows were grazed on either, pure ryegrass swards or high white clover/ ryegrass swards and were further subdivided into three treatments each, where they were either buffer fed hay, Italian ryegrass silage or high white clover/ryegrass silage. The silage was offered individually to the cows using the individual feeding gate system (American Calan Inc Ltd). The hay was group fed in the farm buildings. Intake, milk production, condition score and sward measurements were recorded throughout the trial.

4.1.1 Cow management

The cows were ranked in relation to milk yield and calving date and then allocated to six treatment groups in a 3 by 2 factorial design in relation to pasture and forage type (Figure 1).

The cows were milked at 06 00 hrs and 15 00 hrs and offered buffer feed for 30 minutes twice a day after being milked and were then turned out to the experimental pasture. The buffer silage was fed in the Dairy Research Unit where the individual intake of the cows was recorded daily. Each cow was fitted with a collar and transponder on it's neck, which would only open the door allocated to the cow. Coloured plastic tape was attached to the collar to distinguish cows within a particular treatment. The two groups recieving the hay buffer, Ch and Rh were fed seperately at a feeding barrier where all the cows within the group had free access to the hay. These cows also had a collar with coloured tape attached round their neck to distinguish treatment groups. Cows in Treatment Cc, Cr and Ch were grazed on the two clover/ ryegrass swards at a stocking rate of 0.48 ha/cow, whereas the cows in Treatments Rc, Rr and Rh were grazed on a perennial ryegrass/Italian ryegrass sward at a stocking rate of 0.35 ha/cow. This variation in stocking rate was estimated to account for the reduced herbage productivity of clover/ryegrass swards compared to ryegrass swards as illustrated by Frame (1990). To reduce bloat cows in Cc, Cr and Ch were grazed on the clover/perennial ryegrass sward with the least clover percentage during the night.

Figure 4.1 Treatment, sward and forage allocation.

Treatment	Sward		Buffer	
Cc	clover/ ryegrass	(C)	clover/ ryegrass	(c)
Cr	clover/ ryegrass		ryegrass	(r)
Ch	clover/ryegrass		hay	(h)
Rc	ryegrass	(R)	clover/ ryegrass	
Rr	ryegrass		ryegrass	
Rh	ryegrass		hay	

4.2.2 Pasture

The experimental pasture consisted of four fields;two high white clover/ ryegrass swards, one had been reseeded in the previous Autumn with 4 Kg/acre Olwen prg and 1 Kg/acre of Huia white clover combined with grass and the other had been sown in 1986 and two ryegrass swards, one permanent perennial ryegrass sward and a predominantly Italian ryegrass sward which had been reseeded the previous Autumn. All the fields were supplied with fresh water. Primary growth was ensiled from the reseeds during May before initiation of the trial. The sward height was maintained at approximately 4cm on both sward types. Only the ryegrass sward received 300 Kg N/ha fertilizer. Fertilizer was not applied to the clover swards during the trial. Cows on the clover/ ryegrass sward (Cc, Ch and Cr) were grazed on 36.6% clover during the day and 8.2% clover during the night. The ryegrass swards had a maximum of 1.7% clover. Pasture ME was calculated using Modified acid detergent fibre, MADF (MAFF,1984 , Equation 4.1).

Equation 4.1 Calculation of pasture Metabolisable energy.

$$ME(MJ/Kg\ DM) = 15.9 - 0.19\ MADF$$

where

ME = Metabolisable energy
MJ = megajoules
DM = Dry matter

4.2.3 Diet Allocation.

The cows in Treatments Ch and Rh were group fed hay produced on the farm during 1989. The bales of hay were broken up into individual slices and placed along the feeding barrier so that the cows had equal access to the hay. The cows were initially offered 2-3Kg DM/cow/day. This was freshly supplied at each feeding period after milking. The refusals were weighed daily which allowed daily adjustment of feed supplied to provide an *ad libitum* intake, i.e the level at which wastage approached 10%.

The remaining Treatments Cc, Cr, Rc and Rr were individually fed fresh silage daily for 30 minutes between 10.00 and 12.00 hrs. Any waste silage was removed and recorded daily to adjust the silage allocation to each cow, to allow *ad libitum* intake i.e where wastage approached a level of 10%.

4.2.4 Silage

The silage used was primary growth harvested on the last week of May and ensiled using 2.84 l/tonne Siloform a British Petroleum product (active ingredients, maximum of 55% Formic acid and 35% Formalin). Clover content of the clover/ ryegrass silage was determined prior to ensilage. Fifty samples were taken from each clover/ ryegrass sward.Then every 10 samples were bulked and thoroughly mixed and a sub-sample was sorted out into the various components clover, grass and weeds. These samples were then weighed and placed in an oven at 80^{o}C to calculate dry matter content. Clover content of each sward was then calculated on the dry matter ratio of clover:grass and weeds (the latter sward components were combined because the weed component of the swards were minimal <1 g/Kg DM). The final clover content of the silage was calculated in relation to the proportion (area) of each sward contributing to the silage.

4.2.5 Animal measurements.

Individual milk yields, live weight and body condition score were measured weekly. Condition scores were assessed using the scale described by Lowman, Scott and Somerville (1973).

4.2.5.1 Milk yield

Milk yield was recorded once a week in Kg/day. The daily value was taken to be the sum of the evening and following morning milk yield and was defined as the visible line of milk below the froth,in all cases 0.2Kg was added to compensate for the milk contained in the froth layer.

4.2.5.2 Milk sampling and chemical analysis

Individual aliquot whole milk samples were taken weekly at an afternoon milking (15.00hrs) and the following morning milking (06.00hrs). The milk samples were taken from the milk storage jar as recommended by the milk marketing board (MMB) and preserved with potassium dichromate tablets (Lactabs Mark 3). The samples were stored in a commercial cold store ($4^{0}C$) for up to seven days, until analysis for crude protein and butter fat content by the Kjeldahl and Gerber methods were determined respectively (MAFF,1985). Lactose values were obtained from monthly MMB records.

4.2.5.3 Cow Behaviour.

4.2.5.3.1 At pasture.

Behaviour studies were conducted three times during the trial, week 2,5 and 7. The study was carried out over 23 hours in one day. Behaviour observation began at 7 00 hrs, after morning milking and continued until 06 00 the following morning. Large conspicuous numbers were painted on the cows' side with emulsion paint to prevent skin dissoders. A rechargeable 12 volt torch was used to identify the cows during darkness. Grazing, ruminating, standing, lying, walking and biting rate were recorded as in experiment 1 and 2. Sleeping time was not recorded separately due to differences in judgement of time spent sleeping by observers and was therefore combined with lying time. Forage eating time was recorded every five minutes for cows on silage and hay, but due to different locations of feeding, cows on c and r were recorded one day and cows on hay were recorded the following day.

4.2.5.3.2 Forage eating behaviour.

Rate of eating bites, number of chews and swallows per minute were recorded on a separate day to pasture data due to insufficient time to accuretly record all the cows.

Eating bites: the bite was characteristically distinguished by an upward jerking movement of the head each time the cow grasped the forage. The measurement was taken when there was a continuous eating bout of at least one minute.

Chews per minute were recorded as the number of jaw movements the cow made when her head was raised above the feed. Two recordings were taken per observation for each cow. Swallows per minute were also recorded twice and were defined as the number of visible swallows taken by the cow in one minute.

4.2.6 Sward sampling

Sward height was recorded twice a week using a rising plate meter produced by the MMB (Baker, 1980). The mean value of forty random measurements were taken on a set 'W' shape course on the sward. Composition was determined on three occasions during the trial, week 1,4 and 6. A strip of grass/clover was cut from a quadrat 1m x 0.1m by the following method:- four identical quadrats were laid on the sward with their position pre-determined by set random co-ordinates. These were then ranked for visual clover content-low (L), medium (M), high (H) and very high (VH). This was carried out four times in order to bulk up a sample containing one cut of L,M,H and VH and the whole process repeated 10 times to obtain 10 bulk samples. These samples were then placed in a cold store until all field samples were obtained and could be thoroughly mixed to obtain a sub-sample ready for sorting out into the various sward components. The sward components were then dried in an oven at 80 ^{0}C for 48hrs or until there was no weight change. This weight was recorded to determine clover content on a dry matter basis. The samples were milled (using a 2mm sieve) for chemical analysis:- crude protein, ash and MADF (MAFF, 1985).

4.2.7 Feed sampling

The silage was sampled by taking two bulked samples of approximately 200g fresh weight per silage type and approximately 100g fresh weight for the hay three times a week. A sub-sample of each feed was dried in an oven at 80^{0}C until there was no weight change. This dry matter weight along with the measured fresh weight was used to calculate the circulating air oven dry matter(DM) content of the buffer feed and was then analysed for the crude protein (CP), modified acid detergent fibre (MADF) and ash (MAFF 1985). The metabolisable energy (ME) contents of the hay and silages were estimated from the MADF and DM of the feed (MAFF, 1984).

4.2.8 Intake measurements

4.2.8.1 Hay

Dry matter intake per group was calculated daily by subtracting fresh weight of the wastage from total fresh weight of hay supplied and multiplying by the hay DM content. Then average eating bites x eating time were used to provide a ratio to calculate the proportion of hay eaten by each cow within the Treatment group. This value was then divided by the number of days in the trial to give an average daily DM intake.

Figure 4.2 Calculation of Forage Metabolisable energy

Silage Metabolisable energy

Grass silage ME(MJ/Kg TDM)=15.33 - 0.152 MADF(corrected)

where TDM is ODM + 1.9

corrected MADF = (MADF on ODM basis)x ODM/TDM

where ODM = oven dry matter

TDM = toluene dry matter

Hay Metabolisable energy

Hay ME (MJ/Kg DM) = 16.5 - 0.21 MADF.

4.2.8.2 Silage

Individual silage DM intake per cow was calculated daily by subtracting refused silage DM from silage DM supplied.

4.2.8.3 Pasture Metabolisable energy

The ME allowance of the cow was calculated from production standards (Figure 4.3) as described by the MAFF Technical bulletin 33, using average cow weight, milk yield, butter fat and solids not fat (SNF). Lactose values were obtained from MMB milk records.

Figure 4.3 Calculation of ME allowances for individual cows

Maintenance Allowance Mn (MJ) = 8.3 + 0.091 W - (1)

where W = live weight in Kg

Energy value of milk secreted

$EV_1 = 0.0386\ BF = 0.0205\ SNF - 0.236$

$M_1 = 1.694\ EV_1$ MJ/Kg milk

therefore ME supplied by milk M_1 x milk yield - (2)

where BF= butterfat in g/Kg milk

SNF= solids not fat in g/KG

milk yield= Kg milk

M_1=ME requirement to produce milk

Add (1) + (2) to give total ME allowance (A)

Considering weight change

Loss

weight loss (Kg) x 28=b

Total ME allowance = A - b

Gain

weight gain (Kg) x 34 = c

total ME allowance = A + c

Pasture ME was calculated by subtracting forage ME(DM intake/cow x forage ME) from the back calculated ME allowance. This was then divided by the number of bites per day i.e mean grazing time x mean bite rate, to give the ME intake per bite of pasture measured in Joules.

4.2.9 Statistical analysis

Data analysis was performed using programmes available on the University of Wales, Bangor, vax cluster. Milk yield and composition and behaviour parameters were analysed in an eight week period by anova with treatment, pasture and forage as factors and a covariate (initial milk yield prior to the trial). This was carried out using the statistical package Genstat 5 (1987).

Liveweight and condition score changes were initially analysed by linear regression using Minitab (1989) to obtain the slope and then by Anova highlighting treatment,pasture and forage effects using the Genstat package (1987). Pasture and forage ME intake were also analysed by anova using the same Genstat package.

Milk yield and daily forage intake were also correlated with behaviour parameters and further analysed by stepwise and linear regression using minitab.

4.3 RESULTS

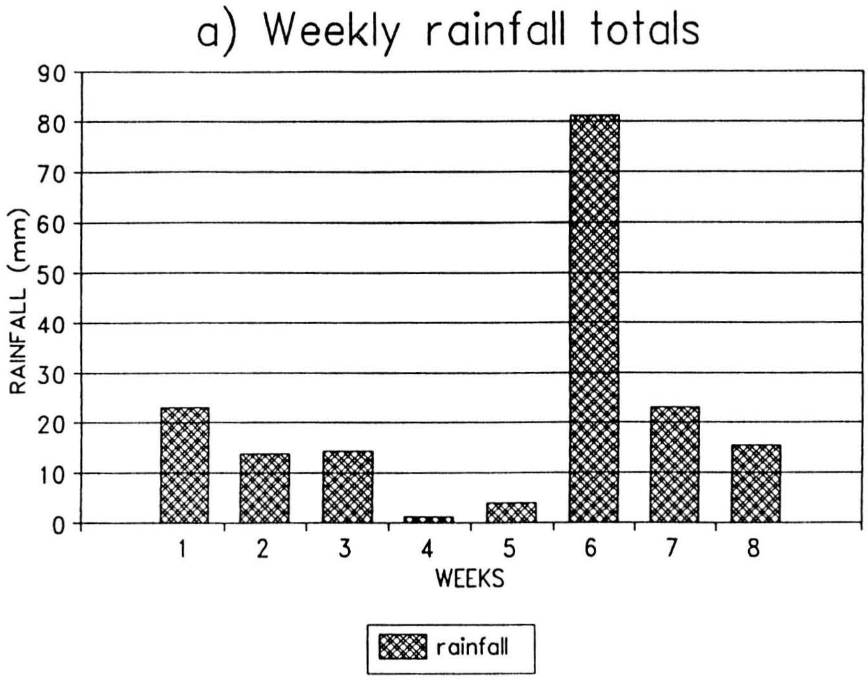
4.3.1 Weather.

Total rainfall for the experimental period was 176 mm and mean daily sun hours 4.8 hrs/day. Weekly total of rainfall and sun hours are illustrated in Figure 4.4.

4.3.2 Herbage height.

Statistical analysis of mean weekly herbage height per treatment indicated that differences between sward type and variation with time were small (Table 4.1). The ryegrass sward tended to maintain a higher herbage height.

Figure 4.4. Rainfall and sun hours.



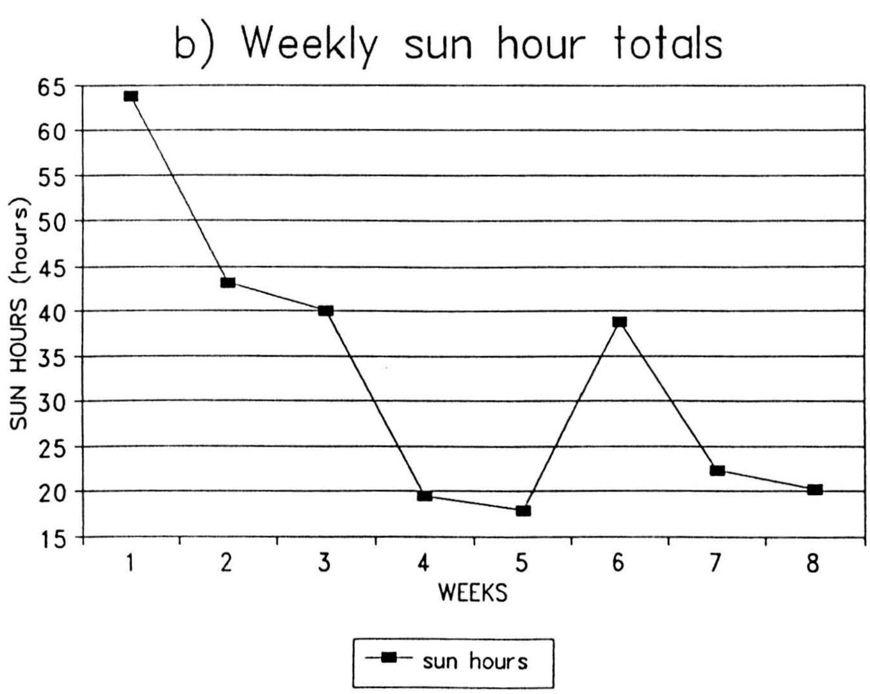


Table 4.1 Weekly mean values of herbage height in cms.

week	SWARD clover/prg	prg	Prob %	SED
1	4.15	3.60		
2	3.05	4.55		
3	3.25	4.30		
4	3.80	3.95		
5	3.85	3.70		
6	3.85	3.70		
7	3.80	3.70		
8	3.80	3.60		
MEAN	3.69	3.89	30	(0.18)

4.3.3 Pasture.

The botanical content and chemical composition of the sward components are given in Table 4.2 and 4.3 respectively.

Table 4.2 Sward botanical composition in g/Kg DM.

	SWARD clover/rg			ryegrass		
time	clover	rg	weed	clover	rg	weed
1	222	763	15	12	977	11
2	232	755	13	16	977	7
3	217	750	33	21	948	31
MEAN	223	756	21	16	968	16

Probability (%) (SED) (g/Kg DM)

	sward		period		sward x period	
clover	0	(19.36)	>25	(23.70)	>25	(33.53)
grass	0	(19.94)	>25	(24.43)	>25	(34.54)
weed	>25	(4.84)	0.1	(5.92)	>25	(8.38)

Table 4.3 Dry matter and chemical composition of **sward** components in g/Kg DM.

a) Dry matter

Period	species	SWARD clover/rg	SWARD rg
1	clover	206	209
	grass	311	299
	weed	189	189
2	clover	198	195
	grass	262	271
	weed	205	202
3	clover	185	189
	grass	245	241
	weed	180	180
MEAN	clover	197	198
	grass	273	271
	weed	191	190

Probability (%) (SED) (g/Kg DM)

	sward	period	sward x period
clover	<25 (1.24)	0 (1.54)	>1 (1.75)
grass	>25 (1.85)	0 (2.27)	0 (3.21)
weed	>25 (1.83)	0 (2.25)	>25 (3.18)

b) Crude protein

Period	species	SWARD clover/rg	SWARD rg
1	clover	227	NA
	grass	142	198
2	clover	278	NA
	grass	158	180
3	clover	242	NA
	grass	159	160
MEAN	clover	249	NA
	grass	153	180

Probability (%) (SED) (g/Kg DM)

species	period	species x period
0 (4.87)	0 (4.87)	0 (8.45)

c) Ash

Period	species	SWARD clover/rg	rg
1	clover	89	NA
	grass	97	89
2	clover	100	NA
	grass	101	111
3	clover	150	NA
	grass	151	151
MEAN	clover	113	NA
	grass	117	117

Probability (%) (SED) (g/Kg DM)

species		period		species x period	
>25	(5.97)	0	(5.97)	>25	(11.32)

Grass dry matter content was consistently higher than that of the clover component. Differences between the same species within the two sward types were not statistically significant. Clover crude protein value was significantly higher than grass values, irrespective of sward type. Grass crude protein was higher for grass in the rg sward than the clover/rg sward (180 and 153 g/Kg DM respectively). There was a general decline in crude protein with time. Ash values were consistently higher for the grass component in each sward, but differences were not statistically significant. Ash content increased with time (Table 4.3).

There was insufficient material to analyse clover and grass Madfibre values.

Ash values were consistently higher for R sward components.

4.3.4 Forage.

The chemical composition of the silages were similar except for ash content (c, 76.2 and r, 67.5 g/Kg DM) (Table 4.4). There was a large difference between the hay and silages. On average the silages contained 4.5 times more water and 50% more CP than the hay.

Table 4.4 Chemical composition of the forages.

	SILAGE		HAY
	c	r	h
Oven DM (g/Kg)	190.3	188.7	843.6
Crude protein (g/KgDM)	155.7	150.4	66.9
Madfibre (g/KgDM)	351.6	352.3	343.0
Ash (g/KgDM)	76.2	67.5	48.4
ME (MJ)	10.47	10.47	9.29

4.3.5 Milk Production

The production parameters of milk yield, fat, protein and lactose contents and fat,protein and lactose yields are given in Table 4.5. Intake, liveweight, condition score change and ME intakes are given in Table 4.6.

Mean milk yield was greater by 1.5 Kg/day/cow for cows grazing the high white clover/ryegrass swards (Table 4.5) than rg only. There was also a trend due to forage type (h) 11.34, (c) 12.16, (r) 13.27 Kg/day (Forage SED 0.91 Kg/day), but this difference was only significant at $P > 10\%$.

Milk fat, protein and lactose content were not affected by treatment. Protein yield was higher for cows grazing clover/rg pasture than rg pasture and higher for cows receiving rg silage, than clover/rg silage and the hay. Lactose yields were also higher for cows grazing clover/rg pasture than rg pasture alone, and there was a tendency for this effect to occur with fat yields.

A loss of liveweight occurred within all Treatments (Table 4.6). Pasture type had the greatest effect with a mean loss of 0.475 Kg/cow/day for cows grazing the rg sward (Pasture SED 0.15),P=<25%. There was also a trend for cows grazing the rg pasture and buffer fed clover/ryegrass silage to have the highest weight loss.

There were no significant differences in mean condition score changes between Treatments.

Forage type had a significant effect on intake, cows tended to consume more rg silage((h) 2.93, (c) 4.03 and (r) 4.72Kg DM/cow/d Forage SED 0.55 KgDM/cow/d P=1% (Table 4.6). Cows grazing a rg sward (R) consumed more clover/rg silage (c) compared to rg silage (r) (Rc, 4.95 and Rr, 4.40 Kg/cow/day). This complementarity effect was also clearly demonstrated in Cc and Cr where cows grazing C consumed a higher quantity of r than c silage 9 Cr 5.04 and Cc 3.11 Kg DM/ day). Hay intake was not affected by pasture type,but produced the lowest forage DM intake/day.

Highest ME intake/bite of pasture occurred with cows fed hay irrespective of pasture type (3174 Joules ME/bite Forage SED 360.3 Joules ME/bite) (Table 4.6), both pasture and forage effects were not statistically significant (P>25% respectively), although pasture type did perhaps have some influence on ME intake/bite.

Table 4.5 Mean milk production parameters for animals within each treatment group.

	Cc	Cr	Ch	Rc	Rr	Rh	Pasture	Forage	PxF
Milk yield (Kg/d)	12.4	14.2	12.4	11.9	12.4	10.2	<10 (0.76)	<25 (0.91)	>25 (1.30)
Fat content (g/Kg)	45.2	39.8	41.6	42.9	42.7	43.7	>25 (1.74)	>25 (2.07)	>25 (2.96)
Protein content (g/Kg)	37.0	34.5	43.7	36.6	35.7	35.9	>25 (0.72)	<10 (0.86)	<25 (1.23)
Lactose content (g/Kg)	43.5	43.1	41.7	40.8	42.5	42.5	<25 (0.66)	>25(0.79)	10 (1.12)
Fat yield (g)	561	550	506	497	526	440	10 (30.2)	<25 (36.1)	>25 (51.4)
Protein yield (g)	453	482	425	428	441	360	9 (25.0)	8 (29.9)	>25 (42.6)
Lactose yield (g)	540	614	522	493	530	438	6 (36.4)	<25 (43.5)	>25 (61.9)

Table 4.6 Mean intake and weight change parameters for animals within each treatment group.

	T R E A T M E N T						Probability (%) (S.E.D.)		
	Cc	Cr	Ch	Rc	Rr	Rh	Pasture	Forage	PxF
Forage DM intake (Kg/d)	3.1	5.0	2.9	5.0	4.4	2.9	>25 (0.45)	1 (0.55)	<10 (0.77)
Forage ME intake (MJ/d)	32.6	52.7	27.2	51.8	46.1	27.2	>25 (4.28)	<0.1 (5.24)	5 (7.41)
Pasture ME intake (joules/bite)	2899	2934	3093	2814	2586	3255	<25 (294)	>25 (360)	>25 (509)
Liveweight gain (Kg/d)	-0.22	-0.22	-0.40	-0.77	-0.47	-0.18	<25 (0.15)	>25 (0.19)	<15 (0.27)
Condition score (condition score units)	.0064	.0019	.0005	.0040	.0067	.0025	>25 (.0027)	>25 (.0033)	>25 (.0046)

Ryegrass silage (r)=49.4 MJ/cow/day achieved the highest forage ME intake/cow/day, especially for cows on clover/ ryegrass swards (Cr 52.7 MJ/cow/day) (Table 4.6). Also the forage ME intake of clover/ryegrass silage c was increased for cows grazing ryegrass swards; therefore further supporting the complementarity effect shown by the daily forage dry matter intake.

4.3.6 Cow Behaviour.

The analysis of behaviour parameters studied are given in Tables 4.7 and 4.8.

4.3.6.1 Behaviour data during 24 hour day.

Pasture and forage type did not significantly affect grazing behaviour. Interaction of these factors approached significance (P<25%). Cows on C tended to graze for longer than cows on R. Cows fed r also spent longer grazing R than C and cows fed c would spent longer grazing C than R.

Total ruminating time was not significantly affected by pasture type, but was significantly increased by forage type, i.e. hay. Cows on R tended to spend more time lying ruminating than cows on C (P< 2.5%). Forage type did not influence time spent lying and ruminating. Cows on C tended to spend more time standing ruminating than cows on R. Offering hay significantly increased standing ruminating (P<1%).

Lying time was significantly increased by grazing C, but was not affected by forage type. Time spent standing was increased by offering hay to the cows, irrespective of pasture type. Walking time was similar in all treatments.

Forage feeding time was strongly affected by forage type ($P<1\%$). Cows spent more time consuming hay. Pasture type did not cause a change in feeding times, but interaction of pasture and forage type was significant at the 1% probability level.

Biting rate at pasture were similar between treatments and were not statistically significant. Individual biting rates per cow ranged from 54 to 76 bites/minute.

4.3.6.2 Forage eating behaviour.

The result of forage eating behaviours are given in Table 4.8. Forage type had a significant effect on number of eating bites/min. The range of individual animals was 3.5 to 18.5 with an average of 9.89 bites/min across treatments. The number of chewing bites/minute was not affected by pasture type but was increased by offering the cows hay ($P<1\%$). Number of swallows/minute was significantly increased with offering silage compared to hay. Also Cc was greater than Cr and Rr was greater than Rc ($P<1\%$). Swallowing frequency was increased on R compared to C ($P<5\%$).

4.3.7 Correlation of milk yield forage intake and behaviour parameters.

The results of the correlation coefficients of milk production and DM intake with behaviour parameters are given in Table 4.9 and the relevant regression equations in Table 4.10.

Milk yield was negatively correlated with forage eating time (-0.450).The regression equation of forage eating time indicated that number of boluses/minute and lying time had a strong influence on eating time. Correlation of ruminating parameters at grass indicate that as total ruminating and lying ruminating increase time spent lying is reduced.

Table 4.7 Mean behaviour parameters for animals within each treatment group (minutes/day).

	PASTURE						*SED*			*PROBABILITY (%)*		
	C			*R*								
Forage	*c*	*r*	*h*	*c*	*r*	*h*	*P*	*F*	*PF*	*P*	*F*	*PF*
grazing	433	344	382	353	393	368	14.7	18.0	25.5	NS	NS	2.5
lying	194	183	168	156	144	97	17.2	21.0	29.7	1	25	NS
LYRUM	332	385	365	417	400	446	23.7	29.0	41.0	2.5	NS	NS
SRUM	93	82	111	71	64	111	9.4	11.5	16.3	25	1	NS
TOTRUM	424	467	476	488	464	557	26.0	31.3	44.2	25	10	NS
walking	110	110	110	110	110	110	-	-	-	NS	NS	NS
stand	176	203	154	199	215	154	15.4	18.6	26.3	NS	5	NS
Feeding	43	73	86	75	54	94	5.8	7.1	10.0	25	0.5	1
Biting rate at pasture	68	66	66	64	68	68	1.7	2.0	2.9	NS	NS	15

Table 4.8 Forage eating behaviour.

	PASTURE						SED			PROBABILITY (%)		
	C			R								
Forage	c	r	h	c	r	h	P	F	PF	P	F	PF
No of eating bites/minute	9.67	11.92	5.92	11.92	13.92	6.00	0.9	1.14	1.61	20	0.01	NS
No ofchewing bites/minute	38.92	37.83	41.33	35.08	36.58	44.58	1.6	1.9	2.8	NS	1	20
No of swallows per minute	2.58	2.25	1.75	3.08	3.33	1.58	0.22	0.27	0.38	5	1	10

where
SRUM = standing ruminating
LYRUM = lying ruminating
TOTRUM = total ruminating time

Table 4.9 Correlation coefficients of milk yield and behaviour parameters.

	MILK	FDMI	GRAZE	LYING	LYRUM	SRUM	TOTRUM	FET	BITES	FEB	CHEWS	BOL
FDMI	0.065											
GRAZE	0.007	-0.405										
LYING	-0.146	-0.139	-0.069									
LYRUM	0.117	0.429	-0.416	-0.689								
SRUM	-0.282	-0.217	-0.072	-0.155	0.011							
TOTRUM	-0.007	0.303	-0.408	-0.690	0.915	0.413						
FET	-0.450	0.007	-0.217	-0.219	0.140	0.155	0.189					
BITE	0.061	-0.226	0.274	-0.117	-0.187	-0.159	-0.235	0.051				
FEB	-0.050	0.365	0.017	0.232	-0.175	-0.349	-0.300	-0.229	0.091			
CHEWS	0.010	-0.141	0.292	-0.173	0.013	-0.139	-0.044	0.081	0.016	0.072		
BOL	-0.042	0.125	0.063	0.004	0.068	0.144	0.120	-0.422	-0.122	0.070	-0.097	
IBI	0.100	-0.207	0.049	0.067	-0.109	-0.071	-0.128	0.197	-0.069	-0.156	0.267	-0.795

Table 4.10 Regression equations.

	r^2(%)	Prob(%)
Milk = 16.7 - 0.0632(+-0.0215) eating time	20.3	6
Forage DM intake = -2.33 = 0.0114(+-0.0031)LYRUM + 0.178(+-0.544)FEB	38.4	0
Grazing = 706 - 0.621(+-0.129)LR - 0.542 (+-0.147)Lying	41.5	0
FEB = 16.2 + 1.28(+-0.385)FDMI - 0.0236(+-0.079)TOTRUM	31.9	2
BOL = 3.53 - 0.0310(+-0.004)IBI-0.00439(+-0.0015)FET	70.6	0
Lying = 877 - 0.717(+-0.09)TOTRUM -0.467(+-0.142)GRAZE - 3.0(+-1.429) BITES	67.0	0
FET = 186 - 3.64(+-0.918)MILK-27.8(+-8.014)BOL - 0.116(+-0.051)lying	48.0	0

Key for Table 4.3 and 4.4

FDMI = forage DM intake
SRUM = standing ruminating
LYRUM = lying ruminating
TOTRUM = total ruminating time
FET = forage eating time

BITE = biting rate
CHEW = chews/ minute
BOL = boluses/minute
IBI = interbolus interval
FEB = forage eating bites

4.4 DISCUSSION.

4.4.1 Herbage parameters

Clover and grass contents remained relatively stable throughout the trial, whereas weed content increased during the latter stages of the trial possibly associated with the natural increase in weed content during the Autumn.

The dry matter content of the sward components decreased with time, particularly during sampling time three. This corresponds to a higher rainfall total at this time. Possibly this increase in rainfall after two relatively dry weeks prompted the onset of young succulent herbage growth which was reflected in the lower DM value at this time.

Clover crude protein was consistently higher than values recorded for grass and agrees with results obtained in Experiment 1. Differences between species in relation to crude protein were significant, the results indicated that the crude protein values obtained for the grass component in R were higher than values obtained for the grass component in C. This could be due to the grass species and age in the sward, however detailed botanical separations of the grass species in each sward type were not undertaken.

4.4.2 Forage intake.

Forage DM intake was significantly influenced by forage type (P=1%). Cows tended to consume the silages to a greater extent than the hay. There were also pasture x forage effects in that cows tended to consume more clover silage when they were grazing grass and cows grazing the clover based sward tended to eat more ryegrass silage (Pasture type did not affect hay DM intakes). This complementarity effect by the cows is surprising because the chemical composition of the silages used were very similar, they had identical ME values. Therefore this complementarity effect can not arise from crude protein or energy synergism due to the similar chemical content of the silages. Further chemical analysis of the silages could possible reveal other differences which could account for the selective DM intake by the cows. The low hay intakes were due to the nutritional quality of the hay in that CP content and ME value were both lower than the silages and the high DM content of the hay would also reduce DM intake. Work conducted on grazing behaviour of the cows in this experiment found that the forage preferences were buffered by the cows grazing behaviour. Cows offered r would graze for longer on R than cows grazing C and cows offered c would graze for longer on C than cows on R (Cc 433, Cr 344, Ch 382, Rc 353, Rc 393, Rh 368, Interaction SED 25.5).

The grass silage produced the highest forage ME intake per cow per day which was statistically significant ($P<0.1\%$). There was also an interaction between forage and pasture. Complementarity was again reflected in high ME intakes for clover silage for cows grazing ryegrass and visa versa. The reason for this complementarity effect may be due to the cows preferring a combination of two species in the diet to one i.e dietary variation. The cows select to consume the forage in this way without any sign of advantage in milk production or weight gain.

4.4.3 Animal parameters.

Milk yield was increased by 1.5Kg/cow/d (13%) by grazing the clover based sward irrespective of forage type. This agrees with results obtained experiment 2 where milk yield was increased by grazing a clover based sward. Rogers et al (1980) reported increased milk yields of 22% for cows fed a sole diet of clover, but mixed swards of 50% clover and 50% grass increased milk yields by 7.4% compared to cows grazed solely on prg swards. The increase of 13% achieved in experiment 3 could be the result of an additive effect of combining a forage buffer with the grazed swards. Forage type alone did not affect milk yield, it was concluded that this was due to the buffering effect of the grazing behaviour of the cows. Milk composition was not altered by the inclusion of buffer forages. Lactose yield was marginally affected by grazing the clover sward (P=6%). Clover content of c was comparatively low to produce a substantial effect on silage quality. Castle et al. (1983) demonstrated that milk yields were increased as the proportion of clover in type silage increased. Although the clover silage used did produce differences in DM intake, the nutritional quality of c was not sufficiently greater than r to affect milk composition.

Liveweight and condition score were not different between treatments. This was because cows grazing R tended to lose more weight than cows on C, but cows receiving c tended to loose more weight than cows receiving r, this would therefore reduce the affect of any one parameter. Liveweight changes were reflected in changes in condition score.

The predicted pasture ME intake was not significantly different between treatments, but the highest value was recorded for the clover/rg sward.

4.4.4 Cow Behaviour.

Cows tended to graze for longer on C than R, which agrees with results obtained in experiment 2 and was again possibly due to the nutritional quality of the clover. Grazing time in relation to forage was not significantly different, but cows receiving c were found to graze for up to 24 minutes longer than cow given r. This is the result of the ability of cows to adjust their behaviour primarily grazing to compensate for reduced nutrient intake (Jamieson,1975). The passage of clover through the rumen is quicker than prg and therefore enables the cow to consume and digest clover at a quicker rate than grass. This would in effect allow the cow to graze the clover for longer. Cows on R tended to ruminate for longer than cows on C therefore again restricting time available to graze.

The inclusion of clover as a forage and grazed herbage had a wide range of effects on behaviour parameters and the interaction of forage and pasture approached significance. Clover contents of the pasture and silage were relatively low but affect behaviour. Further work in this area could be carried out using silage and pasture containing a higher clover content which could possibly significantly affect behaviour parameters.

4.4.5 Conclusions.

Cows would appear to prefer a combination of grazing a high white clover/rg sward with a buffer fed ryegrass silage and visa versa. Intakes were low for both sward types with buffer fed hay. This complementarity effect by the cows did not lead to an increase in milk production or weight gain because the cows actively increased or decreased grazing time to buffer the effect of the forage. Cows eating a preferred forage tended to reduce grazing time. Analysis of pasture effects demonstrated that pasture type had a strong influence on milk yield, favouring the clover/rg sward. The results indicate that pasture type had a stronger influence on milk yield than the forage type. The similar chemical composition of the silages used would indicated that the complementarity effect of grazing C and consuming more r and visa versa probably does not arise from nitrogen or energy synergism.

Behaviour studies indicated that some of the cows preferred to spent more time consuming forage than grazing, which reduced milk production because of the poor quality of the forage compared to the fresh herbage.

4.5 SUMMARY.

A continuous design experiment was conducted using thirty-six spring calving Friesian cows in late lactation to determine the effect on milk production during the late grazing season by buffer feeding ryegrass or white clover/ryegrass silage to cows grazing either a clover/ryegrass or ryegrass sward. The cows were grazed on pasture of equal height containing either, 244:776 or 17:964 g/KgDM clover:ryegrass clover/rg and ryegrass sward respectively and offered silages of the same composition or ryegrass hay in a randomised block design.

Cows grazing the clover based sward had higher intakes of ryegrass silage and visa versa, hay intakes were low for both sward types.

Forage preferences were buffered by grazing time therefore reducing the effect on milk yield and composition. Grazing the clover sward significantly increased milk yield, but did not affect milk composition.

Liveweight and condition score decreased with time but there were no treatment effects.

The cows preferred to complement clover swards with ryegrass silage and visa versa, but grazing behaviour buffered the effect and since the chemical composition of the silages were similar this preference probably does not arise from nitrogen or energy synergism.

EXPERIMENT FOUR THE EFFECT OF ENERGY AND PROTEIN CONCENTRATION OF A STRAWMIX SUPPLEMENT ON THE PRODUCTIVITY OF DAIRY COWS GRAZING A HIGH CLOVER PASTURE.

5.1 INTRODUCTION.

Maintaining high milk yields during summer months using a forage based buffer is now an established technique that is particularly relevant with high milk prices during the latter part of the summer. Arnold and Holmes (1985) found that low quality forages such as straw are eaten in small quantities. In experiment three hay intakes were lower than silage. Straw intake can be increased by combining straw with nutritionally appetising molasses and this mix can be used to supplement silage in winter (Roberts,1988) This mix was again used by Roberts et al. (1989) as a buffer feed fed to cows grazing perennial ryegrass (prg) swards to maintain high milk yields at high stocking rates.

Straw based supplements are particularly attractive as a means of disposing of surplus straw and do not impinge on a farm's stocking rate as home produced grass based supplements will. Stocking rates are generally already low on clover based swards therefore straw based supplements would appear to be advantageous in clover systems.

The aim of this experiment was first, to evaluate the use of straw mix supplements fed to dairy cows grazing a high white clover/perennial ryegrass sward and second to determine the effects of varying the energy to protein concentration of the strawmix supplement on the buffer intake and productivity of the dairy cow.

5.2 MATERIALS AND METHOD.

The trial was conducted at the University college farm at Aber, Gwynedd (Lat 652, Long 727, sheet 115, scale 1:50,000). The study was carried out for fifteen weeks using twenty spring calving Friesian cows from turn out in April 1990. All the experimental cows had minimum dry period of six weeks prior to calving and calved within a period of four weeks. During this time the cows were housed and fed a complete diet. Two weeks prior to turn-out the cows were trained to feed from the Calan individual feeding gate system (American Calan Inc Ltd) used in the Dairy research unit at college farm. A complete diet was used initially to entice the cows to eat from the gate system. The cows were initially turned out onto prg swards and were then gradually turned out onto the clover/prg sward for increasing amounts of time until they remained on the sward 24 hours a day. From the commencement of the trial on the April 27^{th} to August 10^{th} the cows were grazed on a high white clover/prg sward (731 g/Kg DM clover) at 0.23 ha/cow and individually fed various straw mix supplements.

5.2.1 Cow management.

Twenty cows were allocated to a five treatment, five period change-over design trial with three week periods. Experimental cows of similar milk yield age and calving date were selected from the main herd and grouped together. They were then placed in four groups, very high (VH), high (H) medium (M) and low (L) milk yield and allocated to four replicates of a Latin square design (Table 5.1). Each period lasted three weeks with two weeks for the cows to adjust to the new strawmix supplement before milk production and strawmix DM intake were recorded in the last week.

Table 5.1 Latin Square design.

			(VH)					(H)					(M)					(L)		
Cow No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
					T	R	E	A	T	M	E	N	T	S						
PERIODS 1	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2	2	3	4	5	1	5	1	2	3	4	2	3	4	5	1	5	1	2	3	4
3	5	1	2	3	4	2	3	4	5	1	5	1	2	3	4	2	3	4	5	1
4	3	4	5	1	2	4	5	1	2	3	3	4	5	1	2	4	5	1	2	3
5	4	5	1	2	3	3	4	5	1	2	4	5	1	2	3	3	4	5	1	2

The cows were milked at 06 00 and 15 30 hours and individually offered strawmix supplements twice a day for approximately 30 minutes after each milking before being turned out to the clover/prg sward. A collar and transponder were fitted to the cows which could only open the cow's own gate to record daily strawmix intakes. Coloured tape attached to the collars was used to distinguish cows within a treatment. Cows in the treatments were grazed on a different paddock each day to prevent sequences of treatments grazing a particular paddock. This was achieved by using random numbers to allocate treatments to each paddock throughout the trial.

5.2.2 Pasture.

The experimental pasture consisted of one permanent high white clover/ prg sward which had been resown in 1988 with 5Kg/acre of Huia white clover under arable barley and was ensiled in 1989 and grazed by sheep throughout the subsequent winter. The field was divided into five equally sized paddocks by electric fencing. Each paddock contained a strip of natural hedging to provide shelter and a source of fresh running water. One application of 62.5 Kg N/acre was applied to the field during the first week of June.

5.2.3 Diet allocation.

One kilogramme of rolled barley, 200 g of calcined magnesite and 5 ml of vegetable oil were supplied to the experimental cows daily irrespective of treatment. This was given separately in a bucket to accurately measure refusals. Cows in NOSUPP only received the rolled barley, magnesium calcite and the vegetable oil. Cows in the remaining treatments received the various strawmix supplements. The cows were initially supplied with 4 Kg DM of freshly made strawmix supplements daily between 10.00 - 13.00 hours. Any waste strawmix supplement was removed and the weight recorded daily to adjust the strawmix allocation to each cow to allow *ad libitum* intake (i.e. where wastage approached a level of 10%)

5.2.4 Strawmix supplement.

The strawmix supplement consisted of straw, molasses and soya. These were mixed together in various proportions (Table 5.2) to achieve the energy:protein ratio required. The amount of each component was calculated on a DM basis and then converted to fresh weight to facilitate calculation of weight for mixing. The conversion ratio required for DM to fresh weight was predetermined from weekly sampled DM contents of the straw, molasses and soya. The strawmix was mixed together manually with a fork. A known quantity of hot water was added to the molasses to aid mixing and distribution of the molasses through the strawmix (1, 0.75, 0.25 and 0.25 Kg water were added to every 4Kg DM strawmix for LEHP, LELP, HELP and HEHP respectively). The straw was chopped to approximately 2.5cm using a Paylor chopping machine to increase the surface area available for attachment of the molasses and to improve palatability.

Table 5.2 Feed composition.

	g/Kg Dry matter			Nutrient concentration	
Treatment	STRAW :	MOLASSES :	SOYA	ME(MJ/Kg/DM)$^{+}$	CP(g/Kg/DM)
LELP	500 :	500 :	0	8.9	42
HELP	250 :	750 :	0	10.9	43
LEHP	500 :	250 :	250	8.8	167
HEHP	250 :	475 :	275	10.7	169

$^{+}$ Predicted from ME standard values (MAFF,1985)

5.2.5 Animal measurements.

Milk yield was recorded on four consecutive days at the end of each three week period throughout the trial. Strawmix DM intake was recorded daily for each cow.

5.2.5.1 Bloat detection and treatment.

The occurrence of bloat was recorded to determine a possible reason for bloating, the following were recorded:- cow number, strawmix supplement, weather conditions, time of day and severity of bloat(treated, untreated or death). The cows were checked twice a day at 13.00 and 21.00 hours for the occurrence of bloat. If the cow appeared to be bloated by the extension of her abdomen she was walked up to the milking parlour (0.5 Km) in an attempt to reduce the bloat, if the cow was still bloated she was then dosed orally with poloxalene (Birp, Arnolds Veterinary Products). If this did not alleviate the bloat within a specified time (30 minutes) veterinery assistance was required. If poloxalene was successful in reducing the bloat the cow was returned to the experimental paddock, but in severe cases where bloat was not completely reduced the cow was returned to a clover/prg sward of lower clover content (approximately 200 g/Kg DM) and was checked after two hours. The cow was returned to the experimental paddocks after the next milking. During the first period of the trial cows were grazed on the low clover/prg sward on three very wet days when bloat incidence was expected to increase.

5.2.5.2 Milk yield

Milk yield was recorded in Kg/day on four consecutive days at the end of the last week of every three week period throughout the trial. The daily value was taken to be the sum of the evening and following morning milk yield and was defined as the visible line below the froth, in all cases 0.2 Kg was added to compensate for the froth.

5.2.5.3 Milk sampling and chemical analysis.

Individual whole milk samples were taken on four consecutive days at the end of the last week of the three week period. A sample was taken at an afternoon milking (15 30 hrs) and the following morning milking (06 00 hrs) from the milk storage jar as recommended by the Milk Marketing Board (MMB) and preserved with potassium dichromate tablets (Lactotabs Mark 3). The samples were kept in cold storage at 4^{o}C for up to seven days until analysis for crude protein and butterfat content by the Kjeldahl and Gerber methods were determined respectively (MAFF,1985). The mean value of the 4 days were used for data analysis of the period and for individual cows in the trial.

5.2.6 Sward measurements.

The sward height in each paddock was recorded twice weekly, using a rising plate meter produced by the MMB (Baker,1980). sward height was taken as the mean value of 20 measurements taken randomly along a set `W' shaped course in each paddock.

Sward composition was determined by cutting fresh sward samples from each paddock and sorting into the various sward components every 3 weeks throughout the trial. Four identical quadrats (1m x 01m) were laid on the ground, their position pre-determined by set random co-ordinates. These were then ranked in relation to visual clover content, low (L), medium (M), high (H) and very high (VH) and only one sample was cut each time the quadrats were set out. Initially the L quadrat was cut and the sample obtained was kept in a separate sealed plastic bag. This procedure was continued until three samples of each rank L,M,H and VH were obtained. The samples were kept in cold storage (to reduce respiration and weigh loss) until they could be sorted into the various sward components and oven dried at 80^{0}C until there was no further change in weight on two subsequent weighings. This weight was used to calculate clover percentage and other sward component relationships on a DM basis. The samples were then milled using a 2mm sieve and placed in a sealed plastic bag, so that chemical analysis of crude protein, ash and modified acid detergent fibre (MADF) could be carried out at a later date (MAFF, 1985).

5.2.7 Feed sampling.

A bulked sample of each strawmix component of approximately 100 g fresh weight was taken three times a week. These were accurately weighed and dried in an oven at 80^0C until the weight remained constant on two subsequent weighings. The fresh and oven dry weight were used to calculate the DM content of the samples.

5.2.8 Intake measurements.

Individual strawmix supplement intake per cow was calculated daily throughout the trial by subtracting refusal strawmix from the amount supplied daily. For data analysis the DM intake value was described as the total DM intake per cow in the final week of each period.

5.2.9 Statistical analysis.

Data analysis was performed using programmes available on the university of Wales, vax cluster. Milk yield and composition were analysed using the Latin square analysis in Genstat 5 (1987) with treatment and period as factors. Strawmix intake was also analysed using Genstat 5, but was modified to analyse four treatments.

Incidence of bloat was analysed using the chi-square test, where differences between 1) strawmixes, 2) treated and untreated animals and 3) incidence in relation to time within each period were tested.

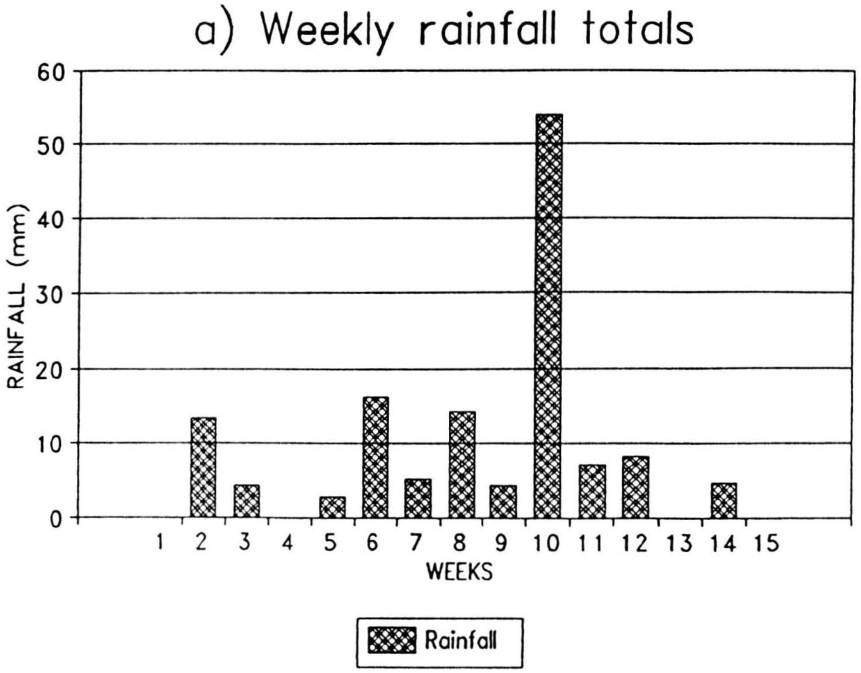
Herbage data per paddock was analysed by Anova using the statistical package Minitab (Copyright 1989) with paddock and time as factors. Botanical content of the paddocks were analysed by Anova using Minitab with paddock and period as factors. A subsequent analysis by Anova was conducted to determine rank effects in the sampling technique. Anova was carried out separately for the sward components. Chemical content of the sward components were also analysed by Anova in Minitab. Missing values for milk production parameters and DM intake were calculated using an iterative scheme using the equation described in Appendix 2.

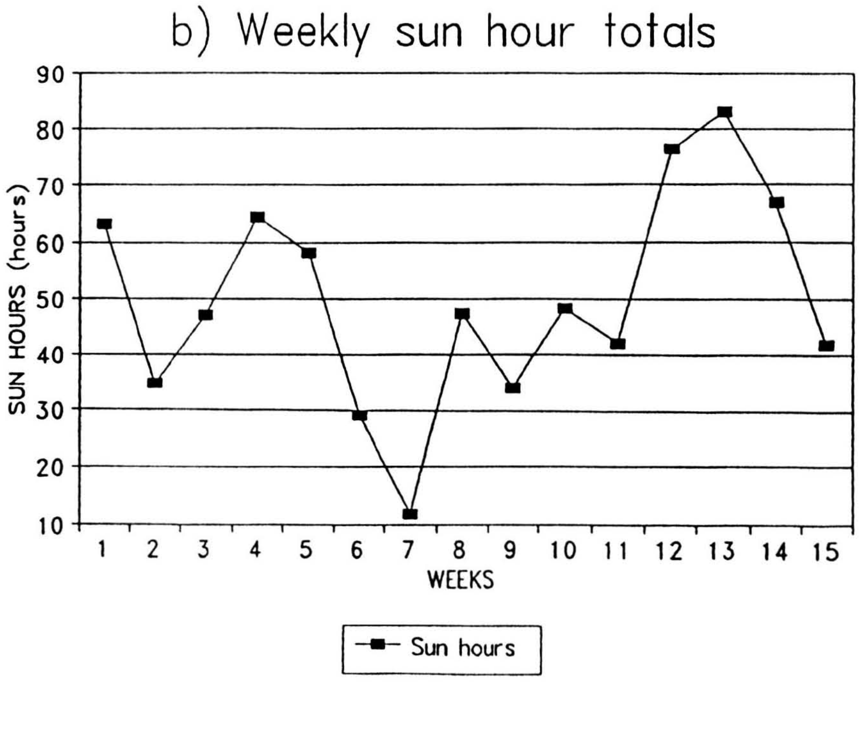
5.3 RESULTS.

5.3.1 Weather.

Total rainfall for the experimental period was 134.8mm and mean daily sun hours was 7.1 hrs/day. Weekly totals of rainfall and sun hours are given in Figure 5.1.

Figure 5.1 Rainfall and sun hours.





5.3.2 Herbage height.

Variation between paddocks over the trial were small. The mean herbage height of the experimental field was 7.0 cm in week one and declined gradually during the first seven weeks, but was reduced by 4.4 cm in the latter half of the trial (P<0% SED 0.50 cm).

Table 5.3 Mean herbage height of the individual paddocks.

Paddock	HERBAGE HEIGHT (cm)	Standard deviation	
1	4.4	(1.86)	
2	4.8	(2.40)	
3	5.0	(2.19)	
4	4.7	(2.24)	
5	5.3	(2.50)	Probability (%)
Mean	4.8		87

5.3.3. Pasture data.

The botanical content and chemical composition of the sward components are given in Table 5.4 and 5.5 respectively.

Mean values of grass and clover taken over the trial indicate that variation in sward components between paddocks was significant. Clover content ranged from 639 to 782 and grass from 200 to 330 g/Kg DM. Clover content peaked during period two (the end of May and beginning of June) and gradually declined. Grass content declined in period two and gradually increased corresponding to the decline in clover. Period effects were only significant for grass. The weed content of the field was 59g/Kg DM at the start of the trial and declined by 54 g/Kg DM during the experiment to a final weed content of 5 g/Kg DM. This decline in weed content with time was statistically significant (P<0%). Thistles were the main constituent of the weed classification. Ranked set sampling used in this trial did not influence weed content of the samples obtained.

Clover dry matter content was consistently lower than the grass. Dry matter content tended to increase with time (Table 5.5)

Clover crude protein values were significantly higher than the grass throughout the trial (p=0%). Clover and grass crude protein values declined with time. (Table 5.5).

Ash values also declined with time, but overall mean values indicated that grass contained a higher ash content compared to clover (Table 5.5).

5.3.4 Intake and milk production.

The high protein supplement (HEHP) produced the highest strawmix DM intakes (Table 5.6). The LELP supplement produced the lowest DM intake, which was 23% (4.0 Kg DM /cow/day) less than the HEHP supplement.

Offering a strawmix supplement did not significantly increase milk production, but the highest milk yield tended to be produced when cows were offered a high energy high protein supplement (HEHP).

Table 5.4 Sward botanical content in g/Kg DM.

Period		PADDOCK 1	2	3	4	5	Period mean
	clover	687	639	759	758	811	730
one	grass	217	285	196	208	146	211
	weed	96	76	45	34	43	59
	clover	653	805	790	802	820	774
two	grass	317	166	189	172	161	201
	weed	30	29	21	26	19	25
	clover	645	734	809	764	738	738
three	grass	335	229	177	224	247	242
	weed	20	37	14	12	15	20
	clover	580	685	788	798	758	722
four	grass	412	295	205	186	223	264
	weed	8	20	7	16	19	14
	clover	629	608	760	692	753	689
five	grass	371	375	238	304	246	306
	weed	0	17	2	4	1	5
Paddock mean							Field mean
	clover	639	694	782	763	776	731
	grass	330	270	200	219	205	245
	weed	31	36	18	18	19	24

Probability (S.E.D.)	paddock	rank	period	padd x per	padd x rank
clover	0 (31.0)	0 (27.7)	>10 (31.0)	NS (69.3)	NS (62.0)
grass	0 (29.4)	0 (26.3)	0.3 (29.0)	NS (65.7)	NS (58.7)
weed	<10 (8.1)	<15 (7.3)	0 (8.1)	NS (18.2)	NS (16.3)

Where NS = not statistically significant P>25%
All values in g/Kg DM.

Table 5.5 Chemical content of sward components.

	DRY MATTER		CRUDE PROTEIN				ASH			
sward component	clover	grass	clover		grass		clover		grass	
PERIOD										
1	166	245	248	(3.8)	172	(3.8)	99	(2.4)	112	(2.4)
2	170	243	220	(3.8)	145	(3.8)	95	(2.4)	97	(2.4)
3	203	268	22	(3.8)	128	(3.8)	91	(2.4)	90	(2.4)
4	215	283	218	(93.8)	157	(3.8)	84	(2.4)	85	(2.4)
5	220	300	190	(4.2)	134	(4.2)	76	(2.7)	78	(2.7)
Mean	195	266	220	(1.7)	147	(1.7)	89	(1.1)	92	(1.1)

	DRY MATTER Prob %	SED	CRUDE PROTEIN Prob %	ASH Prob %
sward component (S)	0	1.29	0	<5
period (P)	0	2.04	0	0
S x P	0	2.88	0	<5

Where
Values in brackets standard deviation
values in g/Kg DM

Table 5.6 Mean milk production parameters for animals within each treatment group.

	TREATMENTS						
	NOSUPP	LELP	HELP	LEHP	HEHP	Prob %	(SED)
Milk yield (Kg/cow/day)	22.97	23.04	23.30	23.13	24.05	<25	(0.461)
Fat content (g/Kg)	37.19	36.44	37.29	37.17	37.10	NS	(0.651)
Protein content(g/Kg)	30.92	30.72	31.4	31.02	31.76	<2.5	(0.360)
Fat yield (g)	836.7	822.2	851.3	840.3	875.7	<5	(17.94)
Protein yield (g)	710.9	713.7	735.0	714.8	762.8	<2.5	(18.03)
DM intake Kg/cow/day	-	4.0	3.7	4.2	4.8	<5%	(0.30)

Where NS= >25% Probability

Fat content was not significantly affected by treatment. Fat yield was significantly increased by the HEHP strawmix supplement.

The HEHP supplement produced the highest protein content and yield followed by HELP. Differences between protein content were low, but were statistically significant at the 2.5% probability level. Cows in NOSUPP produced a marginally higher protein content than cows in LELP.

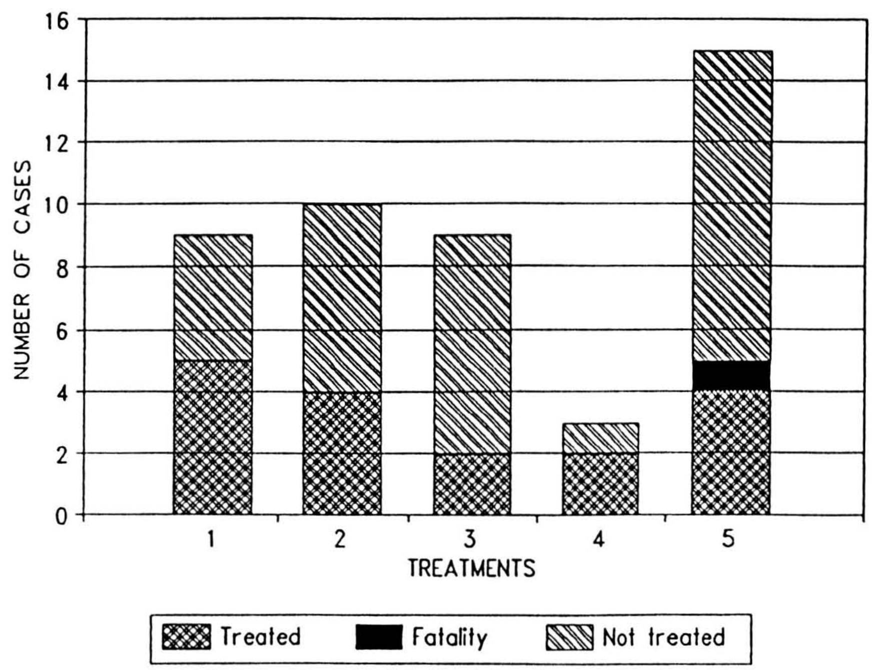
5.3.5 Bloat.

Forty six cases of bloat were recorded and distribution between supplements and time are illustrated in Figures 5.2 and 5.3.

5.3.5.1 Supplement effect.

When all cases of bloat were considered, irrespective of degree of severity, differences between treatments were significant at the 10% probability level. The distribution of bloat is given in Figure 5.2. The HEHP supplement produced the highest total number of recorded bloat cases (14) and caused one fatality. One cow receiving the LPHE supplement had to be cannulated and was subsequently removed from the trial in week 7. The LEHP supplement only had three recorded cases of bloat compared to nine for cows not receiving a supplement.

Figure 5.2. Distribution of treated and untreated cases of bloat.



Where 1= NOSUPP, 2= LELP, 3= HELP, 4= LEHP and 5= HEHP

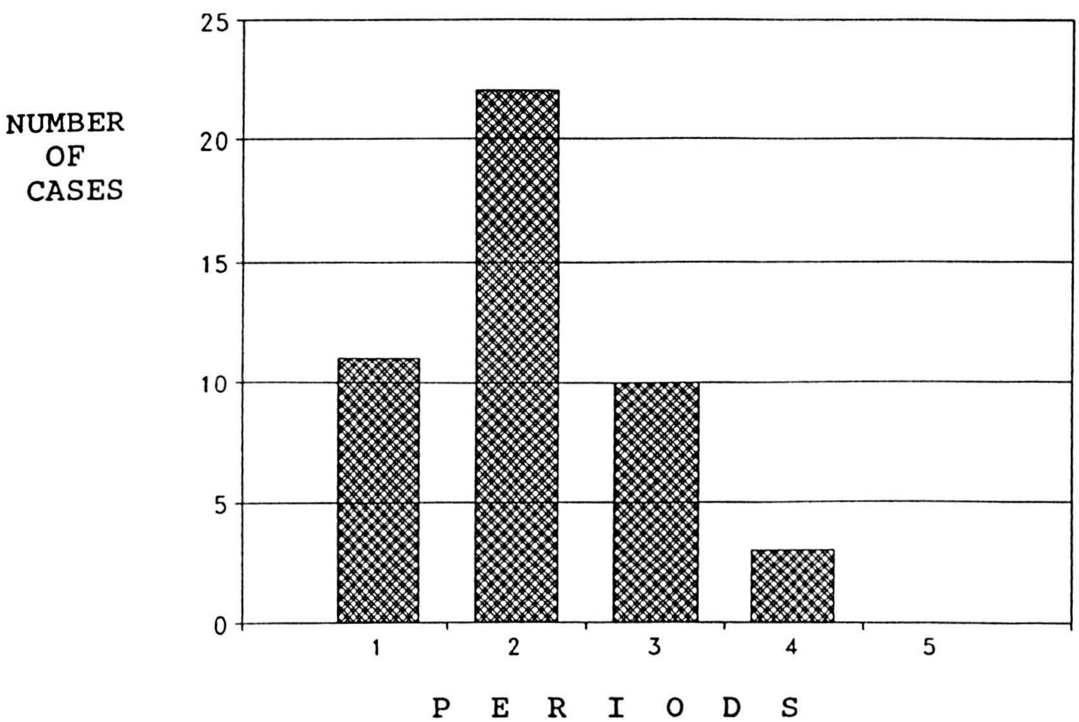
5.3.5.2 Bloating in relation to time within each period.

Analysis of the periodicity of bloat when all cases were considered is given in Table 5.7. Bloating tended to occur in the second week of each period. Treated cases of bloat mainly occurred in the second week and this was statistically significant at the 0.5% probability level.

Table 5.7 Incidence of bloat in relation to time.

	Week in period				
	one	two	three	Probability	(%)
Treated	6	11	0	<0.5	
Untreated	13	10	6	>25	
Total	19	22	6	<2.5	

Figure 5.3 Incidence of bloat during the trial in relation to time.



Bloating peaked in the second period of the trial and rapidly declined to no bloating in the final period (Figure 5.3). Bloating occurred on 13 days during the trial with 17% taking place during the night i.e. bloating observed between 21 00 hrs and 06 00 hrs.

5.3.5.3 Cow effects.

The forty six cases of bloat was the result of 65% (13 cows) of the cows bloating either once or up to 10 times, 15% bloated more than six times and 20% bloated once, while 35%(7) of the cows showed no signs of bloating at any time during the trial (Table 5.8). Yield classification did not appear to influence the bloating susceptibility of the cows P>25% (Table 5.8). The highest incidence of bloat tended to be for the M and H groups followed by the VH and L yielders (14, 13, 11 and 8 respectively).

Table 5.8 Bloating frequency of the experimental cows.

Cow yield classification	Number of times bloated
VH	7
VH	2
VH	2
H	6
H	4
H	2
H	1
M	10
M	4
L	5
L	1
L	1
L	1
Total 13	46

Probability of yield classification P>25%

5.4 DISCUSSION.

5.4.1 Results.

5.4.1.1 Strawmix supplement DM intake.

The strawmix supplements containing high protein contents were consumed to a greater extent by the cows in the trial indicating that these mixes were more palatable, the lowest intake was recorded for the high energy strawmix HELP, this contained a high proportion of molasses i.e. 750 g molasses to 250 g straw. This conflicts with results obtained by Roberts (1990) where maximum intakes and subsequent animal production were achieved by straw/concentrate mixes with high ME values, but the experiment by Roberts involved the use of straw/concentrate mixes in conjunction with a partial storage feeding system and did not look directly at the protein content of the feed. This experiment also demonstrated that the chemical composition of the buffer is very important, in that if the buffer is too palatable and has a high ME value the feed will act as a substitute to the grass and not as a buffer. This reduces the cost effectiveness of the system. The HEHP supplement with a ME value of 10.7 MJ/Kg DM produced the highest intake which agrees with Roberts, 1990.

5.4.1.2 Milk production.

Milk yields were increased on average by 0.4Kg/cow/day by buffer feeding strawmix supplements to dairy cows grazing high white clover swards during the spring and early summer. This was not statistically significant. Herbage availability was high during the first 2-3 periods of the trial and therefore did not reduce herbage intake. A review by Phillips (1988) indicated that buffer feeding when herbage availability is high does not increase milk production compared to cows offered a sole diet of herbage, but milk production is enhanced by buffer feeding when herbage availability is low. Herbage height was drastically reduced during period four and five primarily due to a dry summer and stocking rates could not be relaxed because of a lack of additional land. The milk yield increase observed in this trial was the mean value taken over the experimental period. Therefore any benefit obtained by buffer feeding the cows in the latter half of the trial, when herbage availability was low, would be reduced by the small milk yield increases in periods one to three when herbage availability was high.

The energy:protein ratio of the strawmix supplements did not directly affect the fat content of the milk, but had a significant effect on fat yield i.e. product of milk fat content x milk yield. The inclusion of high protein strawmix supplements in the diet of the dairy cows was reflected by increased milk protein content and yield.

Cows grazing the high white clover/prg sward and not receiving a strawmix supplement (NOSUPP) produced a higher fat yield and similar milk yield to cows receiving the LELP supplement. This supplement was very bulky therefore cows consuming this supplement would theoretically be filling their alimentary canal with a low value food, which reduces the available space and subsequent time to consume and digest nutritionally superior clover. Therefore the cows in NOSUPP were able to maximise their output because they had more time available to graze than cows in LELP. Experiment three demonstrated the ability of cows to adjust their grazing time to maximise nutrient intake. Although grazing time was not recorded in this experiment grazing time is depressed by offering a buffer fed straw/conc mixture to dairy cows,(Roberts, 1990).

Milk production data in this experiment indicate that the balance of energy:protein in the strawmix supplement fed to the dairy cows is to some extent reflected in milk yield and composition, particularly in relation to protein.

5.4.1.3 Bloat.

A mean clover content of 731 g/Kg DM in the grazed pasture precipitated the occurrence of bloat, this was expected since bloating normally occurs when the clover content of the pasture exceeds 50% (Howarth,1975). Vegetable oil was given twice a day as a preventative measure, but 46 cases of bloating occurred. Analysis of the occurrence of bloat indicated that the provision of a strawmix supplement did not reduce bloat, but in some treatments actively increased bloating (HEHP). This supplement caused 14 cases of bloat and one fatality, the cow being found dead prior to morning milking. The LEHP supplement tended to reduce bloating with only 3 recorded cases. This supplement contained a high proportion of straw and therefore provided the cow with a substantial amount of fibre, which would slow down fermentation and subsequent degradation of the rumen contents. The HEHP straw mix supplement contained a low quantity of straw but a high proportion of rapidly degradable molasses and soya which could possible precipitate the onset of frothy bloat.

Bloating was increased in the second week of each period

(P<2.5%). During the first week of each period the cows' total supplement intake was reduced because the cows were gradually given more strawmix supplement to reduce the harmful effect of a rapid change of diet, by the second week the cows were fed to appetite. This could account for the onset of bloat in the second week since the cows were consuming to appetite and possibly not quite accustomed to the new diet and therefore the rumen contents were primed to bloat. The reduction of bloating in the final week could be because the rumen was fully adjusted to the new diet. As the season progressed bloating increased to peak value during the second period, this coincided with the immature nature of the clover and prebloom stage of growth, this has also been demonstrated by Theodorou et al,(1984). As the clover matured bloating was reduced to zero in the fifth period where the clover had flowered. Also another contributory factor to the reduction in bloating during the latter periods was that the moisture content of the sward was reduced at this time due to a dry summer.

During the experiment bloating only occurred on 13 out of a possible 105 days, with only 17% of cases recorded at night. Bloating did not appear to coincide with wet conditions, since the majority of cases occurred on warm dry days, during the afternoon. The cows tended to bloat in the field prior to milking or bloated on the way to be milked. The action of milking or the walking prior to milking alleviated bloating in a high proportion of the cows (untreated).

Carruthers et al. (1987) demonstrated that susceptibility to bloat varies between breeds. Howarth (1975) stated that 30% of cattle are susceptible to bloat under normal bloating conditions. In this experiment 65% of the cows bloated, this value is high due to the bloating nature of some of the strawmix supplements, primarily the high energy high, protein supplement. Also 15% of the cows bloated more than six times, while 20% only bloated once. One cow bloated ten times during the experiment but only had to be treated three times. The cow which had to be cannulated and subsequently removed from the experiment had bloated seven times during the first half of the experiment. The unpredictable nature of bloat was demonstrated by the one fatality on the HEHP supplement in this experiment. This cow had only bloated once on the HEHP supplement and the previous night was dry and bloating was not expected.

5.4.2 Experimental techniques.

5.4.2.1 Strawmix supplement.

The ratio of molasses to straw (3:1) required in the HELP supplement was very high. Once the mix was completed and placed in the tub the molasses tended to sink to the bottom due to it's weight. This caused a lot of wastage and could have affected the expected nutritional intake of the cows.

Due to the high molasses content of the strawmixes they had to be made fresh every day because the molasses tended to spoil in the hot weather. This could be a problem to its use on a farm scale and also the fact that these supplements contain such a high molasses content makes mechanical mixing difficult.

5.5 SUMMARY.

A 15 week change-over trial was conducted using 20 spring calving dairy cows in early lactation to determine the effect on milk production of a strawmix supplement fed to dairy cows grazing on a high white clover/prg sward, ratio by mass 730.7:269.3 g/Kg DM.

The HEHP supplement produced the highest mean milk yield and significantly increased protein content and yield compared to cows grazing entirely on the clover based sward and not receiving a supplement. This supplement also produced the highest DM intake per cow. Provision of a strawmix supplement significantly increased fat yield (P<5%).

The LELP supplement was bulky and less palatable to the cows and was reflected in the low DM intake.

Analysis of the incidence of bloat indicated that the HEHP diet was strongly associated with bloat (P<10%). Bloating mainly occurred in the second week of each period (P<10%) and declined as the season progressed. The LEHP supplement tended to reduce bloating.

In conclusion combining high clover/prg swards with various strawmix supplements can be used to manipulate milk production and composition and in some cases reduce the incidence of bloat i.e. LEHP reduced bloat while increasing milk yield, without affecting fat content.

CHAPTER SIX.

GENERAL DISCUSSION.

6.1 The inclusion of grazed white clover in the diet of dairy cows.

This series of experiments conducted during 1988-1990 have shown the benefit of incorporating clover with traditional perennial ryegrass swards under various management systems. It was demonstrated in Experiments 2 and 3 that increasing the proportion of clover in the diet of the dairy cows tended to increase milk production. Milk yield was increased by the addition of only 10% clover in the cows'diet (at these levels the risk of bloating is reduced). Fat and protein yields were also increased, but fat content was reduced. This agrees with results obtained by Rogers et al. (1980) and O'Brian (1989). The initial experiment studied the effect of grazing the sward at contrasting herbage heights. Although grazing the sward to the lower herbage height increased sward clover content, herbage availability was drastically reduced, which was reflected in lower milk production.

The milk yield response associated with clover in Experiments 1,2 and 3 were achieved without the use of fertilizer N. This provides the farmer with the option of using clover based swards to increase milk yield from a set number of cows, but stocking rates would be reduced.

A comparison of grazing behaviour in different treatments in experiment two demonstrated the ability of cows to adjust their grazing behaviour to maximise nutrient intake, as the cows would actively select to graze the clover based sward. In the choice treatment cows spent longer grazing the clover/prg sward while cows on the enforced grazing regime of clover/prg during the day and prg at night would reduce their night grazing to increase the amount of time spent grazing the clover during the day. However the intermediate milk production values of the choice and enforced grazing regime between the C and R treatments in Experiment 2 demonstrates that they could not exert a strong influence on their diet.

In Experiment 1 a low herbage allowance (4cm) increased grazing time and biting rate, but the cows were unable to compensate for the low herbage allowance. Grazing time was longer for cows offered a choice of sward types (4 or 8 cm). The diurnal grazing pattern indicated that this increase was associated with cows grazing for longer during the day time. Results of grazing behaviour in Experiments 1 and 2 have clearly shown that cows tend to graze for a longer period of time at night between afternoon and morning milking compared to the day between morning and afternoon milking. When the cows were subjected to a restricted diet via a reduced herbage allowance, or differential sward type or an enforced grazing regime the cows would actively increase their day time grazing period to compensate for the above parameters. In effect this was the only available time when the cows could increase the grazing period, since the cows were already utilising the night grazing period to its maximum.

As demonstrated in this series of experiments the inclusion of clover in the diet of dairy cows will increase productivity. The establishment of a clover based dairy system, or partial system could be achieved by gradually increasing the proportion of clover/prg swards on the farm or by increasing the clover content of existing permanent prg swards on the farm over a number of years thereby spreading out the initial outlay. This would also allow the cows sufficient time to adjust to a clover diet. The farmer could provide the cows with a choice system of either grazing the prg or clover/prg since, behaviour studies clearly indicated that although the cows prefer to graze the clover/prg sward they would also graze the prg sward. Since milk yields were similar between the enforced grazing regime and choice system the farmer therefore has the choice of either grazing the cows on clover/prg during the day (aiding bloat detection) and grazing the prg swards at night, or offering the cows free access to either sward.

With the introduction of milk quotas it is in the farmers interest to maximise the profit margin and not necessarily milk yield. In Experiment 2 the inclusion of only 10% clover in the diet of the dairy cows increased milk production without the use of fertilizer N, therefore it would be profitable to introduce clover at low rates and still achieve significant results i.e increased profit margin/litre of milk via reduced fertilizer and concentrate costs, primarily demonstrated in Experiment 2. A cost effective method of introducing clover into a dairy system would be to oversow a number of established prg swards by slot-seeding with white clover species such as Huia or Blanca, thus reducing the cost of ploughing, resowing and loss of grazing.

In Experiment 2 cows actively increased daytime grazing when grazed on clover during the day and prg swards at night. In the last experiment when cows were subjected to a high white clover sward 24 hours a day they tended to bloat during the afternoon and only a few cases were recorded at night.

Combining the results of these two experiments provide a means to safely incorporate clover into the diet of dairy cows. Cows could be grazed on clover based swards during the day and prg swards at night, this would reduce the problem of bloat detection during the night and give peace of mind, also since cows can actively increase day time grazing and produce a substantial increase in milk production from this grazing regime (Experiment 2) overall productivity would be increased. To go one step further it has been demonstrated that some cows do not bloat under normal bloating conditions, therefore if the farmer over a period of time could select non-bloating cows in the herd then clover could be used to greater effect with these cows. The occurrence of bloat is unpredictable and more research is needed in this area to fully understand the onset and possible prediction of bloat. The loss of one cow can completely outweigh any advantage gained from using clover based swards. Further work is needed on the grazing behaviour of dairy cows grazing clover based swards to provide a means to manipulate the way in which clover could be safely incorporated into dairy systems.

6.2 Buffer feeding.

The first two experiments looked at sole diets of clover/prg or prg and demonstrated a milk yield response to clover. Maintaining cows on a low herbage height needed for a clover based system reduces production, therefore the use of buffer feeding was considered in Experiment 3 and 4 to increase production and to possibly prevent the occurrence of bloat. Using a buffer would be a means to further increase the profit margin per hectare on clover systems by allowing the farmer to increase the stocking rate i.e increase grassland utilisation and output of UME/ha. In a grassland sward increasing the stocking rate by 36% over the first eight weeks of the grazing season can increase the UME over this period by 30%, (Baker,1980). In this series of experiments stocking rates were not studied directly. It was intended that swards should be maintained at a constant herbage height, therefore stocking rates were not constant. In a farming practice the farmer does not have the available land to adjust the stocking rate, but results obtained from these experiments could be used as a guide to clover incorporation in primarily grass based systems.

6.2.1 Silage supplements.

Experiment 3 demonstrated that the cows preferred a combination of clover based silage with grazed prg swards and visa versa, but milk yields were not affected due to the ability of the cows to adjust their grazing behaviour. Intakes were low for hay and this was reflected by low milk yields. Using clover as a buffer fed silage would provide the farmer with a safe means of incorporating clover into a dairy enterprise. Bloating could be reduced by taking a silage crop of a high white clover/prg sward, since the cows would not be grazing the immature clover/prebloom stage which is highly correlated with the incidence of bloat (Theodorou et al. 1984) and would be able to safely graze the aftermath when the clover has matured/flowered and contains a higher fibre content. Work by Roberts et al. (1989) indicated that successive crops can be harvested from a clover sward without detriment to clover contribution. Although the quality of clover silage is dependent upon the stage of growth at cutting (Morrison et al, 1985), clover silage can produce crude protein values consistently higher than grass silage receiving fertiliser N. Silage chemical composition in Experiment 3 was similar in ME, but the high clover silage (c) contained a higher proportion of crude protein compared to the ryegrass silage (r). This experiment demonstrated that cows preferred a combination of c with R and visa versa. This would allow the farmer the freedom to either graze the clover sward and feed a grass silage buffer or to ensile the clover crop and use at a later date as a buffer forage fed to cows grazing a perennial ryegrass sward. Whether to graze or ensile the clover sward would be determined in relation to herbage availability of clover/perennial ryegrass and perennial ryegrass swards on the farm and also whether the weather conditions are suitable to graze clover i.e incidence of bloat increases in wet, cold weather (Reid,1973).

6.2.2 Strawmix supplements.

The final experiment looked in detail at milk yield response to various energy to protein ratios in strawmix supplements. Straw contains a high proportion of crude fibre and this is believed to reduce the risk of bloating. Therefore it was felt that the use of straw in straw mix supplements would both provide additional nutrients via the added energy and protein and the fibre would prevent bloating on the high clover/perennial ryegrass sward. The provision of a high energy, protein buffer fed strawmix supplement did increase milk yield, but when a low protein supplement was given to the cows, milk yields were not improved and fat and protein contents were reduced compared to cows grazing clover/perennial ryegrass and not receiving a supplement. The ratio of energy to protein content in the strawmix supplement was to some extent reflected in the milk yield and composition particularly protein. Incidence of bloat increased when the cows were given the HEHP supplement while being grazed on the clover based sward, this was possibly due to the high ratio of molasses and soya present in the strawmix, which would precipitate the onset of rapid fermentation and subsequent gas production resulting in bloat. Conversely the LEHP supplement tended to reduce the incidence of bloat, only three cases were recorded compared to nine cases for NOSUPP.

These results provide scope for further investigation into the correct balance of energy:protein ratio required to enhance milk production and possible reduce bloat on high white clover/perennial ryegrass swards. Under the experimental conditions in Experiment 4 the cows were given the various strawmix supplements for 17 days prior to the 4 days milk recording. This was sufficient time for the energy:protein content of the strawmix supplement to influence milk production parameters. Using a strawmix supplement would therefore provide the farmer with a versitile concentrate replacement, which he could vary the energy:protein content on a weekly or daily basis by adjusting the proportion of molasses to soya to straw to either, maintain milk production when herbage availability is reduced or to manipulate milk production parameters to meet the required milk quota. The LEHP supplement could be used to reduce bloat when a farmer has to graze a high white clover/perennial ryegrass sward during conditions that would tend to precipitate bloat (wet and cold). This experiment also demonstrated that susceptibility to bloat varies between cows. This could allow the farmer to select cows from the herd which appear to be bloat resistant and use them to safely graze a clover/perennial ryegrass sward on the farm.

This series of experiments has given an insight into the incorporation of clover as a clover/perennial ryegrass sward into the dairy system either as grazed herbage with or without supplements or as a buffer fed forage. More work is needed into the use of feeding clover silage to dairy cows throughout the winter. As discussed in experiment 3, ensiled clover would reduce the risk of bloating caused by grazing immature clover and would provide relatively safe grazing of the aftermath. Bloat is a problem on clover swards particularly when clover content exceeds 50%, but the farmer will have the choice to decide whether to graze the clover sward on a particular day which was not possible under experimental conditions. There is the potential for the use of clover in the dairy system, but any benefit gained from using clover can be lost by the death of a cow by bloat. The unpredictability of bloat and clover swards still inhibits the use of clover by many farmers.

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APPENDIX 1

Rank sampling analysis for Experiment 1

PERIOD		RANK L	M	H	VH
	clover	136	263	290	377
1	grass	855	708	684	560
	weed	9	29	26	23
	clover	227	250	292	367
2	grass	748	722	694	619
	weed	25	28	14	14
	clover	150	245	289	363
3	grass	801	721	699	614
	weed	49	34	12	23
M	clover	171	252	290	369
E	grass	802	717	692	610
A	weed	27	31	18	21
N					

	Probability treatment x rank	(SED) rank x period	**rank**
clover	>25 (40.4)	>25 (49.5)	**= 0 (28.6)**
grass	>25 (41.5)	>25 (50.8)	**= 0 (29.3)**
weeds	>25 (11.6)	<25 (1.42)	**>25 (8.2)**

All values in g/Kg DM

APPENDIX 2

Equation to calculate missing values

$$X = \frac{aT \pm bB - S}{(a-1)(b-1)}$$

where

a= Number of treatments
b= Number of blocks
T= sum of items in treatment
B= sum of block of missing item
S= sum of all observed items

source:Snedecor and Cochran (1978)