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SUPPLEMENTARY FEEDING OF DAIRY COWS

A Study of the Value of Greenfeed Maize as a

Summer Supplement

A Thesis

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ABSTRACT

An experiment is described in which the nutritive value of greenfeed maize as a supplement to lactating dairy cows during the Summer dry period was investigated.

Forty Spring calving Friesian cows were allocated to one of two treatments in a randomised block design experiment. One group of 20 cows was fed on grazed pasture alone (control) on a separate 7.95 ha farmlet while the other group of 20 cows was fed a supplement of greenfeed maize in addition to the pasture from a 7.75 ha farmlet. The farmlets of both groups were divided into 7 paddocks and the cows were rotationally grazed. A 1 week standardisation period was followed by a 5 week experimental period.

The herbage present on both farmlets was estimated at the beginning of the experiment and, during the experiment, estimates of the pasture remaining after grazing were made which gave an indication of the grazing intensity.

Two crops of greenfeed maize were fed, Crop A and Crop B. Crop A had a low yield of D M , poor plant density and a high weed population. Crop B had a high plant population with thin stalks and few weeds.

Mean daily milk, milk fat, milk protein yields and liveweights were not significantly different between groups. There were significant differences between the slopes of the regression lines relating pretrial to experimental milk yields ($P < 0.01$) and milk protein yield ($P < 0.05$) of the two groups. There were significant differences ($P < 0.10$) between the slopes of the regression lines of milk yield against time of the two groups and between the low yielders of each group but no significant difference between the high yielders of each group.

The control group maintained their liveweight during the first half of the trial and lost weight in the second half of the trial. The maize group lost weight initially then increased steadily in liveweight. However, the differences in mean liveweight between groups were not statistically significant.

The high yielders lost more weight in the second half of the trial than the low yielders in the control group.

It would appear that, while the overall differences in the mean daily milk yields between groups were too small to be statistically significant, the milk yield of the control group declined at a faster rate than the maize group with the low yielders in the control group declining at the fastest rate. The weight lost by the high yielders in the control group was slightly greater than that of the low yielders in the same group. The high yielders in the control group maintained their rate of decline in milk yield similar to that of the supplemented group and this was probably achieved by a greater reduction in liveweight relative to the low yielders.

The yield of Crop B was 11,008 kg D M /ha and the digestibility varied from 71.2 - 75.4 % of the O M . Maize intake was 3.0 and 3.5 kg/DM/cow/day and utilisation 76.5 and 82.1% of the D M for Crops A and B respectively.

The control group completed two rotations on their farmlet with rotation lengths of 19 and 12 days. At the end of the experiment they were very short of pasture. The maize group had completed one rotation in 26 days and had grazed 1.1 ha for a second time. They had adequate supplies of herbage at the end of the experiment.

Supplementation with greenfeed maize permitted the adoption of a longer rotation length, a better distribution of the available pasture over the Summer period and slowed the rate of decline in milk yield in the supplemented group.

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CHAPTER ONE

The Supplementary Feeding of Lactating Dairy Cows -

- A Review of Literature

1.1 INTRODUCTION

A supplementary feed is usually offered to lactating cows when it is believed that a shortage of a nutrient or nutrients is limiting milk production. The supplements offered can range from high energy concentrates if the basal ration is a low energy roughage, to a roughage such as hay or grass silage if the actual supply of feed is restricted. The supplement offered then will depend both on the quantity available and the nutrient quality of the basal ration and on such factors as the stage of lactation, the expected yield potential of the cows, milk prices to the farmer and the costs of alternate feeds. Aspects of this subject have been covered in reviews by Leaver *et al.* (1968) and in the comprehensive reviews of Broster (1971) and (1972).

In New Zealand cows are normally fed on pasture as the basal diet with supplements of hay, silage or fresh forage such as greenfeed maize or marrowstem kale being offered when pasture supply or quality is deficient. Concentrates, while they are fed to some extent to town supply herds or in droughts, are not used on the same scale as many other countries. This review will deal mainly with the supplementation of cows fed basal rations of grass, hay or silage.

1.2 SUPPLEMENTARY FEEDING OF GRAZING DAIRY COWS

In very many temperate areas of the world dairy cows are fed entirely on pasture herbage for at least part of the year. However, herbage production and quality varies throughout the year and the requirements of the cow vary with the stage of lactation and milk yield. Thus supplementation may be necessary at certain times.

Pasture may be supplemented when herbage supply is plentiful or when the supply of herbage is obviously inadequate to meet the requirements of the grazing cow.

1.2.1 SUPPLEMENTARY FEEDING WHEN THE SUPPLY OF GRAZING
HERBAGE IS ADEQUATE

In many countries it has been the practice to feed supplements, mainly of high energy concentrates, to high yielding dairy cows who are grazing pasture ad lib. Leaver, et al. (1968) reported that the practice was still widespread in the United Kingdom at the time of their review and Boxem (1976) reported that the feeding of concentrates during the grazing season had increased considerably in the Netherlands in recent years.

When concentrates are fed to lactating cows who have access to adequate high quality pasture, the increase in milk yield is generally small. Wallace (1957) fed 2.7 kg concentrates to freshly calved cows receiving adequate supplies of pasture for eight weeks after calving and compared their milk yields with cows that were not supplemented; afterwards both groups were rotationally grazed on good pastures with abundant feed. The cows in the supplemented group yielded 70 kg milk more than the unsupplemented group during the 8 week period and 196 kg milk more over the full lactation. The response was equivalent to 0.45 kg of additional milk for each 1 kg of concentrate fed. Castle et al. (1960) in Scotland, when feeding 2.7 kg of concentrates per cow per day over the Summer and Autumn periods found that in no month was there a significant difference in milk yield between groups which received supplements and those which did not although the group fed concentrates from 1st July to 30th October had the highest total yield. Their response was 1kg additional milk for 3.4 kg of concentrate fed. In a second change-over trial Castle et al. (1960) also reported that where three groups of cows were fed for nine weeks

- (a) pasture only
- (b) pasture + 0.73 kg hay/day
- (c) pasture + 2.6 kg concentrates which was made up of undecorticated cotton cake, bruised oats and locust beans

and where the pasture being offered had a low fibre (21.5% Crude Fibre) and dry matter content (17.6% D M), that the hay had no significant effect on milk yields but the group fed concentrates yielded 0.6 kg extra milk/cow/day. However, the feeding of hay over the period did increase milk fat content significantly from 3.77 to 3.91%. Shepherd (1962), in trials over 4 seasons, when grazing was supplemented with 3.2 kg of barley or balanced concentrates, obtained a response of 0.9 kg and 1.4 kg extra milk from the barley and concentrate supplementation respectively.

Laird and Walker-Love (1962) fed concentrates to high yielding Spring calving cows, at grass in early Summer, according to milk yield. The amount of concentrate fed was increased from 4.0 kg per 10 kg milk produced over 18.2 kg at the beginning of the experiment to 4.0 kg concentrates per 10 kg milk produced over 4.5 kg towards the end of the experiment. During the first 11 week period the additional milk yield attributable to the concentrates was 2 kg per cow per day or 153 kg per cow over the 11 week period. Over the 21 week season the milk yield was increased by 143 kg per cow, although the amount of concentrates fed had increased over the season. Thus 2.2 kg concentrates were required to produce 1 kg extra milk over a 21 week season as compared to 1.0 kg over the initial 11 week period. Milk composition was not affected and no residual effects were observed.

Castle *et al.* (1964) also attempted to feed concentrates according to milk yield to cows at grass over two seasons. They fed 4 kg concentrates/10kg milk produced over 20.5 kg in early Summer and reduced this threshold yield by 1.1 kg per week as the season progressed so that by mid-Autumn the cows were receiving 4 kg concentrates for every 10 kg milk produced. A group of cows fed pasture only acted as controls. There were no significant differences in total milk yields between the two groups although small but non-significant differences in yield between the two groups were recorded during the season, the maximum difference of 2.3 kg per cow occurring in mid-October. Wood (1966) fed grazing cows 3.75 kg concentrates/10kg milk produced over 20.5, 13.6 and 6.8 kg per cow and obtained milk yields of 16.8, 17 and 17.5 kg/cow respectively.

Hutton and Parker (1967) fed relatively low levels of concentrates (1 kg and 2 kg) to groups of cows on pasture during short term trials at two different stocking rates. The response to feeding the concentrates was higher at the higher stocking rate in terms of milk yield, but the feeding of concentrates was accompanied by a decrease in the fat content of the milk. Thus they concluded that the feeding of concentrates to cows on grass was not generally worthwhile. They also reported that in long-term trials the feeding of concentrates to cows stocked at 4.8 cows per hectare was worthwhile compared with cows not fed supplements stocked at 3.7 cows per hectare. Concentrate feeding here increased the efficiency of pasture utilisation at the high stocking rate. It is also possible that the higher stocked cows did not have adequate pasture at all times.

Bryant (1970) reported that when concentrates were fed to grazing cows with ample supplies of pasture herbage that the response was 1 kg of extra milk for 7 kg of meal fed. Gordon (1974) in Northern Ireland fed three levels of concentrates (0.45, 2.25 and 4.05 kg per day) to cows calved 0-6 weeks before turnout to pasture and yielding 28 kg milk/day, in a changeover trial lasting 14 weeks. The response is summarized in Table 1.1.

TABLE 1.1 Effect of level of concentrate feeding on milk yield of Spring calving cows at pasture (GORDON 1974).

Concentrate intake (kg/day)	0.45	2.25	4.05
Milk yield (kg/cow)	23.6	23.6	24.8

Pres et al. (1976) reported an experiment in which three groups of cows (yielding 10, 16, 18 kg milk/cow/day) were fed on pasture fertilized with 200 kg nitrogen per hectare. Half of each group were fed concentrates at the rate of 0.3kg per kg of milk produced above 8 kg. The supplementary feeding increased the daily milk yield of the low and medium groups by 1.5 - 2.0 kg per cow per day but had no effect on the high yielding group and had no effect on milk composition.

Boxem (1976) in the Netherlands concluded that supplementary feeding of cows kept on good grass day and night was not justified economically and that yields of 25 kg/cow/day were possible on Spring grass alone and 18 kg/cow/day were possible on good Autumn pasture alone. The lower nutritive value of Autumn pasture for milk production has also been demonstrated by Corbett and Boyne (1958) who obtained greater responses from supplementing Autumn pasture with concentrates, the response being 1.3 kg increase in milk yield when 4.5 kg concentrates were fed in the Autumn against 0.6 kg increase in milk yield when 3.6 kg concentrates were fed in the Spring.

A summary of the results of the experiments reviewed in which cows with adequate supplies of herbage were fed concentrate supplements is presented in Table 1.2. The responses are given in kg of extra milk/kg concentrate fed (assuming that the difference between the mean milk yields of the cows receiving and not receiving supplements was completely attributable to the supplementary feed). Many of the results are not directly comparable as there were differences in stages of lactation and yield/cow between and within experiments. The response ranged from 0.14 to 1.0 (omitting the very high value of Pres et al. (1976) when only a very small quantity of concentrates was actually fed) with a mean of 0.4 kg milk/kg concentrate fed.

From the literature review in this section it is obvious that the response to supplementary feeding with concentrates is small and often non-significant statistically when the cows have access to adequate supplies of good quality pasture.

Supplementing cows, which have adequate supplies of pasture, with roughages has had little effect on milk yield (Castle et al. (1960)). Cole et al. (1957) fed three groups of cows either pasture alone, pasture and hay or pasture and silage over the Summer months. The hay and silage supplementation had no significant effect on milk yield but there was a small but significant increase in fat content. Hutton and Parker (1966) offered hay to freshly calved cows who had access to grazing for 20 hours daily. The cows intake of hay dry matter was 1.4 kg and milk, milk fat and solids - not fat yields were all slightly increased but the increase was not significantly statistical. Feeding roughages to cows with access to adequate good quality pasture may increase the fat content of

TABLE 1.2 SUMMARY OF EXPERIMENTS IN WHICH COWS, WITH ADEQUATE SUPPLIES OF PASTURE HERBAGE WERE FED SUPPLEMENTARY CONCENTRATE FEEDS.

REFERENCE	SUPPLEMENT/COW/DAY	RESPONSE—kg extra milk/1kg conc. fed
WALLACE (1957)	2.7 kg Concentrates for 8 weeks post calving	0.45
CASTLE <u>et al</u> (1960)	2.7 kg Concentrates, Summer and Autumn	0.3
	2.6kg Concentrates, Summer	0.22
SHEPHERD (1962)	3.3 kg Barley	0.25
	3.2 kg Balanced concentrates	0.42
LAIRD AND WALKER- LOVE (1962)	4 kg Balanced Concentrates/ 10 kg milk over 18.2kg- Reducing over experiment	11 wk period 1.0 21 wk period 0.45
CASTLE <u>et al</u> (1964)	Balanced Concentrates to yield - on average 1kg conc/4.5 kg milk	0.56
WOOD (1966)	Balanced Concentrates, 1.7 kg conc/4.5 kg milk produced over 13.5 kg	0.15
HUTTON AND PARKER (1967)	Balanced concentrates 1 kg/cow; 3.7 cows/hectare 1 kg/cow; 4.8 cows/hectare 2 kg/cow; 3.7 cows/hectare 2 kg/cow; 4.8 cows/hectare	0.56 0.45 0.48 0.63
BRYANT (1970)		0.14
GORDON (1974)	4.05 kg/cow/day	0.3
PRES <u>et al</u> (1976)	0.3 kg conc/kg milk above 8 kg to cows yielding 10 kg/day 16 kg/day 18 kg/day	2.5 - 3.3 0.6 - 0.8 0
CORBETT AND BOYNE (1958)	4.5 kg conc, Autumn pasture 3.6 kg conc, Spring pasture	0.29 0.17

milk slightly but this increase is likely to be non-significant statistically in most experiments.

1.2.2 SUPPLEMENTARY FEEDING WHEN THE SUPPLY OF GRAZING HERBAGE IS INADEQUATE

1.2.2.1 CONCENTRATES AS THE SUPPLEMENTARY FEED

Grass supply may be insufficient to meet the requirements of lactating cows at any time of the year due to overstocking or poor growing conditions. Wallace (1957) in the first year of the experiment already referred to in 1.2.1 fed one member of each of 22 sets of monozygotic twins 2.7 kg concentrates for the first eight weeks post calving. Both members of each twin pair were grazed together on a limited supply of grass in a rotational grazing system. At the end of the 8th week the feeding of concentrates was stopped and all of the cows were grazed together on pasture with abundant feed available. The intakes of grass by both groups during the 8 week period after calving were similar. The supplemented group of members of the twin pairs gave 187 kg more milk during the first 8 weeks and this increased to 693 kg additional milk over the full lactation. The response during the initial 8 week period was 1.2 kg milk/kg concentrate fed while this increased to 4.6 kg milk/kg concentrate fed when the response was measured over the full lactation. Hancock (1958) examined the effects of stocking rate and the feeding of concentrates on the milk production of Jersey cows over a three year period. Monozygotic twins were used and the three treatments were

- (a) concentrates fed at the rate of 1kg/5kg milk produced; stocking rate 2.47 cows/ha.
- (b) no concentrates fed; stocking rate 2.47 cows/ha.
- (c) no concentrates fed; stocking rate 4.12 cows/ha.

A rotational grazing system was used in which the cows entered a fresh paddock each day. The use of concentrates was associated with 24% greater production/cow and/hectare than those achieved at an equal stocking rate, and production/cow was 16% greater with (b) than at the higher stocking rate in (c). However, production of FCM/hectare was greatest with (c). The results show the

importance of stocking rate in determining output/hectare. The response to concentrate feeding in this experiment was about 1.25 kg extra milk/kg of concentrate fed. Holmes et al. (1966) compared normal strip-grazing without concentrates with strip-grazing in which the cows were allowed only half the area of pasture allocated daily to the other group but they were fed 5 kg of barley daily. The stocking rate for the unsupplemented group was 4.2 cows per hectare and 8.4 cows per hectare for the supplemented group. While the milk yield per cow was highest in the supplemented group the fat content of the milk was lower so that there was no significant difference in the yields of fat corrected milk (FCM). Supplementation with barley more than doubled the milk yield/ha and estimates of the intakes of digestible organic matter showed that there was little difference between the treatments. Holmes and Curran (1967) repeated the experiment with minor modifications and again found that the group on restricted pasture, being fed concentrates and with only half the daily area of pasture allotted to the normal strip grazed group, produced about twice the amount of milk/ha. In the trial of Hutton and Parker (1967) referred to in 1.2.1 the effect of stocking rate on the responses of cows fed concentrates at pasture was very evident. Concentrate feeding gave the greatest response at the highest stocking rates although the fat content of the milk was depressed by concentrate feeding. In the long term trial reported by them in the same paper, the interdependence of concentrate feeding on stocking rate and date of calving were demonstrated as shown in Table 1.3. The increased response in treatment C was due to the fact that by calving later an improved relationship was achieved between pasture growth and animal requirements. This resulted in increased production despite the fact that the same quantity of meal (250 kg in 1965/66 season) was fed to Groups B and C. Bryant (1970) states that where grazing is inadequate in supply that the response to meal feeding is about 1 kg extra milk/kg meal fed. Table 1.4 summarises the results obtained in experiments in which cows, with inadequate supplies of pasture herbage were fed supplementary concentrates.

TABLE 1.3 RESPONSE TO CONCENTRATE FEEDING, STOCKING RATE AND CALVING DATE (ADAPTED FROM HUTTON AND PARKER 1967)

	GROUP		
	A	B	C
Cows/hectare	3.7	4.9	4.9
Feedstuff	Grass alone	Grass + Concentrates	Grass + Concentrates
CALVING	EARLY	EARLY	LATE
1965 - 1966 Results			
Butterfat/cow (kg)	125	123	127
Butterfat/ha (kg)	464	607	630
1966 - 1967 Results			
Butterfat/cow (kg)	161	147	161
Butterfat/ha (kg)	598	726	796

TABLE 1.4 SUMMARY OF EXPERIMENTS IN WHICH COWS, WITH
INADEQUATE SUPPLIES OF PASTURE HERBAGE, WERE
FED SUPPLEMENTARY CONCENTRATES

REFERENCE	SUPPLEMENT/COW/DAY	RESPONSES - kg extra milk/1kg conc.
WALLACE (1957)	2.7 kg conc./day, grazed on limited pasture for 8 weeks	0 - 8 weeks 1.2 Full lactation 4.6
HANCOCK (1958)	1 kg conc/5kg milk produced	1.25
HOLMES <u>et al</u> (1966)	5 kg barley + $\frac{1}{2}$ normal strip grazing allowance compared with normal strip grazing	No difference in yeild of F.C.M. per cow, Barley Supply doubled F.C.M. yield/ha.
HOLMES AND CURRAN (1967)	Similar experiment	Similar result.
HUTTON AND PARKER (1967)	Compared cows stocked at A) 3.7 cows/ha, No concentrates B) 4.9 " " concentrates C) 4.9 " " concentrates later calving	Milk Fat yield/cow Reduced in (B) despite concentrates but maintained in (C) Milk Fat yield/hectare increased in (B) and (C)
BRYANT (1970)		1.0

1.2.2.2 ROUGHAGES AS THE SUPPLEMENTARY FEED

Hutton and Parker (1966) and Parker (1966), in a split-plot latin square design trial over a three week period, allocated individual members of each of 12 sets of identical twins either to one group which was fed hay as a supplement or to a second group fed on grass alone. Grazing times of 4, 8 or 12 hours were allocated to cows of the same set according to a 3 x 3 latin square arrangement of which there were 4 replicates. Both grazing time and the feeding of hay as a supplement had large and statistically significant effects on milk yield, milk composition and liveweight. The feeding of hay as a supplement significantly increased milk yield/cow in the three grazing times, the increases being greatest for those with the shortest grazing times.

Hutton (1974a) reports on the use of maize and pasture silages as supplements to restricted grazing when fed to Autumn calving cows over the Winter period. During the day an area of pasture was allowed for each cow sufficient to provide either one-third or two-thirds of the dry matter requirements of the separate groups of cows. Within each group the remainder of the ration for one-half of the cows was maize silage and pasture silage for the other half. Feeding either silage was accompanied by an increase in grass utilization from 46 - 47% to 64% when fed as two-thirds of the ration as the stocking intensity was higher but decreased milk yield by 1.5 - 1.6 kg FCM per cow and reduced the milk protein content, though to a lesser extent when maize silage was fed than grass silage.

Bryant and Donnelly (1974) fed groups of cows rations consisting of freshly cut pasture herbage and maize silage in the ratios 1:0, 3:1, 1:3 and 0:1 on a dry matter basis in two experiments; one with cows in Spring in early lactation, the other in Summer with cows in mid-lactation. An additional ration of pasture silage and pasture herbage (1:3) was included in the Summer feeding experiment. When maize silage was fed as the sole ration, feed intake and milk yield declined as the experiment progressed. However in the Spring trial with freshly calved cows, the inclusion of 25% maize silage resulted in a higher intake of digestible energy and higher milk yield than did pasture also. In the Summer feeding trial, while the inclusion of 25% maize silage in the ration decreased the intake of digestible energy (DE), the yield of fat corrected milk was similar. Feed intake and milk yield decreased with increasing proportions of

maize silage in both experiments. Pasture silage, when comprising 25% of the intake, reduced DM intake, DE intake and yield of FCM significantly. Bryant and Cook (1977) compared cows which had access to sufficient areas of grass to provide near full feeding with groups which were offered 80%, 60% and 40% of the area and provided with maize silage to appetite. Milk and fat yields declined as the proportion of maize silage in the diet increased.

1.2.3 RESPONSES OF GRAZING COWS TO SUPPLEMENTARY FEEDING

1.2.3.1 SUBSTITUTION

The response to supplementary feeding depends mainly on whether total feed intake is increased by feeding the supplement or whether the supplement simply replaces some of the other feeds or possibly results in a depression of total feed intake. Supplementary feeding of the grazing animal may yield a response in terms of additional milk produced, less body weight loss or improvement in the compositional characteristics of the milk. The size of the response will depend on the amount of herbage available, the digestibility of the herbage eaten, the type of supplement and its digestibility, the stage of lactation of the cows, their system of management and the season of the year (Leaver et al. 1968)

1.2.3.2 RESPONSES TO SUPPLEMENTARY FEEDING WHEN GRAZING IS ADEQUATE

In Section 1.2.2 the responses to concentrate feeding when the supply of grass is adequate was generally very small and uneconomic. Holmes and Jones (1964) calculated that the effect on "total feed intake" (I) of a supplement of 1 kg concentrates depended on the organic matter digestibility (D) of the herbage, the two being related by the equation

$$I = 2.8 - 0.034D$$

Then if the pasture has an 80% digestibility of the organic matter a supplement of 1kg would increase intake by only about 0.1 kg as there is a reduction in the grass consumption. If the pasture has a digestibility of the organic matter of only 60%, feeding a supplement

of 1 kg concentrate would increase intake by about 0.8kg and cause a reduction of only about 0.2 kg in herbage intake. Taparia and Davey (1970) found that supplementation of Jersey cows, fed pasture to appetite indoors, with 2.7 kg and 4.0kg concentrates/cow/day, decreased the voluntary intake of pasture dry matter by 0.63 and 0.66 kg/kg concentrate dry matter respectively. The supplementation had little effect on milk yield and no significant differences were recorded between milk composition and liveweights of supplemented and unsupplemented groups.

Hibbs and Conrad (1975) state that the intake response to supplementation depends on the digestibility of the ration. Below 67% digestibility feed intake is limited by the indigestible residue in the digestive tract. Above this level factors other than ration digestibility and rate of digestion limit intake.

Boxem (1976) suggests that the reason for the poor response to supplementary feeding on adequate good quality grass is that for each kg DM provided by the concentrates there is a drop of about 0.6 kg DM in grass intake and that grass intake and milk yield depend largely on grass quality. Concentrate feeding to cows on abundant high quality grass results then in substitution of the nutrients in the concentrates for the reduced intake of nutrients from grass to a very large extent. Wallace (1957) noted that the cows fed concentrates in early lactation did not lose weight as rapidly or for as long as their unsupplemented mates. This would indicate that some of the additional nutrients in the additional feed intake were used to prevent loss of body condition. Roughage supplementation to cows with adequate grazing has little effect on milk production as it increases total feed only slightly and the actual intake of roughage is small (Arnold and Holmes 1958, Castle et al. 1960, Hutton and Parker 1966). However, Cole et al. (1957), Castle et al. (1960) showed small but significant increases in fat content when roughages were fed with Spring pasture to freshly calved cows.

1.2.3.3 RESPONSES TO SUPPLEMENTARY FEEDING WHEN GRAZING SUPPLY IS INADEQUATE

An increase in nutrient intake will occur if concentrate are eaten in addition to herbage which is inadequate in quantity instead of partly or completely substituted for it, and providing the cow has not reached its potential this could result in an increase in milk yield.

The responses to feeding concentrates when grazing is inadequate have generally been more favourable (Wallace 1957; Hancock 1958; Holmes *et al.* 1966; Boxen 1976). This is because the supplements tended to increase total feed intake when grass supply was inadequate and did not depress herbage intake to the same extent, although some depression has been found to occur (Leaver *et al.* 1968). The responses to supplementation when herbage was inadequate gained by Wallace (1957) and Hancock (1958) were of such a magnitude that it would appear that the cows which did not receive concentrates in their experiments were underfed in the critical period during early lactation and this may have been responsible for the large differences between the supplemented and unsupplemented groups.

The reduction in milk and butterfat yields when roughages are used to supplement inadequate pasture supply, particularly at levels greater than about 25% of the total ration, are due not so much to a reduction in total feed intake as this may not occur but to a reduction in the intake of D E since the D E content of roughage supplements is usually lower than that of pasture.

1.3 SUPPLEMENTARY FEEDING OF COWS FED HAY AND SILAGE AS BASAL RATION

Dairy cows are fed basal rations of hay or pasture silage for long periods of the year in many countries. Supplementation of the basal diet is often necessary, particularly for lactating cows but also for cows in the pre calving period in many instances. Broster (1971) in a comprehensive review of the literature on the effect on milk yield of the cow of the level of feeding before calving

concluded that for the cow in moderate condition towards the end of lactation a rate of gain of 0.5 kg/day in the dry period appeared to be adequate. Good quality roughage fed ad lib would be adequate to meet the cows requirements before calving while up to 150 kg of concentrates would need to be fed over the last 5 weeks before calving when poor quality roughage is used.

The degree of supplementation required when lactating cows are being fed basal diets of conserved pasture will depend on

- (i) the quality of the forage and the amount consumed
- (ii) the stage of lactation of the cows
- (iii) the milk yield potential of the cows
- (iv) the expected length of the feeding period
- (v) the relative costs of supplements, the basal forage and the value of any increased production.

Broster (1972) reviewed the literature on the effect of milk yield of the cow of the level of feeding during lactation. The importance of adequate feeding in early lactation when the cows appetite may be depressed is stressed, as underfeeding at this stage may result in loss of potential yield throughout the remainder of the lactation.

1.3.1 TYPES OF SUPPLEMENTS FED TO COWS ON BASAL RATIIONS OF CONSERVED PASTURE HERBAGE AND RESPONSES FROM FEEDING

Hutton et al. (1971) fed silages made from direct cut pasture herbage as sole feeding stuffs for milking cows in two series of experiments. Volunatry intakes of silage DM ranged between 2.2 and 3.0% of liveweight. Both milk yields and S.N.F. content of the milk were seriously depressed on a sole diet of pasture silage. Gleeson (1971 and 1973) compared the milk production of groups of cows fed various levels of concentrates after calving, along with pasture silage ad lib. Table 1.5 sets out the experimental design milk yields and DM intakes reported by Gleeson (1971) when freshly calved cows were fed various levels of concentrates for periods indoors with silage ad lib, and grazed outdoors after the indoor feeding period.

TABLE 1.5 FEEDING LEVELS, MILK YIELDS AND D M INTAKES
OF COWS FED CONCENTRATES AS SUPPLEMENTS TO
PASTURE SILAGE AD LIB (GLEESON 1971)

Treatment			Milk yield/cow (kg) at different periods.			Mean daily D M intake during 12 weeks indoors	
Weeks After Calving		13 to end of lactation	6 wks	12 wks	Lactation	1 - 6	7 - 12
H*	H*	on pasture	613	1272	2846	12.0	13.7
H	L	"	669	1112	2730	12.1	7.5
L	H	"	378	897	2463	6.1	14.0
L	L	"	364	675	2121	6.1	6.5

H = Ad lib silage + 5.4 kg concentrates/cow/day

L = Ad lib silage

Supplementation with concentrates increased the total intake and also increased the silage D M intakes during the feeding period. The response to supplementation was greatest in terms of additional milk produced when it was fed during the entire 12 week period but the greatest portion of the additional response occurred when the concentrates were fed during the initial six weeks post calving. There was a considerable carry-over effect when concentrates were fed throughout the silage feeding period compared to silage only being fed. Broster *et al.* (1969) in a large and complicated trial found an even greater carry-over effect when they compared two levels of feeding of Friesian heifers in the first nine weeks after calving. The residual effect in this case was 30% of the earlier effect. Gleeson (1973) compared three levels of concentrate supplementation to freshly calved cows during the first eight weeks of lactation fed silage *ad lib.* After the eight week period the cows were rotationally grazed outdoors on pasture alone. He measured silage D M intake during the supplementary feeding period, milk yield/cow/day, for eight weeks on grass and for the full lactation and live-weight changes during the feeding period and the first eight weeks on grass. He related the response of additional milk produced to kg concentrate fed, both during the supplementary feeding period and over the full lactation. Table 1.6 presents the results obtained in 1972.

Increasing concentrate supplementation from 1.8 to 3.6 kg/cow/day increased slightly silage D M intake also and increased milk yield substantially over the feeding period and during the full lactation. Increasing concentrate supplementation from 3.6 - 7.3 kg/cow/day reduced silage D.M intake but increased milk yield during the feeding period and during the full lactation. Live-weight changes were greatest at the lower levels of concentrate feeding with the lowest group losing almost 1.4 kg liveweight/cow/day during the initial period but when grazed outdoors at the end of the feeding period they gained liveweight at a faster rate than the other groups and at the expense of some milk yield. The response to concentrate supplementation was highest when the level

TABLE 1.6 POST CALVING CONCENTRATE FEEDING, SILAGE D M INTAKE, MILK YIELDS, LIVEWEIGHT CHANGES AND RESPONSES TO SUPPLEMENTATION PER COW OF COWS FED SILAGE AD LIB. (Adapted from Gleeson 1973)

Concentrate Fed (kg/day)	Silage D M Intake		MILK YIELD (kg/day)			LIVEWEIGHT Changes (kg/day)	
	kg/day	% L.W.	1-8 wks	9-12 wks	Lactation	0-8wks	9-16wks
7.3	6.2	1.41	18.0	15.6	3209	-0.65	0.05
3.6	7.7	1.71	15.3	14.9	2942	-0.92	0.15
1.8	7.2	1.72	12.9	13.9	2685	-1.37	0.49
RESPONSE TO SUPPLEMENTATION: (kg conc/kg extra milk)			1.8 VS 3.6 kg/day		3.6 VS 7.3 kg/day		
			0-8 wks	0.73	0-8 wks	1.33	
			Lactation	0.38	Lactation	0.74	

of feeding was raised from 1.8 to 3.6 kg/cow/day and there was a considerable carry-over effect. Whether the highest level of concentrate supplementation is economically justified on the basis of these figures depends entirely on the costs of the supplement and the value of the additional milk produced.

Carry-over effects may be considerably less when the cows are fed basal rations of hay or silage and concentrate supplementation over long periods. Gleeson (1973) also reports on a series of trials in which an Autumn calving herd of cows was divided into groups fed various levels of concentrate supplementation with silage ad lib over the Winter period. The cows had a three month calving period with a mean calving date around September 15th (Northern Hemisphere data). Concentrates were fed to all calved cows from October 1st until 20th March. The cows were grazed outdoors until about 1st October, depending on grass supply, and were again grazed outdoors from about 20th March onwards. Each group was grazed on a self contained farmlet at stocking rates of 2.8 and 3.5 cows per hectare. Table 1.7 contains details of the lactation yields of the three groups fed either 1.8, 3.6 or 5.4 kg concentrate daily. Increasing concentrate supplementation over the Winter period from 1.8 - 3.6 kg/cow/day increased milk yield substantially while the increase gained by increasing supplementation from 3.6 to 5.4 kg/cow/day was very small. This is probably due to the fact that when the cows were grazed on pasture after March 20th they were in the second half of lactation and it was possibly too late for the carry-over effect to express itself significantly. Increasing the stocking rate from 2.8 to 3.5 cows per hectare on the farmlets decreased yield per cow from 3660 to 3356 kg but increased yield per hectare from 10,397 to 11,843 kg.

The response to supplementation obtained by Gleeson (1973) above going from 1.8 to 3.6 kg of supplement/cow/day was about 0.9 kg extra milk/kg concentrate while that obtained by feeding 5.4 kg/cow/day over 3.6 kg/cow/day was only 0.03 kg extra milk/kg extra concentrate. Wood and Newcomb (1976) fed an Autumn calving herd of 140 Friesian cows pasture silage reinforced with brewers grains ad lib and supplemented with mineralised barley cubes at two levels from 8th September to 31st January, (Northern Hemisphere). The higher level of supplementation was approximately 50% higher than the lower level. The cows which

TABLE 1.7 MILK YIELDS OF AUTUMN CALVING COWS FED THREE LEVELS
OF CONCENTRATE SUPPLEMENTATION AND SILAGE AD LIB
(FROM GLEESON 1973)

Level of Concentrate Supplementation (kg/cow/day)	Milk Yield—mean of 2 years (kg/cow/year)
1.8	3323
3.6	3594
5.4	3604

received 50% more supplement showed an improvement in total lactation milk yield of 248 kg/cow while the additional supplement fed was 235 kg/cow, representing a response of 1.1 kg extra milk/kg extra supplement.

Castle and Watson (1975) fed good quality, (70.4% DOMD) grass silage ad lib as control and supplemented it with (i) barley and (ii) high quality dried grass cubes at the rate of 2, 3, 4 kg/10 kg milk. Daily silage D.M. intake was 11.6 kg/cow in the control group and significantly less in the supplemented groups. However, silage intakes were higher in the dried grass than in the barley treatments. Milk yields per cow were - Control 14.5 kg, Barley 15.7, 16.6, 17.0 kg and dried grass 17.8, 20.2, 19.8 kg for the three rates of supplementation respectively. Fat content was highest with barley supplementation while S.N.F. content was lowest in the control and highest in the dried grass treatment. The supplements tended to substitute to some extent for the silage as it was of very high quality. Dried grass substituted to a lesser extent than barley and this is reflected in the higher milk yields.

1.3.2 FACTORS WHICH AFFECT THE RESPONSES OF COWS FED CONSERVED PASTURE HERBAGE AD LIB TO SUPPLEMENTARY FEEDING

The general relationship between the effect of supplementary feeding and the quality of bulk feed found by Holmes and Jones (1964) has been discussed in Section 1.2.3.

Holmes et al. (1965), working with cows and feeding hay and silage as the basal ration, found also that when additional concentrates were given the resulting increase in total digestible organic matter intake was greater when the bulk feed was of low digestibility than when it was of high digestibility. The beneficial effect of concentrate feeding decreased as the quality of the bulk feed offered increased. Blaxter and Wilson (1963) working with sheep and Holmes and Jones (1965) working with cows have shown that the addition of fixed amounts of concentrates to hay ad lib increased total feed intake much more than would be expected from the improvement in total diet alone, particularly with hay of low digestibility (about 62%). While the feeding of concentrates as supplements to good quality roughage then, results in a considerable amount of substitution of concentrate nutrients for roughage nutrients, when the concentrates are fed with roughages of

low digestibility the degree of substitution is much smaller and the concentrate feeds increase total digestible organic matter intake and the total digestibility of the ration. Raymond (1969) states that when the forage is of low digestibility then the intake is determined mainly by rumen fill so that when supplements of high digestibility are fed intake of low digestibility forage is reduced, thus allowing more of the supplements to be eaten as rumen fill will no longer be the limiting factor on intake. Hibbs and Conrad (1975) state that below about 67% ration digestibility, feed intake is limited by the indigestible residue in the digestive tract. Thus, both digestibility and rate of digestion are important factors in determining feed intake on roughage rations. The first few kg of a balanced grain concentrate added to an all roughage ration which is below 67% digestibility can be expected to increase milk production as a result of both its stimulating effect on rate of digestion in the rumen and increased ration digestibility which results in increased digestible D.M. intake. Additional amounts of grain will further increase digestible D.M. intake until digestibility of the ration is raised to about 67%. Above about 67% digestibility, factors other than ration digestibility and rate of digestion limit intake (see review by Baile and Forbes 1974). The experiments of Gleeson (1971) and (1973) highlight the ability of cows to utilise body reserves in early lactation for milk production when feed intake is inadequate, and their ability to recover the weight lost when given sufficient feed later in the lactation. This ability may be profitably exploited for short periods of early lactation, particularly as it has been shown that the efficiency of utilisation of body tissue loss for milk production is very high and, provided the body tissue is deposited during the previous lactation, the overall efficiency of utilisation of body tissue deposited during previous lactation for milk production in early lactation is almost as high as that for milk production from dietary energy (Moe et al. 1970, Moe and Tyrrell 1975). The degree to which this can be done without serious harming future production will of course depend on the body condition of the cows at calving and the actual body reserves available for mobilisation.

1.4 MAIZE AS A SUPPLEMENTARY FEED FOR LACTATING COWS

Maize, in the form of maize silage or greenfeed maize, is frequently used as a supplementary feed for dairy cows. In many parts of Central and Eastern Europe and America maize silage may form the basal roughage in the rations of fattening cattle and dairy cows. However, in New Zealand its main application is as a supplement for scarce pasture herbage during the Summer or Winter months.

1.4.1 SUPPLEMENTARY FEEDING WITH MAIZE SILAGE

One of the most serious limitations of the maize plant for animal feeding is its low protein and mineral contents. However, this limitation is not so serious when the maize is being fed as a supplementary feed. Ensiling whole-crop maize has the effect of converting the water-soluble carbohydrates to short-chain organic acids and the degradation of plant protein to non-protein nitrogenous compounds (Johnson *et al.*, 1967; Bergen *et al.* 1974). The reduction in voluntary intake due to ensiling maize varies from 5 - 29% (Wilkinson 1976), the degree of reduction in voluntary intake varying with the dry matter content of the silage and reaching a minimum at about 30 - 35% D M content.

Reardon (1971) fed maize silage as a Summer supplement to grass to 18 month old Angus and Friesian X Angus steers. Intake measurements showed that for most levels of maize supplementation, silage was replacing about 80% of the equivalent amount of D M from grass. Bryant and Donnelly (1974) in two experiments already referred to in Section 1.2. fed maize silage at two levels as a supplement to pasture herbage. One experiment, in Spring, 1970 was with cows in early lactation, the other in Summer, 1972 was with cows in mid lactation. Treatment effects were assessed over a 3-week period. Table 1.8 contains details of the intakes of D M, D E and the milk yields of the cows fed pasture alone, maize silage as 25% of the ration, maize silage as 75% of the ration and pasture silage as 25% of the ration (second experiment only).

In the Spring feeding trial the inclusion of 25% maize silage resulted in higher D M and D E intakes, although the differences in

TABLE 1.8 INTAKES OF D M , D E AND MILK YIELDS OVER A
3 WEEK PERIOD OF GROUPS OF COWS FED PASTURE
SUPPLEMENTED WITH MAIZE SILAGE AND PASTURE
SILAGE (Adapted from Bryant and Donnelly 1974)

		MAIZE SILAGE: PASTURE HERBAGE			PASTURE SILAGE: PASTURE HERBAGE
		0:100	25:75	75:100	25: 100
	DM INTAKE (kg)	231	264	238	-
1970	DE INTAKE (MJ)	3061	3257	2688	-
(Spring)	MILK YIELD (kg FCM)	313	328	291	-
1972	DM INTAKE (kg)	279	262	216	239
(Summer)	DE INTAKE (MJ)	3379	3102	2667	3052
	MILK YIELD (kg FCM)	279	281	205	249

milk yields were not statistically significant. The inclusion of 75% maize silage in the ration reduced the intakes of D E and milk yield. The apparent digestibility of the maize was 60% and of pasture 75%. The result from the inclusion of 25% maize silage in the ration is difficult to explain. The authors suggest that it could be due to the relationship between D M digestibilities and intakes for rations greater than about 65% digestibility. Baumgardt (1970) suggested that there was an inverse relationship between D E intake and digestibility and the ration D M digestibilities in this case were 69% for the 25% maize silage and 75% for the pasture herbage alone rations. However, as this was an indoor feeding experiment with the pasture herbage cut and fed once daily the results may not be entirely applicable to grazing animals. The results of the Summer feeding experiment show that the inclusion of maize silage in the ration at that stage of lactation reduced D M and D E intakes and milk yield although the digestibility of the pasture (67%) was lower than the maize silage (73%). Bryant and Cook (1977) reported on an outdoor feeding experiment in which maize silage was fed to supplement various grazing herbage allowances. One group of cows in early lactation was grazed on a fresh area of pasture each day, sufficient to provide near full feeding. Three other groups were offered 80, 60 or 40% of this area and provided with maize silage to appetite. Supplementation continued for 5 weeks and for 11 weeks afterwards equal numbers of cows were stocked at 3.7 and 4.9 cows/ha. Maize silage intake increased with increasing pasture restriction so that total D.M. intakes were actually higher with maize supplementation. The size of the area offered to the grazing only group may have been insufficient to ensure maximum intake. Milk and fat yields declined as the proportion of maize silage in the diet increased but the effects on liveweight were not significant. Cow performance after supplementation ceased was not affected by previous treatment.

Maize silage then would appear to be a reasonable supplement to pasture herbage particularly at levels of less half the total ration and when grazing herbage is scarce.

1.4.2 SUPPLEMENTARY FEEDING WITH GREENFEED MAIZE

The use of greenfeed maize as the basal ration or as a supplementary feed for lactating cows has been reported from parts of Europe, (Berke 1954; Gotlib 1958; Seidler and Tobolsha 1968; Cucu et al. 1969 and Beyrich 1975), America (Brickbauer 1962) and New Zealand (Davies 1961; Bartlett 1971; Bartlett et al. 1971 and 1974 and Hutton 1973 and 1975).

Berke (1954) reported that milk yield increased when, in the diet of cows in mid-lactation, sunflower leaves were replaced by green maize and lucerne. Gotlib (1958) showed that feeding 15 - 18 kg head/day of greenmaize + fodder pea/oats mixture increased butterfat, protein and phosphorus content while at 30 kg/head/day or greater it depressed butterfat and calcium content.

Davies (1961) reported that milk production was well maintained by cows feeding on greenfeed maize during dry periods in Canterbury.

Brickbauer (1962) recorded high yields of succulent feed when maize was planted at very high plant densities (600,000 plants/hectare or higher). The maize had low D M content (10%) but 14% crude protein content. It was regarded as an excellent supplement to Lucerne hay and for use during emergency situations.

Seidler and Tobolsha (1968) reported that there was no difference in milk yield or milk fat content when maize, maize + sunflower or maize + field peas formed the basal ration. Cucu et al. (1969) reported that the feeding of concentrates with green maize increased milk yield.

Bartlett (1971) and Bartlett et al. (1971 and 1974) fed greenfeed maize as a supplement to irrigated pasture during Summer drought.

Maize directly replaced pasture intake with no difference in milk yield between the group supplemented with greenfeed maize and the group fed irrigated pasture alone. Reardon (1974) offered supplements

of greenfeed maize, direct cut silage, formic and treated silage or wilted silage to Angus steers stocked at 8.65/ha both ad lib and $\frac{1}{2}$ ad lib. Weight gains were higher in the steers receiving the greenfeed maize and wilted silage than the direct cut or formic silages - the higher weight gains being largely due to intake differences. Groups eating less supplement ate most pasture with severe defoliation of paddocks during the dry period. Part of the better performance of the supplemented cattle was attributable to the accelerated grass growth on their areas after late Summer

rain. Hutton (1973 and 1975) compared cows receiving supplements of greenfeed maize, greenfeed millet and no supplement, grazed at various intensities. Intake of supplement replaced pasture intake at higher grazing intensities and while milk fat yield decreased with increasing grazing intensity, supplementing with both greenfeed maize and millet did increase milk fat yield within grazing intensity treatments. Beyrich (1975) compared greenfeed maize and maize silage as the basal ration for lactating cows. The cows ate more of the green maize than the maize silage - the maize silage D M intake being about 40% less than greenfeed maize intake.

Greenfeed maize then would appear to be a suitable supplement for dairy cows, particularly if grass is the basal diet. It does not appear to have intake limitations similar to maize silage, at least at the levels fed in the experiments reviewed, and can readily replace some pasture herbage in the diet while maintaining milk yields.

1.5 OBJECTIVES OF THE EXPERIMENT AND CHOICE OF DESIGN

The typical grass growth rate curve, Figure 1.1, for soils in many parts of New Zealand graphically illustrates the way the rate of pasture growth varies throughout the year and also in different years due to the effects of climatic variations (Cumberland 1974).

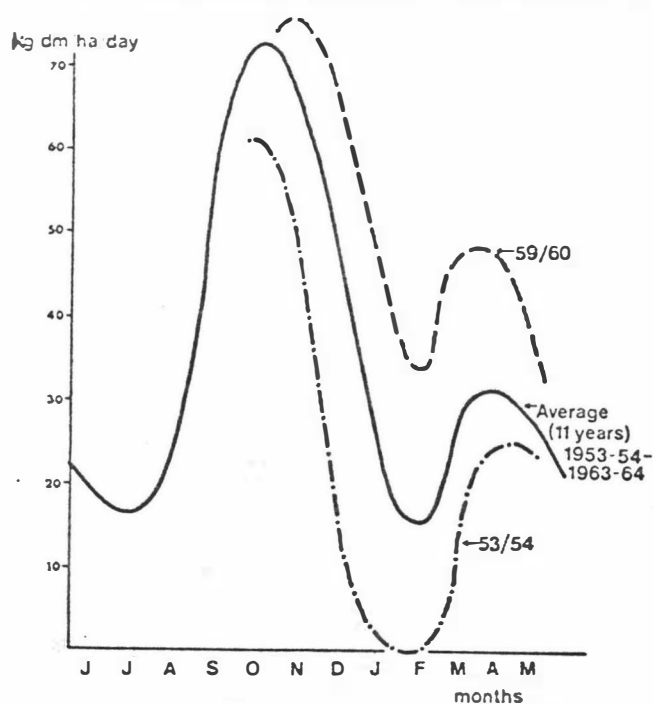


Figure 1.1 Rate of pasture growth (Cumberland 1974)

From this it is apparent that there are two periods of the year in which grass growth rates can be very low, the Winter months of June, July and August and the Summer months of January, February and March. In fact in some drought years Summer growth rates may be almost zero for quite long periods. Animal requirements may be high during the Summer months, particularly in the case of Spring calved dairy cows at high stocking rates and growth rates are frequently too low to allow full feeding from pasture alone (Hutton 1974b). One method of overcoming this feed deficit is to provide a supplementary feed.

Supplementary feeding may have two objectives:

- (i) to increase production to a high level,
- (ii) to maintain the feed supply when pasture availability is below requirements.

With summer supplementation the latter objective is usually the most important and the aim is to maintain milk yields rather than increase them. An additional effect of Summer supplementation is to spare the pasture that is available as the supplement will generally directly replace pasture herbage particularly if it is dry and of fairly low digestibility. This sparing effect is frequently very desirable, particularly when growth rates are very low, and there is some evidence that, by leaving more cover after or during grazing, recover after the dry period is improved (Brougham 1970).

The supplementary feeds normally fed to lactating cows over the Summer months in New Zealand are

- (a) Conserved pasture in the form of hay or silage
- (b) maize silage
- (c) Greenfeeds such as greenfeed maize or marrowstem kale.

Some authors (Matthews 1975) regard the pasture dry matter built up by a long rotation as the same as a supplement of conserved pasture such as hay or silage as the objective in building up the pasture dry matter is the same as that of conserving pasture herbage - namely the provision of a feed store to be used in time of scarcity.

Of the Summer fodder crops, maize consistently produces the greatest bulk of dry matter (Cumberland 1974). It provides large amounts of highly digestible feed at all stages of growth and may be used either as a greenfeed in emergency or drought situations or may be conserved as maize silage for feeding during either the Winter or Summer period.

There is relatively little experimental data on the feeding of greenfeed maize as a supplement to pasture herbage to dairy cows over the dry Summer period. The objectives of the experiment carried out for this thesis were

1. To assess the nutritive value of greenfeed maize for lactating cows as indicated by its chemical composition, digestibility and voluntary intakes achieved.
2. To examine the effects of feeding greenfeed maize on milk yield, milk composition and liveweight of the cows.
3. To measure the yield and degree of utilisation of the crop.
4. To estimate the likely pasture saving effects of feeding the crop during a period of poor pasture growth.

It was decided that to achieve these objectives an experiment should be set up in which two groups of Spring calving cows would be grazed at similar stocking rates on separate farmlets, one group to receive greenfeed maize as a portion of their ration, the other group to receive only the pasture available from its farmlet, the experiment to be carried out during the Summer of 1976.

CHAPTER TWO

MATERIALS AND METHODS

2.1 EXPERIMENTAL ANIMALS

Spring calving Friesian cows from the No. 1 Massey University Dairy Herd (Town Milk Supply herd) were selected for the study.

As far as possible animals of various ages were included in the experimental groups to give age distributions similar to those of commercial herds.

Calving dates ranged from 23/7/75 to 8/10/75, although the majority (34 out of a total of 40) calved between 23/7/75 and 17/9/75. The official milk yield records as provided by the Livestock Improvement Association were available for all the cows up to 25/11/75 and for the 1974/75 season for all except the heifers in the groups, and formed one of the bases for selection.

The cows were identified by means of numbered plastic ear tags, coloured plastic neckbands with a different colour for each of the groups and by paint on the rear of each cow, which corresponded with the colour of the neckband, for easy identification in the milking shed. The experimental cows were milked in a 10 a side lowline herringbone shed. Milking commenced at about 05-00 and 15-00 hours each day.

One cow from the control group had to be removed during the experiment as she aborted. Her place was taken by another animal to make up the stocking intensity and data for the removed animal or her replacement has not been used in the analysis. Further details of the experimental cows are contained in Appendix II.

2.2 GENERAL OUTLINE OF THE EXPERIMENT

A randomised block design was chosen as the nature of the work required the use of a design appropriate to a relatively short continuous experiment. The experiment was divided into two periods of observation; a standardisation period for obtaining information on concomitant

variables and a comparison period in which to compare the treatments.

The cows were blocked on the basis of their milk yields during the previous lactation and their current lactation to date, age and date of calving (see Appendix II). The members of each block (or pair as there were two cows per block) were allocated at random on a within block basis. Twenty cows were allocated to each treatment making a total of 40 cows. Table 2.1 presents a short plan of the experiment.

The one week standardisation period began on 26/1/76 and the experimental period began on 3/2/76 and concluded on 4/3/76.

TABLE 2.1 PLAN OF THE EXPERIMENT

1. SUPPLEMENTARY FEEDING TRIAL:
 - STANDARDISATION PERIOD - 1 WEEK
 - EXPERIMENTAL PERIOD - 5 WEEKS
 - (a) FEED - CONTROL GROUP, PASTURE ONLY
 - MAIZE GROUP, PASTURE + GREENFEED MAIZE
 - AFTER EVENING MILKING.
 - (b) RECORD - MILK YIELD
 - MILK FAT CONTENT
 - MILK PROTEIN CONTENT
 - (c) WEIGH COWS WEEKLY.
2. GRASS SAMPLING
 - ESTIMATE TOTAL HERBAGE ON EACH FARMLLET
 - AT BEGINNING OF EXPERIMENT (see section 2.3.1)
 - ESTIMATE GRAZING INTENSITY DURING EXPERIMENT
 - SAMPLE GRASS HERBAGE FOR CHEMICAL COMPOSITION AND DIGESTIBILITY.
3. MAIZE
 - RECORD OBSERVATIONS ON STAGE OF GROWTH
 - ESTIMATE YIELD/ha as fed.
 - SAMPLE FOR CHEMICAL COMPOSITION AND DIGESTIBILITY
 - ESTIMATE UTILISATION OF CROP AT FEEDING
4. IN VIVO DIGESTIBILITY OF MAIZE
 - PRELIMINARY FEEDING PERIOD OF 10 DAYS
 - BALANCE 1, AT MIDDLE OF EXPERIMENT
 - BALANCE 2, TOWARDS END OF EXPERIMENT.

2.3 EXPERIMENTAL FEEDS AND FEEDING

Pasture herbage grazed in situ was the sole feed of the control group during the experiment and represented the major proportion of the diet of the experimental group (the "maize" group). The maize group had access to greenfeed maize between the evening and morning milkings and were on pasture between the morning and evening milkings. Both groups were rotationally grazed with the main No. 1 Dairy Farm herd during the standardisation period.

2.3.1 GRAZING SYSTEM

During the experimental period the two groups were rotationally grazed on separate farmlets of unirrigated pasture on the No. 1 Dairy Farm. Both groups had 7 paddocks each. The paddocks were paired according to their geographic location, soil type and amount of pasture herbage present on them. They were allocated to the groups at random. The control group received 7.96 hectares and the maize group 7.75 hectares of pasture. The area of greenfeed maize was additional to the area of pasture. Since the maize group depended on the pasture herbage for only a portion of their feed it was decided to rotate them at a slower rate around the farmlet. The control group grazed their farmlet in 19 days on the first rotation and had just completed a second rotation in 12 days at the end of the experiment. The maize group completed its first rotation in 26 days and had grazed 1.12 ha for a second time at the end of the experiment. Figure 2.1 shows a map of the No. 1 Dairy Farm and the location and areas of the experimental paddocks.

2.3.2 GREENFEED MAIZE

Two crops of greenfeed maize were used. The first crop - Crop A - had been severely attacked by ducks and Argentine Stem Weevil. The area in which it had been sown had stony areas of low fertility and a period of cold weather followed sowing. These factors resulted in a crop that was uneven, had a low plant density and yield and a high weed population. The maize was cut with a single chop

CONTROL		MAIZE	
Paddock No.	Area (ha)	Paddock No.	Area (ha)
82A	0.88	82B	0.91
87	0.70	86	0.76
49	1.40	45	0.92
43	1.65	36	1.98
16	1.10	15	0.94
17	1.19	19	1.12
25	1.04	22	1.12
	<u>7.96</u>		<u>7.75</u>

I Irrigated pasture
L Lucerne

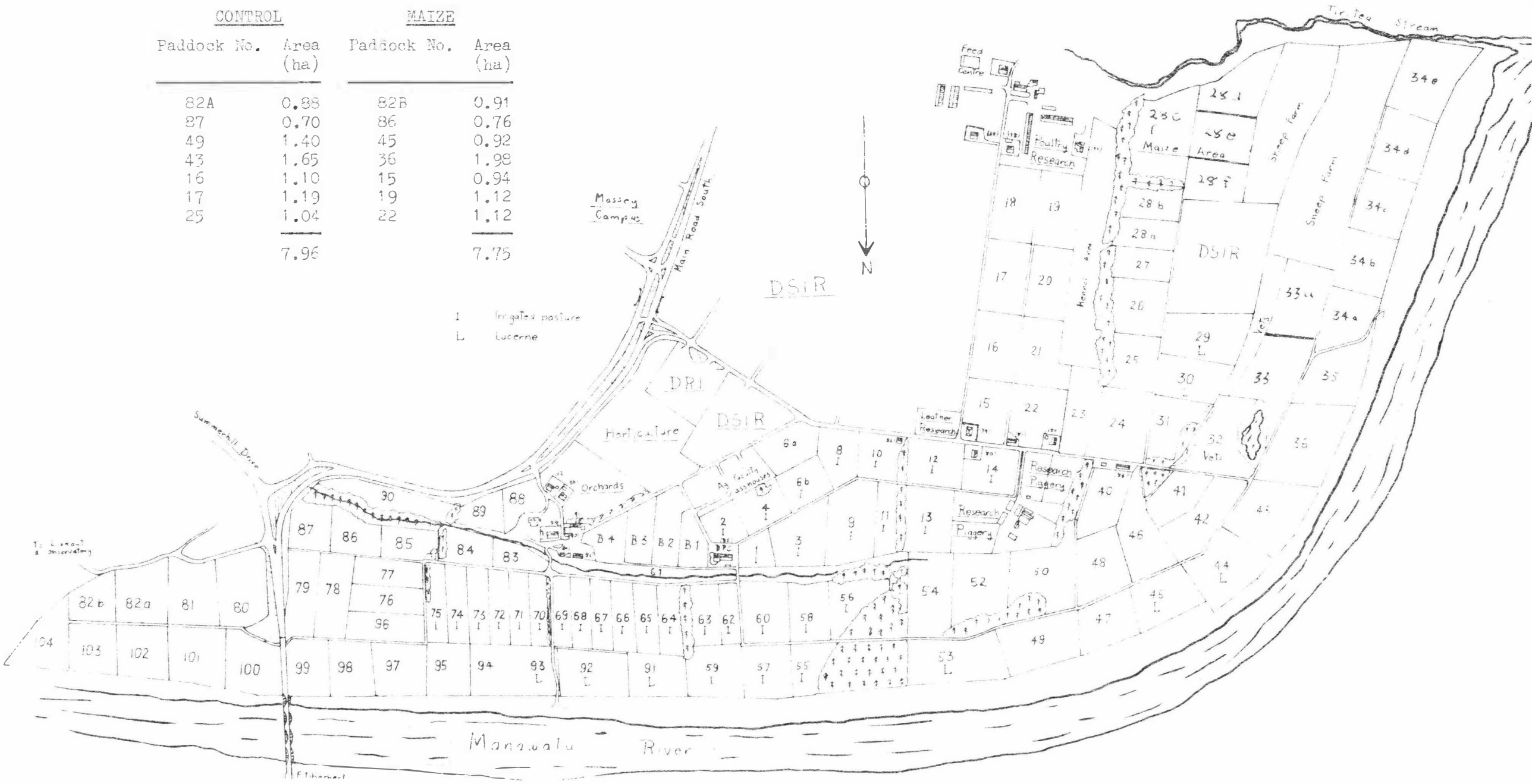


FIGURE 2.1. Map of No.1 Dairy Farm [supplied by Massey University]

forage harvester and fed in a hayrack in a feeding pad on the farm.

The trailers of maize were weighed after cutting each day and the refusals were collected and weighed each morning. From 12/2/76 to 13/2/76 inclusive the maize was cut with a sickle bar mower, loaded on to a trailer and fed in the hayrack in the feeding pad.

The second crop - Crop B -, although grown in an adjacent paddock had largely escaped attack from the duck and Argentine Stem Weevil and was a thick dense crop with thin stalk and satisfactory yield. It was fed from 19/2/76 in situ in the paddock. A strip of maize was cut each day with a sickle bar mower along the width of the paddock and a temporary electric fence was erected along the centre of the strip. The width of the strip varied between 1.5 and 1.8 metres approximately. Appendix I contains details of the sowing and treatment of the two maize crops.

The level of feeding with greenfeed maize had been calculated to replace about a third of the expected daily dry matter intake from grazed herbage.



PLATE 2.1: Greenfeed Maize Crop B.



PLATE 2.2: Greenfeed Maize Strip, Cut with Mower Prior to Feeding.



PLATE 2.3: Feeding of Greenfeed Maize.



PLATE 2.4: Refusals of Greenfeed Maize.

2.4 EXPERIMENTAL PROCEDURES

Since it was expected that the main treatment response would be in the milk yield, milk composition and changes in liveweight of the cows, these were the main measurements taken. However, a number of other measurements were taken where it was considered that they would assist in the interpretation of the response data and contribute information on the nutritive value of the greenfeed maize under study. These included the yield and stage of growth of the maize crop, chemical composition and in vitro digestibility of the maize and pasture herbage fed, in vivo digestibility of the maize, pasture availability and maize intake and utilisation.

2.4.1 YIELD AND STAGE OF MATURITY OF THE MAIZE CROPS

The stage of maturity and height of both crops were recorded regularly throughout the feeding period. Dry matter determinations were carried out on the material as fed by sampling from the cut maize and drying the samples in a forced draught oven at about 100°C for 24 hours. The yield of Crop B was estimated on three occasions by sampling areas 1.83 x 1.83m across the width of the paddock, cutting the areas by hand, weighing and taking a subsample for DM determination. The yield of Crop A was not measured as the crop was generally poor and very variable.

2.4.2. CHEMICAL COMPOSITION OF MAIZE AND PASTURE

Maize samples (200 g wet weight) were taken at intervals from that being fed, dried, ground through a 1mm sieve (Wilcy Mill) and stored in airtight glass jars. Samples (300 g wet weight) of the fresh chopped maize used in the in vivo digestibility trials as outlined in Section 2.4.3.2 were composited over the feeding period and stored in a cold room at 3°C. At the end of each feeding period the composite sample was thoroughly mixed and a 200 g subsample dried, ground and stored in an airtight glass jar. The pasture herbage on offer to both groups of cows was sampled (200 g wet weight) on a number of

occasions prior to grazing and the samples were dried, ground and stored in airtight glass jars.

Acid detergent fibre, crude protein, ether extract and ash determinations were carried out in duplicate on the samples (AOAC 1975).

2.4.3 DIGESTIBILITY OF MAIZE AND PASTURE

2.4.3.1 IN VITRO DIGESTIBILITY OF MAIZE AND PASTURE

In vitro digestibilities (Tilley and Terry 1963) were carried out in triplicate on portions of the samples of maize and pasture which had been retained for use in Section 2.4.2.

2.4.3.2 IN VIVO DIGESTIBILITY OF MAIZE CROP B.

The in vivo digestibility was determined twice (Balance 1 and Balance 2) using three wether sheep fitted with harnesses and bags to collect the faeces and housed in individual pens at the Animal Physiology Unit at Massey. The determinations were preceded by a 10 day preliminary period in which the sheep were fed maize to appetite. During each balance the sheep were fed close to appetite to minimise selection and refusals. A supply of maize sufficient for 2 days was collected each alternate day, from that being fed to the cows, chopped by means of an Atlas Chaff Cutter, supplied by D.S.I.R. Ruminant Nutrition Centre, Palmerston North. The maize was chopped to 2-3cm lengths. A 200 g sample was taken each day for D M determination. In addition a 300 g sample was taken each day of the actual balance and composited. The chopped maize was stored in a cold room at 3⁰C between feeds as were the composite samples. The sheep were fed a weighed amount of chopped maize once daily and any refusals were weighed, dried and DM content determined. The faeces was removed daily from the collection bags and stored in 25 l. plastic buckets in the cold room. The sheep had access to clean water at all times. They were weighed at the beginning and end of each balance on an Avery Scales, accurate to \pm 250 g.

2.4.4 PASTURE AVAILABILITY AND GRAZING INTENSITY

The total amount of pasture herbage present on each paddock was estimated at the beginning of the experiment by cutting 13 - 15 random quadrats 0.3 x 0.6m in each paddock. The herbage was cut to ground level, using a shearing handpiece powered by a portable petrol engine. The herbage was washed and oven dried at 100°C for 24 hours. A representative sample was also taken prior to washing and 200 g of it dried in the oven for DM determination.

The grazing intensity during the experiment was estimated by measuring the herbage remaining in some paddocks after grazing by both groups. This was done by cutting 13 - 15 random quadrats 0.6 x 0.6 m. The herbage was cut to ground level, washed, oven dried for 24 hours and DM determinations also carried out.

2.4.5 MAIZE INTAKE AND UTILISATION

The amount of maize offered to the cows when crop A was fed was estimated by weighing each trailer load after cutting on Avery Scales (supplied by D.S.I.R. Palmerston North) and subtracting the weight of the empty trailer. The refusals were collected and weighed using a Salter Spring Balance set-up on a tripod. DM determinations were made on both the fresh maize and refusals. From these the weight of fresh maize fed/cow/day, the maize DM intake/cow/day, wastage at feeding and degree of utilisation could be calculated for Crop A.

The amount of maize offered to the cows when Crop B was being fed was estimated by measuring the area offered and, using the yield estimates described in 2.4.1, calculating the total maize on offer in the area. The refusals were weighed and DM determinations carried out on both the fresh maize and refusals. From these the weight of fresh maize fed/cow/day, the maize intake/cow/day, wastage at feeding and degree of utilisation could be calculated for Crop B.

2.4.6 MILK YIELD COMPOSITION AND LIVEWEIGHT CHANGES

Milk yield was measured at morning and evening milkings using TRU-TEST milk meters (Tru-test Distributors Ltd, Panmure, Auckland). The proportion of the milk from each cow which entered the measuring flask was retained at each evening milking, placed in a glass bottle and stored in a refrigerator overnight. The milk in the measuring flask from each cows morning milking was added to the respective bottle and the total analysed for fat content using a MILKOTESTER Mk III (A/s N. FOSS ELECTRIC, HILLEROD, DENMARK). The protein content was also determined on every second sampling day using a PRO-MILK Analyser (A/s N. FOSS ELECTRIC, HILLEROD, DENMARK).

Milk yield per cow was then determined 4 times, fat content 4 times and protein content twice each week during the standardisation and experimental periods.

The cows were weighed on the Wednesday morning of each week immediately after morning milking using a Donald Weighing machine (DONALD PRESSES, MASTERTON). The scales were checked and adjusted each morning prior to the start of weighing.

2.5 STATISTICAL ANALYSIS

2.5.1 PRELIMINARY ANALYSIS OF THE DATA

Milk yield, milk fat yield and milk protein yield were calculated on a/cow/day basis for each week of the experiment. The milk yield and milk fat content were the mean of 4 recordings while the milk protein content was the mean of 2 recordings. Milk yield and composition data for both groups during the 1st week of the experimental period was omitted from the covariance analysis as a change of diet had occurred in the maize group. Data for the liveweights of the control group during the 4th week of the experimental period was omitted as it had been unduly influenced by gut-fill.

2.5.2 STATISTICAL ANALYSIS OF MILK, MILK FAT, MILK PROTEIN YIELD AND LIVELWEIGHT CHANGES

Analysis of covariance (Snedecor and Cochran 1967) was used for testing the significance of differences between group means and to examine relationships between variates. Linear regression analysis (Snedecor and Cochran 1967) of milk yield and liveweight against time were used to indicate differences in the rate of change in milk yield and liveweight in the two groups and analysis of variance (Snedecor and Cochran 1967) was used to test the significance of the differences between the regression coefficients.

CHAPTER THREE

RESULTS

3.1 GENERAL DESCRIPTION OF THE MAIZE CROPS

Crop A was 1 - 1.4m high at the beginning of the experiment. It was at the leafy stage of growth with stalk of varying diameter due to variations in the plant density. By the end of the feeding period, 18/2/76, the crop was up to 1.5m high and tassles had not yet appeared.

Table 3.1 contains details of the physical characteristics of Crop B as fed during the experiment. The crop was fed in situ from one end of the paddock.

The yield of Crop B was estimated as fed on three occasions and was found to be 11,008 kgDM/ha, SE = + 882.

3.2 CHEMICAL ANALYSIS OF MAIZE AND PASTURE

The chemical composition of the greenfeed maize fed on various dates during the experiment is presented in Table 3.2.

The chemical composition of samples of pasture herbage taken from the paddocks prior to grazing is presented in Table 3.3. The results were influenced to some degree by variations in the stage of growth between paddocks.

3.3 DIGESTIBILITY OF MAIZE AND PASTURE

3.3.1 IN VITRO DIGESTIBILITY OF THE MAIZE AND PASTURE

The in vitro digestibility (Tilley and Terry 1963) of the greenfeed maize was determined for samples from the maize fed on various dates during the experiment and the results are presented in Table 3.4. and expressed as a percentage of the organic matter.

TABLE 3.1 PHYSICAL CHARACTERISTICS OF MAIZE CROP B as fed

DATE	HEIGHT (m)	STAGE OF MATURITY	DM %
19.2.76	1.6 - 1.8	Tassles Appearing	13.0
24.2.76	1.8 - 2.0	Tassles throughout, Silking Beginning	17.2
3.3.76	2.0 - 2.1	Silking Throughout the Crop	16.2

TABLE 3.2 CHEMICAL COMPOSITION OF MAIZE (D M BASIS)

DATE SAMPLED	CHEMICAL FRACTION				
	DRY MATTER %	ACID DETERGENT FIBRE %	CRUDE PROTEIN %	ETHER EXTRACT %	ASH %
13.2.76 ¹	16.0	35.7	10.6	4.5	9.0
19.2.76	17.1	38.3	9.4	2.0	8.4
25.2.76	13.7	32.8	8.5	2.5	9.2
Composite I ²	15.0	37.6	9.4	3.5	8.6
2.3.76	15.0	30.8	7.6	3.8	6.0
8.3.76	18.8	32.9	7.2	2.5	5.2
Composite II ³	16.6	32.4	8.3	3.2	6.2

1. CROP A. All other samples from Crop B.
2. Composite of maize fed from 19 - 27.2.76
3. Composite of maize fed from 29.2.76 - 9.3.76

TABLE 3.3 CHEMICAL COMPOSITION OF PASTURE (D M BASIS)

DATE SAMPLED	CHEMICAL FRACTION				
	DRY MATTER %	ACID DETERGENT FIBRE %	CRUDE PROTEIN %	ETHER EXTRACT %	ASH %
GRAZED BY CONTROL GROUP					
29.1.76	20.0	29.8	18.8	4.6	11.5
11.2.76	15.3	26.6	22.4	6.5	11.3
20.2.76	24.9	31.6	16.9	6.0	10.6
27.2.76	33.5	30.3	17.8	6.3	9.3
1.3.76	20.9	29.3	20.9	6.6	11.1
GRAZED BY MAIZE GROUP					
29.1.76	21.0	26.3	21.3	5.6	10.5
20.2.76	24.7	29.6	17.0	5.2	10.0
23.2.76	24.9	29.5	19.4	6.7	10.1

TABLE 3.4 IN VITRO DIGESTIBILITY OF MAIZE (O M BASIS)

DATE SAMPLED	DIGESTIBILITY %
13.2.76 ¹	77.1 SE = \pm 1.6
19.2.76	70.1 SE = \pm 1.8
25.2.76	68.8 SE = \pm 0.9
COMPOSITE I ²	74.9 SE = \pm 1.3
2.3.76	74.9 SE = \pm 1.4
8.3.76	71.6 SE = \pm 1.8
COMPOSITE II ³	75.7 SE = \pm 1.3

1. CROP A. All other samples are from CROP B.
2. Composite Sample of maize fed from 19 - 27.2.76
3. Composite Sample of maize fed from 29.2.76- 9.3.76

Table 3.5 contains details of the in vitro digestibility (Tilley and Terry 1963) of various samples of pasture herbage taken prior to grazing by the respective groups of cows and the results are expressed as a percentage of the organic matter.

The results were influenced by variations in the stage of growth between paddocks. The sample taken on 27/2/76 was from a paddock which had dried out considerably and had little fresh growth apparent. The samples taken on 23/2/76 and 1/3/76 were of fresh aftermath as a hay crop had been cut from these paddocks at the end of January.

3.3.2 IN VIVO DIGESTIBILITY OF MAIZE CROP B.

Results of the *in vivo* determinations carried out on Crop B over two periods (Balance 1 and Balance 2) and with three sheep are presented in Table 3.6.

The difference between the values recorded for sheep 3 in Balance 1 and those for the other two sheep in that Balance could be due to the fact that this sheep scoured during the first balance.

Further details of these determinations are contained in Appendix III.

The in vitro digestibility determinations were carried out to monitor changes in the digestibility of the pasture and maize during the experiment. Tilley and Terry (1963) and Drew (1966) have demonstrated the value of in vitro digestibility as an indicator of the nutritive value of pasture. As the sample size is small (0.5g) it may be difficult to obtain a representative sample of pasture in a paddock or a crop such as greenfeed maize which tends to separate out when being chopped on ground mechanically. Difficulties in sampling may be compensated for by carrying out multiple determinations. The in vivo digestibility determination is carried out over an extended period (usually 10 days) and so large samples of material are required. About 3 sheep must be used at each determination to overcome differences between sheep. It is not feasible to carry out determinations on grazed herbage in situ as intake must be measured accurately. It is possible to carry out large numbers of in vitro determinations in a short period and, for pasture herbage, it has

TABLE 3.5 IN VITRO DIGESTIBILITY OF PASTURE (O.M. BASIS)

DATE SAMPLED	DIGESTIBILITY %	
GRAZED BY CONTROL GROUP		
29.1.76	70.0	SE = \pm 2.4
11.2.76	72.4	SE = \pm 0.5
20.2.76	68.1	SE = \pm 0.03
27.2.76	63.5	SE = \pm 2.1
1.3.76 ^I	70.1	SE = \pm 0.8
GRAZED BY MAIZE GROUP		
29.1.76	75.3	SE = \pm 1.2
20.2.76	69.3	SE = \pm 2.3
23.2.76 ^I	74.6	SE = \pm 3.5

^I HAY AFTERMATHS

TABLE 3.6 IN VIVO DIGESTIBILITY OF MAIZE CROP B (O M BASIS)

BALANCE	SHEEP	DIGESTIBILITY %
1	1	77.7
From 19.2.76	2	77.9
to 27.2.76	3	70.7
	Mean	75.4
	S.E. of mean	\pm 2.37
2	1	73.6
From 29.2.76	2	69.8
to 9.3.76	3	70.1
	Mean	71.2
	S.E. of mean	\pm 1.22

been shown that the relationship between in vitro and in vivo determinations is highly correlated (Tilley and Terry (1963)).

3.4 PASTURE AVAILABILITY AND GRAZING INTENSITY

The total pasture dry matter present on each farmlet for both groups of cows is presented in Table 3.7. The area closed for hay was grazed at the end of the first rotation by each group and for a second time at the end of the second rotation by the control group. It was not possible to estimate the pasture dry matter present on each farmlet at the end of the experiment as one paddock on the control group and three paddocks on the maize group had been topped after grazing by the Farm Manager as part of the normal grazing management of the farm.

Evidence of the grazing intensity of the two groups is provided by the estimates of pasture remaining after grazing by the two groups and these are presented in Table 3.8.

It would appear that the control group were required to graze their farmlet more intensively than the maize group despite the fact that they had more grass at the beginning of the experiment, grazed a greater area (as they grazed the hay paddock twice) and had a much shorter rotation length.

3.5 MAIZE INTAKE AND UTILISATION

The intake of greenfeed maize and its utilisation were estimated for both crops and the results are presented in Table 3.9.

The greater intake with Crop B could possibly be accounted for by the fact that the amount of maize offered was greater, while this may also be the reason why the utilisation was lower with Crop B. However, the refusals were collected and weighed after feeding each day and had the cows been allowed access to the maize refusals (mainly stalk) at subsequent feeds the utilisation may have been higher and intake of fresh maize lower.

TABLE 3.7 PASTURE AVAILABILITY AT THE BEGINNING OF THE EXPERIMENT

	GRAZING AREA			CLOSED FOR HAY	
	TOTAL GRASS DM on 2.2.76 (kg)	AREA (ha)	YIELD/ha	YIELD/ha	AREA (ha)
CONTROL	18787	7.08	2654	3731	0.88
MAIZE	15222	6.84	2225	3785	0.91

TABLE 3.8 PASTURE REMAINING AFTER GRAZING BY THE TWO GROUPS OF COWS

	POST GRAZING D M. YIELD		ROTATION LENGTH
	kg/ha	S E. of mean	Days
FIRST ROTATION			
CONTROL	1715 ¹	\pm 120	19
MAIZE	1918 ²	\pm 62	26
SECOND ROTATION			
CONTROL	1736 ³	\pm 89	12
MAIZE	1958		1.1 ha grazed

1 ESTIMATE IS MEAN OF FIVE PADDOCKS. ONE PADDOCK
REQUIRED TOPPING AFTER GRAZING.

2 ESTIMATE IS MEAN OF FOUR PADDOCKS. THREE PADDOCKS
REQUIRED TOPPING AFTER GRAZING.

3 ESTIMATE IS MEAN OF FIVE PADDOCKS.

TABLE 3.9 MAIZE INTAKE AND UTILISATION

	CROP A	CROP B
Fresh maize offered (kg)	422.2 SE = \pm 19.2	567.0 SE = \pm 39.3
Maize D M offered (kg)	73.7 \pm 3.1	91.7 \pm 7.3
Fresh Refusals (kg)	83.1 \pm 12.8	119.9 \pm 16.1
Refusals D.M (kg)	13.2 \pm 2.3	21.9 \pm 4.6
INTAKE (kg D M)	60.5 \pm 3.6	69.7 \pm 3.2
INTAKE PER COW (kg D.M)	3.0 \pm 0.2	3.5 \pm 0.2
UTILISATION (%)	82.1 \pm 2.9	76.5 \pm 3.4

3.6 MILK YIELD, COMPOSITION AND LIVE WEIGHT CHANGES

3.6.1 MILK YIELD

The mean values for daily milk yield (1) of the two groups of cows are presented in Tables 3.10 and Figure 3.1. Week 1 of the experimental period was omitted from the calculation of the experimental mean in the covariance analysis as it was felt that the change of diet for the maize group may have unduly influenced it. The differences between the pretrial and experimental means were tested using covariance analysis and found to be not significant. The differences between experimental means adjusted by covariance techniques, were also not significant. It was found that there was a significant difference ($p < 0.01$) in the regression relationship between the pretrial and experimental yields between groups (Figure 3.2). Linear regressions of milk yield against time were calculated and are shown in Figure 3.3. Analysis of variance (Snedecor and Cochran, 1967) showed that the regression coefficients were significantly different ($p < 0.10$). Appendix IV contains details of the analyses of milk yield data.

It was decided to investigate the relationships further by dividing the groups into high yielders and low yielders. Nine of the control cows had milk yields of 14.0 l/day or greater in the pretrial period. These and their corresponding pair member in the maize group were designated as the high yielders and the remaining 10 pairs were designated as the low yielders in each group. The milk yields/day of the high and low yielders are presented in Table 3.11 and Figure 3.4. The differences between pretrial, experimental and adjusted mean yields of the high yielders and the low yielders were found to be not significant using covariance analysis. The regression coefficients for milk yield against time for the high yielders were not significantly different but were significantly different ($p < 0.10$) for the low yielders (Figure 3.5). The low yielders in the control group declined in milk yield at a faster rate than the low yielders in the maize group.

TABLE 3.10 MEAN VALUES FOR DAILY MILK YIELD (1) OF
TWO GROUPS OF COWS

PERIOD (WEEKS)	CONTROL	MAIZE	SIGNIFICANCE OF DIFFERENCE
PRE TRIAL	13.7 SE \pm 0.40	13.2 SE \pm 0.59	N.S.
Experimental			
1	13.3	12.0	
2	12.4	11.6	
3	10.8	11.1	
4	10.3	10.4	
5	10.3	10.7	
EXPERIMENTAL MEAN ¹	11.0 SE \pm 0.41	10.9 SE \pm 0.32	N.S.
ADJUSTED MEAN ²	10.9	11.0	N.S.

¹ MEAN OF WEEKS 2,3,4 and 5

² EXPERIMENTAL MEAN ADJUSTED BY COVARIANCE

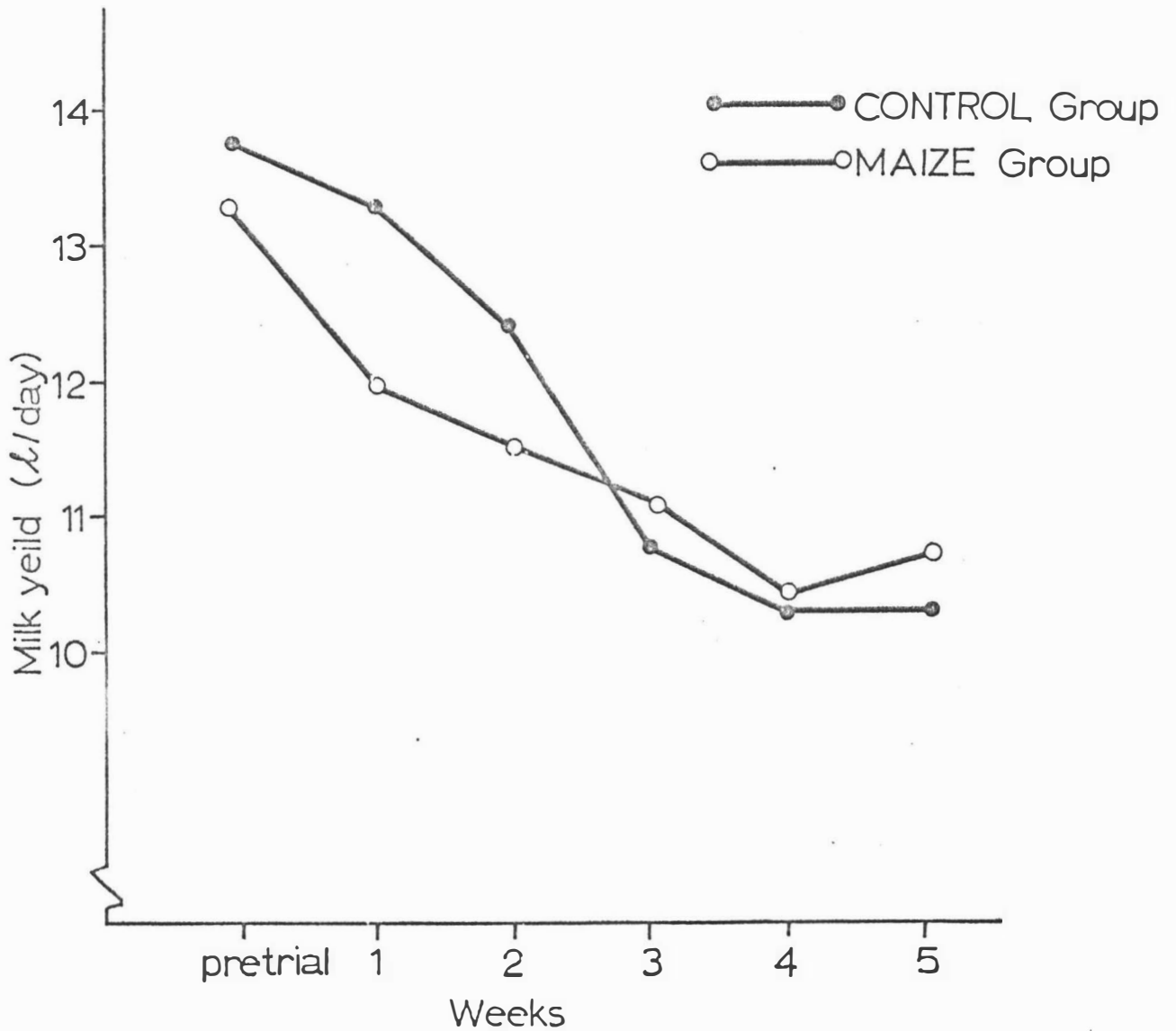


Figure 3.1: Mean daily milk yield during pretrial and experimental periods

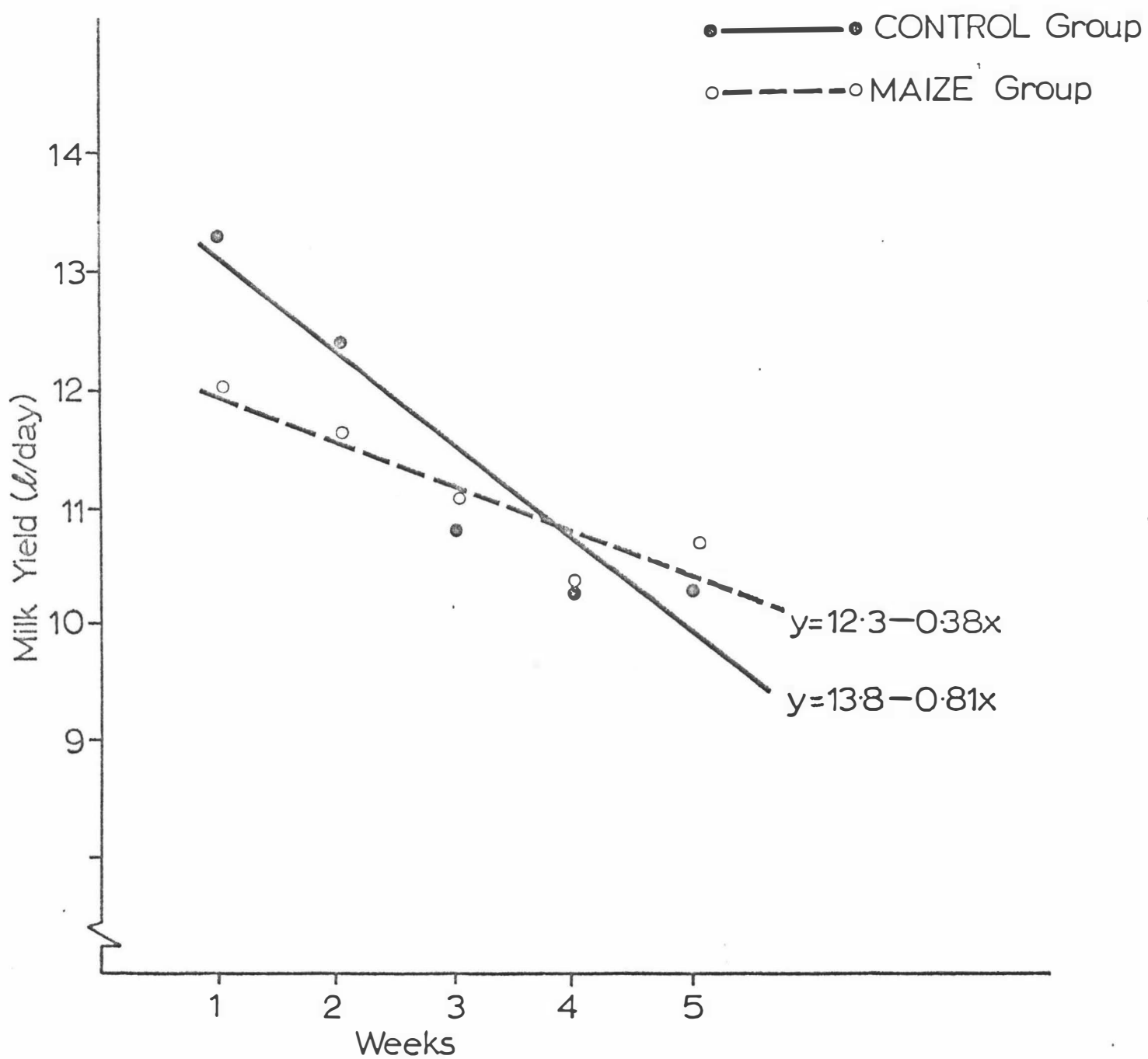


Figure 3.3: The relationship between experimental milk yield and time

TABLE 3.11 MEAN VALUES FOR DAIRY MILK YIELD (1) OF HIGH YIELDERS AND LOW YIELDERS
OF 2 GROUPS OF COWS

PERIOD (WEEKS)	CONTROL		MAIZE		SIGNIFICANCE OF DIFFERENCE
	HIGH	LOW	HIGH	LOW	
PRETRIAL	15.3 SE = \pm 0.3	12.3 SE = \pm 0.27	14.3 SE = \pm 0.67	12.1 SE = \pm 0.91	N.S.
Experimental					
1	14.3	12.4	12.6	11.5	
2	13.9	11.1	12.7	10.5	
3	12.2	9.6	11.7	10.5	
4	11.6	9.1	11.2	9.6	
5	11.7	9.1	11.4	10.0	
EXPERIMENTAL MEAN	12.4 SE = \pm 0.49	9.8 SE = \pm 0.29	11.7 SE = \pm 0.48	10.2 SE = \pm 0.32	N.S.

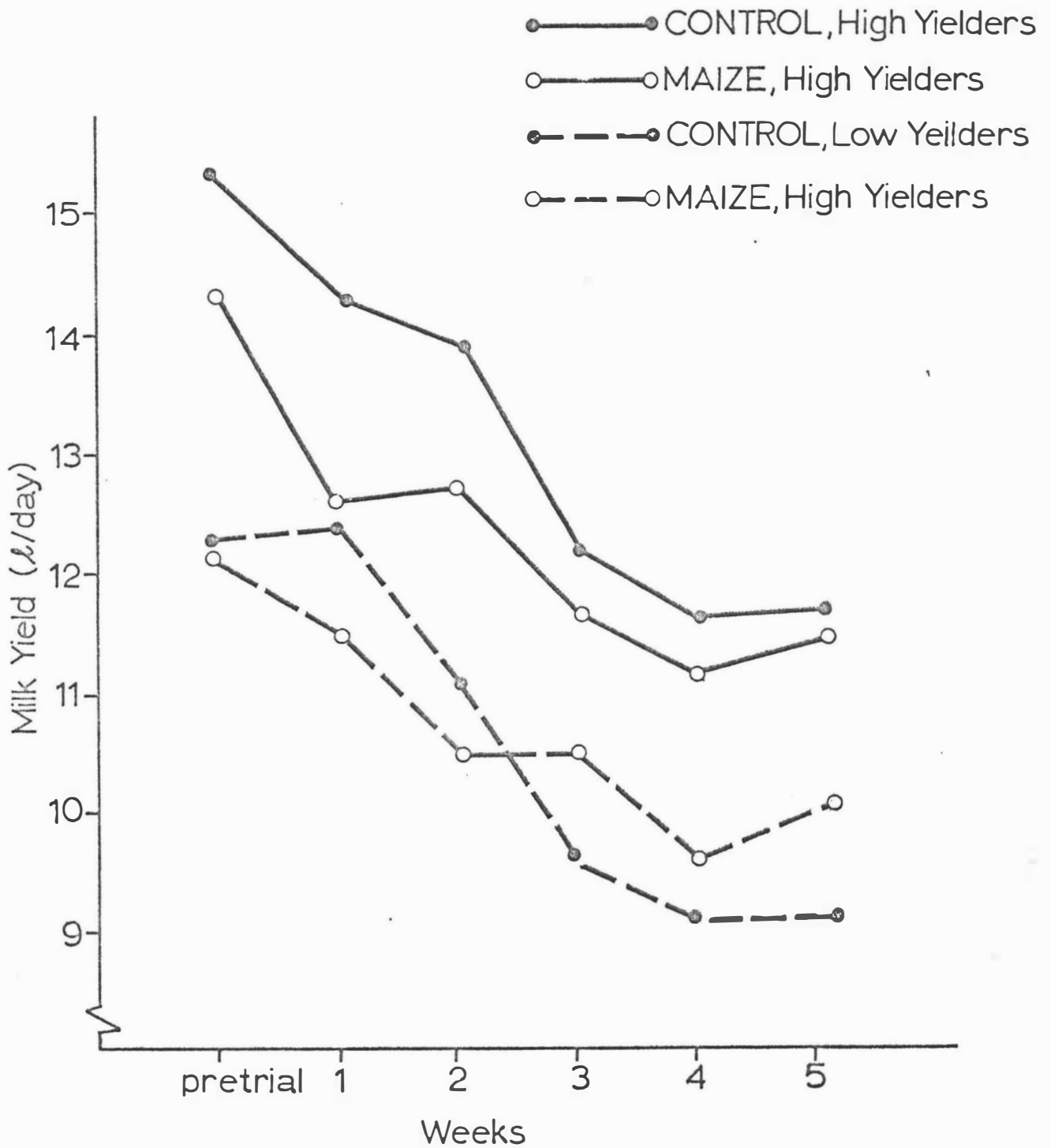


Figure 3.4: Mean daily milk yield during pretrial and experimental periods of high and low yielding cows in each group

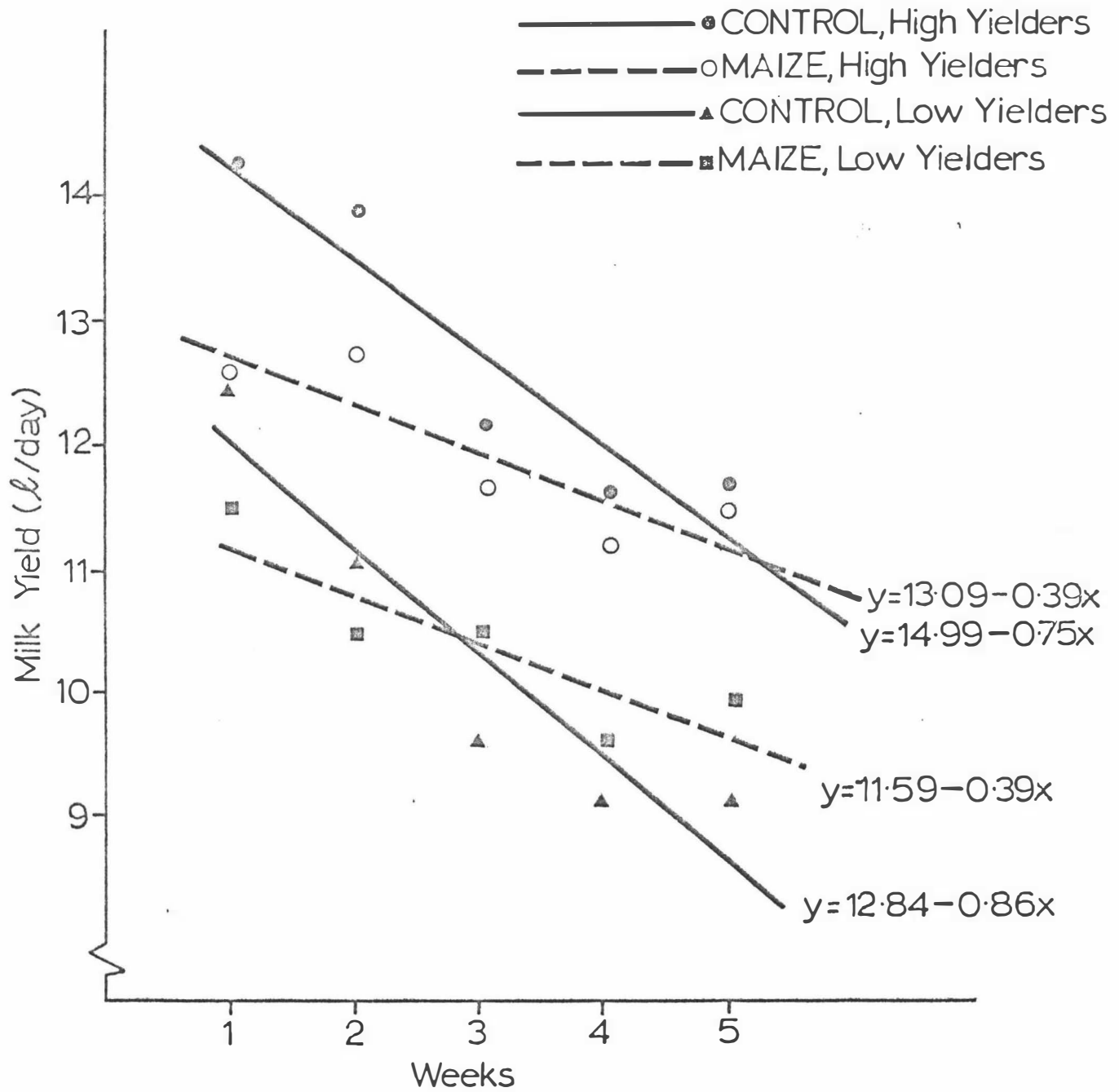


Figure 3.5: Relationship between milk yield and time for high and low yielders in two groups

3.6.2 MILK COMPOSITION

The mean values for daily milk fat yield and milk fat content of the two groups of cows are presented in Table 3.12. and Figure 3.6.

The differences between the pretrial means, experimental means and adjusted means of the two groups were not significant and there was no significant difference in the regression relationship of pretrial and experimental fat yields between groups.

Table 3.13 and Figure 3.7 contain the mean values for daily milk protein yield and protein content of the two groups.

The weekly protein values are the mean of two determinations only and the values for the control group in experimental week 4 were unduly influenced by high milk yields on one day that week. As the milk yield and milk fat figures are means of samples taken on four days of the week, they were affected by this high yield on one day to a much smaller extent. The differences between the pretrial, experimental and adjusted means of the protein yields of the two groups were found to be not significant. There was a significant difference ($p < 0.05$) in the regression relationship of pretrial and experimental protein yields between the two groups. Analysis of variance of the differences between the regression coefficients of milk protein yield against time for the two groups showed that there was no significant difference in the regression coefficients of protein yield against time for the experimental period. Both groups declined in protein yield at about the same rate.

From the analysis of the results it appears that the milk yields of the two groups declined at different rates, with the decline in the lower yielding cows in the control group being significantly different ($p < 0.10$) from that of the lower yielding cows in the maize group. Yields of milk fat would not appear to have been significantly affected by treatment and while the yields of milk protein were affected it is not possible to say whether this was confined to high or low yielding cows in each group. as the differences were too small to be significant.

TABLE 3.12 MEAN VALUES FOR DAIRY MILK FAT YIELDS (g) AND
FAT CONTENT OF TWO GROUPS OF COWS

PERIOD (WEEKS)	CONTROL		MAIZE		SIGNIFICANCE OF DIFFERENCES N.S.		
	FAT YIELD (g)	FAT%	FAT YIELD	FAT			
PRE TRIAL	615	SE = ± 19.2	4.49	578	SE = ± 22.0	4.38	
Experimental							
1	583		4.38	516		4.30	
2	550		4.44	505		4.35	
3	508		4.70	485		4.37	
4	483		4.69	475		4.57	
5	491		4.77	489		4.57	
EXPERIMENTAL MEAN	508	SE = ± 15.7	4.62	489	SE = ± 13.7	4.47	N.S.
ADJUSTED MEAN ²	498			499			N.S.

1 MEAN OF WEEKS 2,3,4 and 5

2 EXPERIMENTAL MEAN ADJUSTED BY COVARIANCE

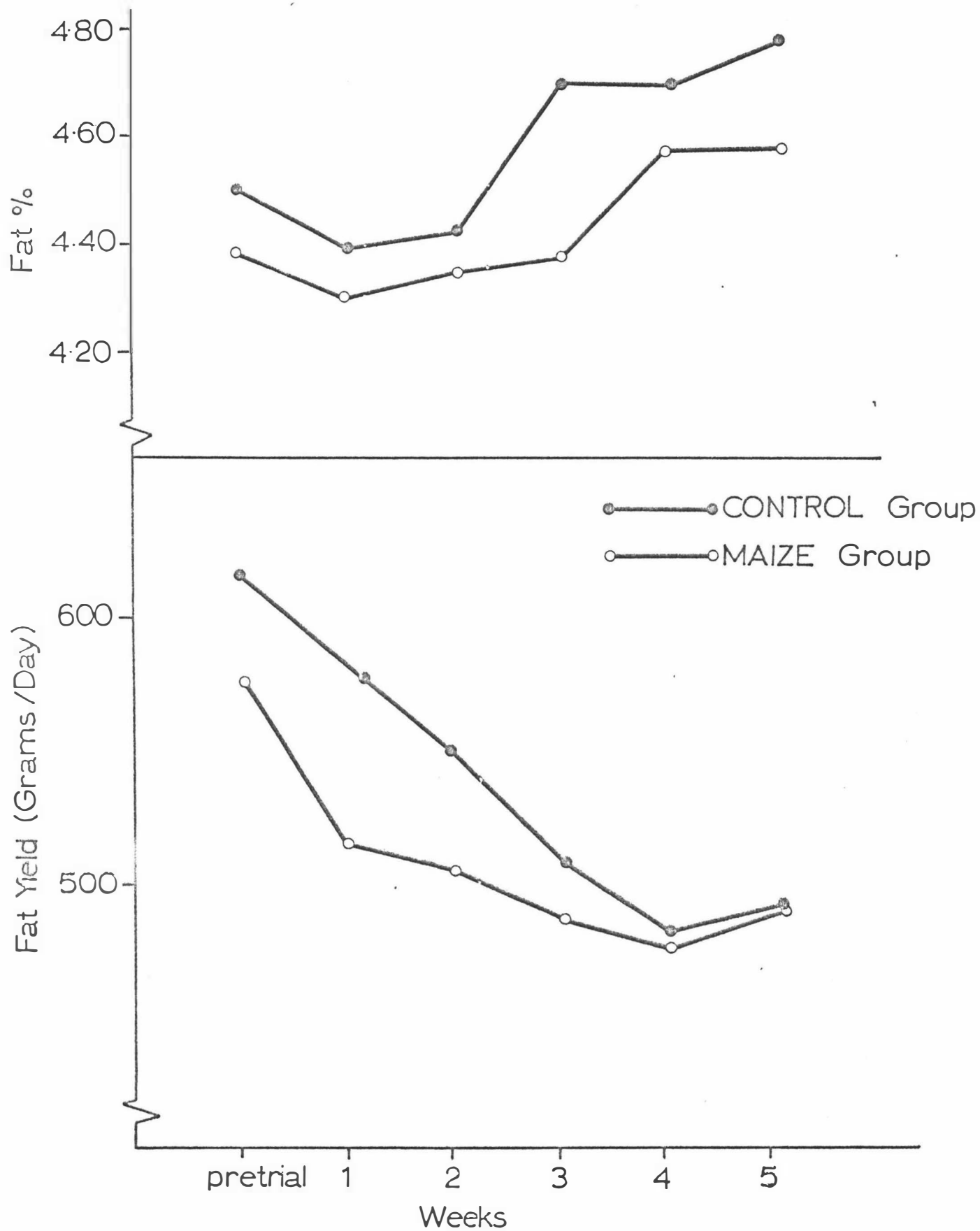


Figure 3.6: Mean daily fat yields (g) and fat % during pretrial and experimental periods

TABLE 3.13 MEAN VALUES FOR DAILY MILK PROTEIN YIELD (g)
AND PROTEIN CONTENT OF TWO GROUPS OF COWS

PERIOD (WEEKS)	CONTROL		MAIZE		SIGNIFICANCE OF DIFFERENCE
	PROTEIN YIELD(g)	PROTEIN%	PROTEIN YIELD(g)	PROTEIN%	
PRE TRIAL	432 SE = \pm 14.2	3.15	408 SE = \pm 18.2	3.11	N.S.
EXPERIMENTAL					
1	422	3.17	364	3.06	
2	392	3.16	378	3.05	
3	355	3.29	338	3.16	
4	372	3.61	354	3.28	
5	351	3.41	353	3.30	
EXPERIMENTAL MEAN ¹	368 SE = \pm 13.1	3.35	356 SE = \pm 10.7	3.27	N.S.
ADJUSTED MEAN ²	362		362		N.S.

1 MEAN OF WEEKS 2,3,4 and 5

2 EXPERIMENTAL MEAN ADJUSTED BY COVERIANCE

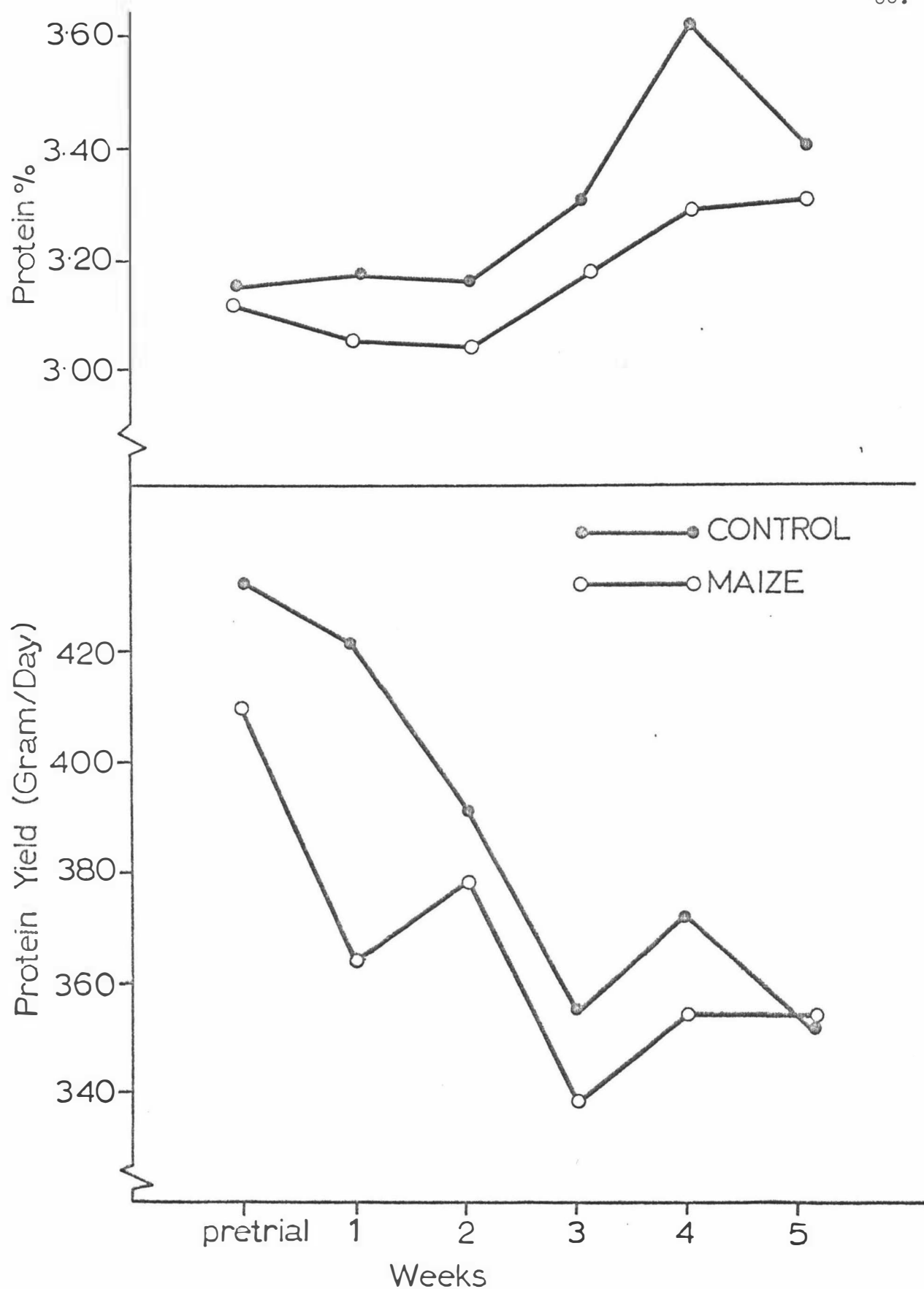


Figure 3.7: Mean daily milk protein yield (g) and protein % during pretrial and experiment periods

From Figures 3.1 it can be seen that, while the control group had a higher milk yield in the pretrial period, from week three of the experimental period onwards the yield of the maize group was higher than the control group. These differences however, were too small to be statistically significant.

The maize group would appear to have maintained their yields of milk fat and protein slightly better than the control group in the latter half of the experiment although again the differences were not statistically significant.

3.6.3 LIVEWEIGHT CHANGES

The mean values for liveweight of the two groups of cows are presented in Table 3.14 and Figure 3.8. The values for the cows in the control group during the fourth week of the experimental period were very high due to excessive gutfill. During the day prior to weighing, the groups had grazed a paddock with little feed available, and were changed to a fresh paddock with ample pasture on the night before weighing.

The differences between the pretrial and experimental mean liveweights of the two groups were not significant and there was no significant difference in the regression relationship of pretrial and experimental liveweight between groups. The linear regressions of liveweight against time were not significantly different.

The mean liveweights of the high and low yielders in both groups are also presented in Figure 3.8. The high yielders in the control group appeared to have suffered a greater decline in liveweight than the low yielders in the same group from the third week of the experimental period onwards. However, the differences were not large enough to be statistically significant.

The liveweight of the control group declined from the third week of the experimental period onwards while that of the maize group declined sharply initially but recovered later in the experiment.

TABLE 3.14 MEAN VALUES FOR LIVeweIGHTS (kg) OF TWO GROUPS OF COWS

PERIOD (WEEKS)	CONTROL (kg)	MAIZE (kg)
PRE TRIAL	437 SE = \pm 14.0	431 SE = \pm 11.9
Experimental		
1	438 SE = \pm 14.4	409 SE = \pm 11.6
2	440 SE = \pm 13.8	417 SE = \pm 11.5
3	423 SE = \pm 13.8	414 SE = \pm 11.6
4	*	419 SE = \pm 11.7
5	429 SE = \pm 13.6	424 SE = \pm 11.1
EXPERIMENTAL MEAN	434 ¹ SE = \pm 13.7	417 ² SE = \pm 11.4

* VERY HIGH VALUE RECORDED DUE TO INCREASED GUT FILL

1 Mean of weeks 1,2,3 and 5 only

2 Mean of weeks 1,2,3,4 and 5

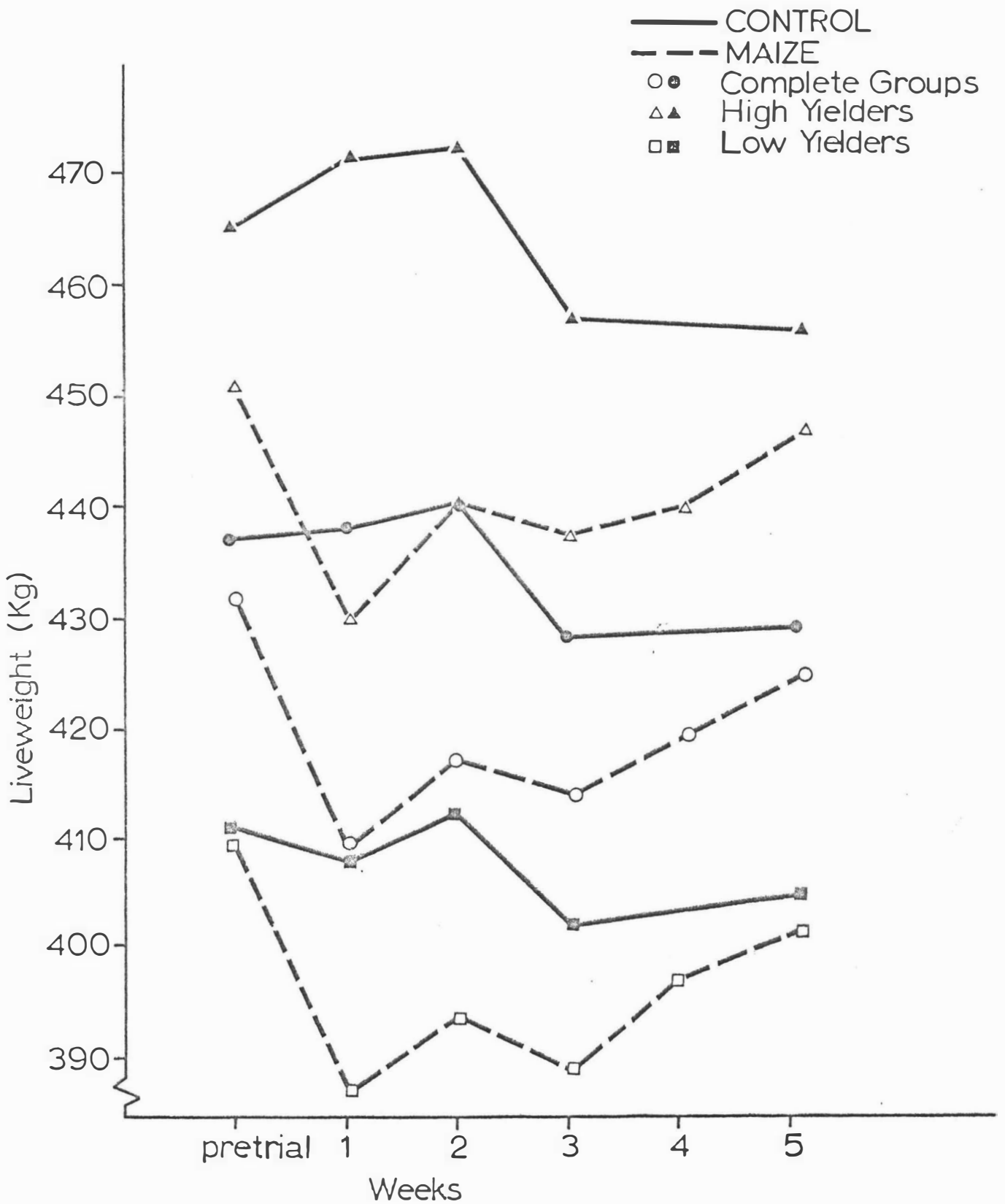


Figure 3-8 : Liveweights of 2 groups of cows and high and low yielders in each group

CHAPTER 4

DISCUSSION

All the animals appeared to be in good health except one cow which aborted as reported in Section 2.1

The experimental design chosen was satisfactory. Other factors which were outside the control of the Author had important effects on the results. These were the length of the experimental period and the weather conditions during the experiment. It was not possible to continue the experiment for a longer period as the No. 1 herd is a Town Supply herd with a supply quota to maintain. The weather conditions during Summer 1975/76 were seasonably favourable for grass growth with rainfall higher than the 30 year average and much higher than the 5 year average (Table 4.1). The need for Summer supplementary feeding was not as great as it had been over the previous five dry Summers.

4.1 YIELD OF MAIZE CROP B.

The yield of maize Crop B, estimated as fed, is presented in Section 3.1. Brickbauer (1962) suggests that yields of over 10,000 kg/DM/ha are common in solid stand maize grown at very high seeding rates after eight weeks growth in U.S.A. Matthews (1975) reports that yields of 10,000 kg DM/ha are likely under New Zealand conditions and Buxton (1975) reported that a yield of 7,000 kg digestible dry matter could be expected from greenfeed maize. The estimated yield in this experiment, 11,003 kg/ha, was slightly higher than the expected yield of greenfeed maize, based on available data.

TABLE 4.1 MONTHLY RAINFALL (mm) DURING SUMMER 1975/76 AND
COMPARISONS WITH 5 YEAR AND 30 YEAR AVERAGES (DATA
SUPPLIED BY D.S.I.R. PALMERSTON NORTH)

MONTH	1975/76	5 YEAR AVERAGE	30 YEAR AVERAGE
DECEMBER	103.3	53.9	98.3
JANUARY	88.9	63.7	80.1
FEBRUARY	61.5	48.1	68.0
MARCH	79.2	68.7	65.4
TOTAL 4 MONTHS	332.9	116.8	311.8

4.2 NUTRITIVE VALUE OF MAIZE

4.2.1 CHEMICAL COMPOSITION

The chemical composition of fresh maize varies considerably with the stage of growth (Morrison 1959). The dry matter content is low (about 10%) in immature plants grown at high plant densities. This increases to about 15% when the tassels appear and the D M content steadily increases up to maximum values of about 35% for harvesting as maize silage or 45% for harvesting as maize grain. Greenfeed maize is usually fed at about 13 - 18% D M in New Zealand. The ether extract or fat content of the maize plant is low throughout the life of the plant while the protein content is highest in leafy immature plants. The nitrogen-free extract content (mainly soluble carbohydrates) increases significantly with maturity and the crude protein decreases (Nehring and Laude (1959)). The chemical composition values recorded in Table 3.2 are very similar to values recorded by other workers (Morrison 1959; Nehring and Laude 1959; Bartlett 1971).

4.2.2 DIGESTIBILITY OF GREENFEED MAIZE

The in vivo digestibility of greenfeed maize measured in this study was over 70% (Table 3.6). While the literature on the digestibility of greenfeed maize is rather limited, Table 4.2 compares the values obtained with those available from in vivo feeding studies in the literature.

Sheep are most commonly used in digestibility trials as they are smaller and more convenient animals to work with than cattle.

Digestibility values determined using Sheep may be applied to cattle as Blaxter (1962), after an examination of the literature on the differences between sheep and cattle in their ability to digest food, concluded that there were negligible differences.

TABLE 4.2 DIGESTIBILITY OF GREENFEED MAIZE (O M BASIS):
COMPARISONS BETWEEN THIS STUDY AND PUBLISHED
VALUES

DIGESTIBILITY %	STAGE OF GROWTH	REFERENCE
68.0 - 75.5	Unspecified, 13-23% D M	Nehring and Laude (1959)
67.7	Intassel, 15% D M	Morrison (1959)
70.7	In milk corn stage, 19.9% D M	Morrison (1959)
81.99 SE \pm 1.24	About 1 m. high	Bartlett (1971)
61.17 SE \pm 10.47	1 - 2 m high	Bartlett (1971)
66.17 SE \pm 1.42	About 2m high	Bartlett (1971)
75.4 SE \pm 2.37	1.6 - 2.0 m high, In tassels	This Study
71.2 SE \pm 1.22	Over 2.0 m high, In silk	This Study

The results of in vitro digestibility (Tilley and Terry 1963) determinations of the maize (Table 3.4) were somewhat variable. Composite 1 should have compared very closely with the in vivo determination of Balance 1 and composite 2 with the in vivo determination of Balance 2. The digestibility determined in Balance 1 was higher than Balance 2 but the digestibility determined in Composite 1 was lower than Composite 2. While some of this difference may have been due to sampling problems, other workers have noted poor agreement between in vitro and in vivo determinations on maize. Dent (1963), working with maize silage has noted that the reproducibility of in vitro determinations carried out on a large number of samples was very poor. Digestibility tended to rise with storage of the milled samples. Harris (1963) reports the results of comparisons between in vivo and in vitro digestibilities of maize silage and they are reproduced in Table 4.3. The material was produced at the National Institute of Agricultural Botany, Cambridge, England, where in vitro determinations were carried out and transported to the Grasslands Research Institute, Hurley, England, and stored in a cold store where the in vivo and another in vitro determination were carried out.

The reasons why the relationship between in vitro and in vivo determinations is variable for maize are not very clear. It has been shown both in vivo and in vitro by Brooks et al. (1954) and in vivo by Grainger et al. (1961) that corn oil may depress the digestibility of a feed. Rumen liquors appear to vary in their ability to deal with feeds containing appreciable amounts of starch (Dent 1963). This could account for the lack of reproductibility in the results when the starch content changed. Warner (1956) observed that the rate of starch digestion depends on the previous diet of the sheep and while the sheep in the in vivo study had a 10 day preliminary period to adjust to the diet of greenfeed maize, the rumen liquor used for the in vitro determinations was from cows grazing pasture only. Weinmann (1947) suggested the use of diastase either between or after the rumen liquor and pepsin stages in the in vitro test and, using this treatment, Dent (1963) has found that in many cases it increased the digestible-dry-matter percentage.

TABLE 4.3 COMPARISON OF IN VIVO AND IN VITRO MEASUREMENTS OF
MAIZE SILAGE (HARRIS 1963)

MAIZE SILAGE	DRY MATTER DIGESTIBILITY, PERCENT .		
	IN VIVO	IN VITRO	
		GRI	NIAB
EARLY SOWN	69.8	72.5	70.9
MEDIUM SOWN	68.5	72.4	75.3

The in vivo determinations then are probably better indicators of the digestibility of the greenfeed maize than the in vitro determinations and the digestibility of the maize was probably higher than that of the pasture grazed during some periods of the trial (Table 3.5).

4.3 INTAKE OF GREENFEED MAIZE

The intake of greenfeed maize was slightly higher for Crop B than Crop A (3.5 kg D M /cow/day Vs 3.0 kg D M /cow/day). This could be expected as the quality of the grass being fed to the maize group was deteriorating when Crop B was fed. Also the fact that the amount offered was greater with Crop B probably influenced the intake.

Unfortunately it was not possible to estimate the total feed intakes of both groups of cows, so it is not possible to say what proportion of total feed intake the maize constituted. However, using the values for the metabolisable energy (M E) requirements for maintenance and production, published in M.A.F.F. (1975), and M E values for the pasture also published by them it is possible to calculate the intake requirements of the cows. Figure 4.1 contains the calculated D M intake of the maize group of cows during the experimental period based on their mean liveweight, milk yield and milk fat content during the entire experiment.

Liveweight of cows 419 kg
 Yield/cow 11.2 kg milk, 4.41% fat
 assuming no real weight change over the
 experimental period then requirements (including safety
 margin) are:

MAINTENANCE (M_m)

$$= 8.3 + 0.091 W$$

M_m = ME Required for maintenance

W = weight in kg.

$$M_m = 46.4 \text{ MJ ME/cow/day}$$

PRODUCTION (M_1):-

$$M_1 = 5.3 \text{ MJ ME/kg milk at } 4.41\% \text{ Fat and } 8.87\% \text{ SNF}$$

$$M_1 = 59.4 \text{ MJ ME/cow/day}$$

$$\begin{aligned} \text{TOTAL REQUIREMENTS} &= M_m + M_1 \text{ at constant liveweight} \\ &= 105.8 \text{ MJ ME/cow/day} \end{aligned}$$

Pasture quality deteriorating during summer period.

Assume ME content 10.5 MJ ME/kg DM

$$\text{INTAKE REQUIRED} = \frac{105.8}{10.5} = 10.1 \text{ kg Pasture DM per cow per day}$$

FIGURE 4.1 DM INTAKE REQUIRED BY MAIZE GROUP OF COWS DURING THE EXPERIMENTS (CALCULATIONS BASED ON MAFF 1975)

On this basis then the intake of greenfeed maize was about 29.7% of total D.M. intake with Crop A and 34.7% of total D.M. intake with Crop B. However, the liveweights of the maize group did not remain static during the experiment, they dropped initially and then increased slightly as the experiment progressed. The difficulty here is that it is impossible to say how much of the weight change was due to real liveweight change and how much was due to changes in gut-fill. It would appear however, that the greenfeed maize probably replaced 30 - 35% of the pasture dry matter intake. This is a reasonable intake of maize particularly as pasture was never really limited in supply for the maize group during the day and it was observed during the experiment that the cows tended to have one large feed of the maize when they were put in after the evening milking and then rested until they were removed at about 04-30 hours for the morning milking.

4.4 RESPONSE TO SUPPLEMENTARY FEEDING OF GREENFEED MAIZE

Although the pasture was deteriorating in quality as the experiment progressed (Tables 3.2, 3.3 and 3.5) the control group had access to adequate pasture supplies during their first rotation but were forced to graze fairly hard during their second rotation. Had the experiment been continued longer, the control group would have been quite short of feed as the pasture growth rates during the second half of the experiment were very low and the intensity of grazing had been reasonably severe in the second rotation. The estimated post grazing D M yields for the control group were lower than those for the maize group (Tables 3.7 and 3.8).

There was no significant difference in milk, milk fat and milk protein yields between groups. This result agrees with the result of Bartlett (1971) who supplemented irrigated pasture with greenfeed maize and found no significant difference in the milk yield or milk composition between groups. However, there were significant

differences in the regression relationships between pretrial and experimental yields of the two groups and the differences were significant at the 1% level for milk yield at the 5% level for protein yields. In addition the regression coefficients of experimental milk yield against time for both groups were significantly different at the 10% level. Thus it would appear that the maize group had maintained their milk yield better than the control group as the supplementation with greenfeed maize apparently slowed the rate of decline in milk yield. The differences in experimental milk yields could possibly have been significant had the experiment been continued for a longer period or carried out during a season when grass supply was less available.

Further analysis of the results by dividing each group into high yielding and lower yielding cows in each group showed that there was no significant difference between the milk yields or regression relationships between pretrial and experimental yields for either the high yielding or low yielding cows but that for the low yielders only, the regression of milk yield against time over the full experimental period were significantly different at the 10% level.

The relationship between milk yield, intake and liveweight however, is a complex one. Broster (1976) summarises the relationship in Figure 4.2 when he relates changes in milk yield and liveweight to plane of nutrition.

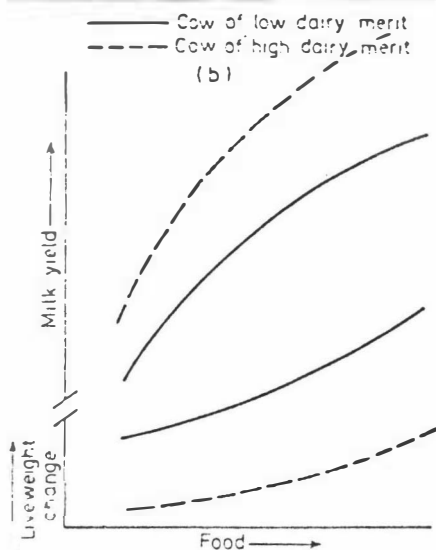


FIGURE 4.2 SIMPLIFIED MODEL TO DESCRIBE THE RELATIONSHIPS OF FOOD TO MILK AND LIVWEIGHT IN DAIRY COWS ACCORDING TO RESPONSES TO LEVEL OF INTAKE (FROM BROSTER 1976).

Figure 4.2 is a model of how the cows yield and rate of liveweight change respond directly and jointly to plane of nutrition. Food is the independent factor and is expressed in absolute amounts. Families of curves describe the responses of cows of different genetic character. A diminishing returns effect of increasing intake on milk yield is apparent although being less pronounced for the high yielding cow than the lower yielding cow. The reverse pattern occurs for liveweight change. From examination of the results of milk yield and liveweight changes of groups of cows in this study it is apparent that, in terms of their changes in milk yield and liveweight, they conformed generally to the model of Broster's above, even if many of the overall differences between groups were not statistically significant. The control group were forced to graze harder than the maize group and their pasture was deteriorating in quality as the experiment progressed. Daily milk yield declined and when the restrictions became greatest, from the 3rd week of the experiment onwards (close to the beginning of the second rotation), liveweight declined also. The maize group, on the other hand, were not forced to graze as intensively and had a substantial portion of their total intake as highly digestible greenfeed maize. Their milk yield declined, but at a slower rate than the control group, over the experimental period and, after the initial loss of liveweight during the first week of the trial (which may have been due to a change in gutfill following the change of diet), maintained or slightly increased their liveweight. It seems likely that the total intakes were higher in the maize

group than the control group as the experiment progressed. Reduction in intake has the effect of reducing milk yield although the reduction may not be very dramatic as liveweight may fall and thus buffer some of the effects of an inadequate food allowance, at least over the short term.

Although digestibility coefficients are not available for all the pasture grazed the majority of the values measured were over 70%. In the second half of the experimental period, with the exception of one paddock of hay aftermath in each group, the digestibility coefficients recorded were below 70%, the lowest value being 63.5%. While the amount of pasture available may have limited feed intake, the digestibility of the pasture herbage and the rate of movement of digesta in the digestive tract could have been responsible for limiting feed intake also (Hibbs and Conrad 1975). However, since the digestibility of the greenfeed maize was 71 - 75% (in vivo determinations) its intake would have been influenced by factors other than gut fill and rate of movement of digesta in the digestive tract (Baile and Forbes 1974). Supplementation with the maize could be expected to result mainly in substitution of the greenfeed maize for grass herbage intake as long as the grass quality remained above 67% and the quantity available was adequate Leaver et al. 1968). However, as the grass quality deteriorated, supplementation with greenfeed maize should have resulted in an increase in nutrient intake.

The poorer response to supplementary feeding in mid-lactation than in early lactation has been noted by many authors (Danasoury 1954; Balch et al. 1961; and Broster et al. 1969). Hutton (1962) concluded that for cows in mid-lactation the limiting factors to milk production were immediate post calving feeding and inherent potential. However Line and Westgarth (1971) found that, when they reduced the rations of groups of cows in mid-lactation for 20 weeks, that the greater the rate of reduction the lower were the milk yield and liveweight gain over the experimental period and that the percentage decline in yield was linearly and positively related to the percentage reduction in food intake. Homb et al. (1965) reported that high yielding cows could be underfed for long periods without a fall in milk yield, at low levels of intake however considerable losses in weight would occur. The relatively poor response to supplementary feeding of cows in mid-lactation and their tendency to increase in liveweight rather than milk yield may partly account

for the fact that the maize group, over the relatively short period of this experiment, did not respond more favourably and maintain milk yield better even though they appeared to be increasing in liveweight. The control group however may have used the apparent losses in liveweight to help maintain milk yield when feed supply became less plentiful in the second half of the experiment, to the extent that the highest yielders in the control group maintained their milk yield as well as the high yielders in the maize group.

4.5 PRACTICAL CONSIDERATIONS

No difficulties were encountered in the feeding of the greenfeed maize in the paddock. It appeared to be acceptable to all the cows in the herd. Utilisation in the paddock was satisfactory at 76.5% and if necessary could have been improved by reducing the allowance somewhat and allowing access to the refused maize in future feeds rather than collecting and weighing it. However, the intention in this experiment was to permit maximum intake of greenfeed maize rather than maximise utilisation. During the experiment it was observed that the best method of feeding the maize in the paddock was to place an electrified wire down the centre of the narrow strip of cut maize. This allowed the cows to feed easily with the minimum of trampling and fouling of the fresh maize.

At the end of the experiment the control group had completed two rotations on their farmlet, the first in 19 days and the second in 12 days. Weather conditions were generally dry and fine and grass growth was very slow. Continuing the experiment would have meant either a substantial loss in milk yield and/or liveweight in the control group unless a supplement was introduced or it would have required some of the cows to have been dried off and removed from the experiment. The maize group, however, had only started their second rotation and had a considerable amount of herbage on their farmlet. The introduction of a supplement then permitted an increase in the rotation length leading to a better distribution of the available pasture herbage over the period when growth was reduced by Summer drought.

4.6 CONCLUSIONS:

The results of this experiment are in close agreement with the reported results of Davies (1961), Bartlett (1971) and Hutton (1973) and (1975).

The value of greenfeed maize as a Summer supplement is that

- (i) It provides a high yield of D M at a time when grazing herbage supply may be inadequate.
- (ii) It is highly digestible.
- (iii) It is readily acceptable to dairy cows and intake does not appear to be limited.
- (iv) It will help maintain milk yield and liveweight when pasture supply is limited in quantity and deteriorating in quality.
- (v) Supplementation allows a better distribution of scarce pasture herbage over the Summer dry period with the possibility of less overgrazing. This may aid the recovery of pasture when Autumn rains come. The evidence presented in this thesis supports all these points.

APPENDIX I

Details of Greenfeed Maize Crops

CROP A.

Date of sowing	5th November 1975
Seeding Rate	170 kg/ha
Fertilizer applied	125 kg/ha "Cropmaster" compound (6N: 6P: 4K)
Insecticides	"Lannate" to control Argentine Stem Weevil
Herbicides	MCPA at 1.4l/ha
Row Width	15 cm

CROP B.

Date of sowing	25th November 1975
Seeding rate	170 kg/ha
Fertilizer applied	200 kg/ha of 8% Superphosphate
Insecticides	Lannate to control Argentine Stem Weevil
Row Width	30 cm

APPENDIX II
EXPERIMENTAL COWS

CONTROL					MAIZE				
COW NO.	AGE	DATE OF CALVING	YIELD (1) to 25/11/75	YIELD (1) 1974/75	COW NO.	AGE	DATE OF CALVING	YIELD (1) to 25/11/75	YIELD (1) 1974/75
158	5	6/8/75	2266	2126(RWC)	177	5	6/8/75	2341	4501
192	5	26/7/75	1919	3751	93	7	26/7/75	2208	4011
67	3	10/8/75	2106	2350(RWC)	123	3	1/8/75	2046	2158
127	6	26/7/75	2603	4856	129	6	23/7/75	2576	4067
10	3	1/8/75	1772	2415	159	3	28/7/75	1783	2344
120	7	6/8/75	2679	5128	5	7	7/8/75	2608	4701
21	8	3/8/75	2698	5549	99	8	31/7/75	2526	5727
111	10	9/8/75	1956	3640	124	10	10/8/75	2033	3892
180	4	10/8/75	2156	4731	165	5	21/8/75	2137	5024
39	7	15/8/75	2049	4045	70	7	5/8/75	1960	5336
94	7	24/8/75	2366	4419	95	7	11/8/75	2342	3607
58	5	28/8/75	1902	4681	166	3	15/8/75	1888	1696(RWC)
117	7	14/9/75	1612	3761	48	9	1/9/75	1744	3931
85	8	19/8/75	2180	4660	80	7	29/8/75	1514	3073
112	3	17/9/75	1270	1880	154	3	16/9/75	1291	2251
77	3	26/9/75	985	1544	186	3	26/9/75	1070	2192(RWC)
110	4	6/10/75	682	3489	19	3	7/10/75	759	3445
149	4	8/10/75	900	3279	160	4	28/9/75	1093	2817
56	2	13/7/75	2298	-	37	2	18/7/75	2298	-
87	2	9/9/75	1126	-	225	2	14/8/75	1427	-
TOTAL			37525	61828(16)				37644	60885(16)
YIELD/COW			1876	3864(16)				1882	3805(16)

RWC - RUN WITH CALVES PRIOR TO END OF LACTATION, SO RECORD INCOMPLETE

APPENDIX III

IN VIVO DIGESTIBILITY OF GREENFEED MAIZE

BALANCE I

DATE	SHEEP	MAIZE OFFERED(g)	DM CONTENT OF MAIZE(%)	REFUSALS (g)	DM CONTENT OF REFUSALS(g)	DM OFFERED(g)	DM REFUSED(g)	DM INTAKE(g)
19/2/76	1	2,800	17.1	200	15.0	478.8	30	448.8
	2	3,000	"	0	0	513	0	513
	3	3,000	"	0	0	513	0	513
20/2/76	1	2,800	16.3	87	16.1	456.4	14	442.4
	2	3,000	"	0	0	489	0	489
	3	3,000	"	0	0	489	0	489
21/2/76	1	2,800	15.2	164	16.5	425.6	27	398.6
	2	3,000	"	0	0	456	0	456
	3	3,000	"	0	0	456	0	456
22/2/76	1	2,800	13.4	116	15.5	375.2	18	357.2
	2	3,000	"	0	0	402	0	402
	3	3,000	"	0	0	402	0	402
23/2/76	1	2,800	21.9	67	17.9	613.2	12	601.2
	2	3,000	"	0	0	657	0	657
	3	3,000	"	0	0	657	0	657
24/2/76	1	2,800	9.2	164	15.9	257.6	26	231.6
	2	3,000	"	0	0	276	0	276
	3	3,000	"	0	0	276	0	276
25/2/76	1	2,800	13.7	187	13.9	383.6	26	357.6
	2	3,000	"	0	0	411	0	411
	3	3,000	"	0	0	411	0	411

APPENDIX III (contd.)

26/2/76	1	2,800	13.5	78	17.9	378	14	364
	2	3,000	"	0	0	405	0	405
	3	3,000	"	0	0	405	0	405
27/2/76	1	2,800	15.0	127	16.5	420	21	399
	2	3,000	"	0	0	450	0	450
	3	3,000	"	0	0	450	0	450

Faeces Collection

Sheep	Wt. of Bucket (g)	Wt. of Bucket and Faeces (g)	Wt. of Faeces (Wet) (g)	DM %		Mean Faeces DM (g)
				A	B	
1	1079	3107	2028	42.1	42.0	852.8
2	1165	5045	3880	25.3	24.9	973.9
3	1166	9577	8411	15.0	15.3	1274.3

Faeces D M Determinations (2 samples/sheep)

Sheep	Tray Wt. (g)		Tray + Faeces (Wet) (g)		Tray + Faeces (Dry) (g)		Faeces Wet (g)		Faeces Dry (g)	
	A	B	A	B	A	B	A	B	A	B
1	135	142	318	404	212	252	183	262	77	110
2	143	142	586	623	255	262	443	481	112	120
3	128	151	1227	1278	293	323	1099	1127	165	172

Faeces Ash Determinations (2 samples/sheep)

Sheep	Crucible No.	Crucible Wt. (g)	Crucible + Faeces, Wet (g)	Crucible + Faeces, Dry (g)	After Ashing (g)	Ash (%)	Ash % of D M
1	1	25.7221	28.3210	26.8240	25.8781	6.0	14.0
	2	24.8954	27.8445	26.1458	25.0681	5.86	
2	3	23.7642	29.3123	25.1842	23.9918	4.1	16.0
	4	23.8136	28.9525	25.1291	24.0269	4.15	
3	5	25.4503	32.9496	26.7327	25.6340	2.45	14.6
	6	25.9845	32.5523	27.1076	26.1504	2.53	

Sheep 1 D M intake = 3600.4 g. O M intake = 3290 g.
 O M in Faeces = 733.4 g.
 Digestibility of the O M = $\frac{3290.8 - 733.4}{3290.8} \times \frac{100}{1} = 77.7\%$

Sheep 2 D M intake = 4059.0 g O M intake = 3709.9g
 O M in Faeces = 818.1
 Digestibility of the O M = $\frac{3709.9 - 818.1}{3709.9} \times \frac{100}{1} = 77.9\%$

Sheep 3 D M intake = 4059.0 g. O M intake = 3709.9 g.
 O M in Faeces 1088.3 g.
 Digestibility of the O M = $\frac{3709.9 - 1088.3}{3709.9} \times \frac{100}{1} = 70.7\%$

Mean Digestibility of OM in Greenfeed Maize During Balance I = 75.4% SE = ± 2.37

BALANCE II

DATE	SHEEP	MAIZE OFFERED(g)	DM CONTENT OF MAIZE(%)	REFUSALS (g)	DM CONTENT OF REFUSALS(%)	DM OFFERED(g)	DM REFUSED(g)	DM INTAKE(g)
29/2/76	1	3,560	16.7%	419	16.7	594.5	70	524.5
	2	4,000	"	29	24.1	668	7	661
	3	4,000	"	74	24.3	668	18	650
1/3/76	1	3,560	16.3%	508	13.8	580.3	70	510.3
	2	4,000	"	395	13.9	652	55	597
	3	4,000	"	474	13.5	652	64	588
2/3/76	1	3,560	15.0%	300	16.7	534	50	484
	2	4,000	"	223	12.6	600	28	572
	3	4,000	"	1412	13.9	600	196	404
3/3/76	1	3,560	16.1%	308	14.9	573.2	46	527.2
	2	4,000	"	435	14.7	644	64	580
	3	4,000	"	1222	13.6	644	166	478
4/3/76	1	3,560	16.2%	118	19.5	576.7	23	553.7
	2	4,000	"	349	16.9	648	59	589
	3	4,000	"	781	16.4	648	128	520
5/3/76	1	3,560	15.9%	545	16.1	566	88	478
	2	4,000	"	7	28.6	636	2	634
	3	4,000	"	659	15.6	636	103	533
6/3/76	1	3,560	16.8%	1045	15.7	598.1	164	434.1
	2	4,000	"	213	16.9	672	36	636
	3	4,000	"	1151	15.3	672	176	496
7/3/76	1	3,560	16.7%	571	16.3	594.5	93	501.5

BALANCE II (contd.)

7/3/76	2	4,000	16.7%	175	16.0	668	28	640
	3	4,000	"	1108	15.1	668	167	501
8/3/76	1	3,560	18.8%	323	18.6	669.3	60	609.3
	2	4,000	"	587	17.6	752	100	652
	3	4,000	"	997	17.0	752	176	576
9/3/76	1	3,560	18.1%	558	18.6	644.4	104	540.4
	2	4,000	"	562	17.6	724	99	625
	3	4,000	"	1024	18.5	724	189	535

Faeces Collection

Sheep	Wt. of Bucket (g)	Wt. of Bucket + Faeces (g)	Wt. of Faeces, Wet (g)	D M. %		Mean Faeces D M (g)
				A	B	
1	1182	5396	4214	35.3	35.3	1487.5
2	1176	9500	8324	24.2	24.2	2014.4
3	1142	8096	6954	24.8	24.9	1728.0

Faeces D M Determinations (2 samples/sheep)

Sheep	Tray Wt. (g)		Tray + Faeces, Wet (g)		Tray + Faeces, Dry (g)		Faeces, Wet (g)		Faeces, Dry (g)	
	A	B	A	B	A	B	A	B	A	B
1	152	139	552	524	293	275	400	385	141	136
2	142	135	738	788	286	293	596	653	144	158
3	133	130	757	781	288	292	624	651	155	162

Faeces Ash Determinations (2 samples/sheep)

Sheep	Crucible No.	Crucible Wt. (g)	Crucible + Faeces, Wet (g)	Crucible + Faeces, Dry (g)	After Ashing	Ash %	Ash % of D M
1	7	26.8208	29.1655	27.6086	26.9234	4.4	14.0
	8	22.3254	25.1728	23.2821	22.4657	4.9	
2	9	22.4802	26.5190	23.5666	22.6350	3.83	13.0
	10	27.9606	31.3651	28.8766	28.0683	3.16	
3	11	25.8631	31.3777	27.4017	26.0799	3.93	14.3
	12	27.3145	31.8117	28.5692	27.4948	4.00	

Sheep 1. D M intake = 5162.8 g. O M intake = 4842.7 g.
 Faeces O M = 1279.3 g.
 Digestibility of the O.M. = $\frac{4842.7 - 1279.3}{4842.7} \times \frac{100}{1} = 73.6\%$

Sheep 2. D M. intake = 6186.0 g. O M intake = 5802.5 g.
 Faeces O M = 1752.5
 Digestibility of the O M = $\frac{5802.5 - 1752.5}{5802.5} \times \frac{100}{1} = 69.8\%$

Sheep 3. D M. intake = 5281 g. O M intake = 4953.6 g.
 O M in faeces 1480.9
 Digestibility of the O M = $\frac{4953.6 - 1480.9}{4953.6} \times \frac{100}{1} = 70.1$

Mean Digestibility of O M in Greenfeed Maize During Balance 2 = 71.2%, SE = ± 1.22

LIVEWEIGHTS OF SHEEP (kg)

	Sheep 1	Sheep 2	Sheep 3
Beginning of Balance I	33.5	31.0	35.0
End of Balance I	32.5	31.25	34.25
Beginning of Balance II	32.5	31.25	34.25
End of Balance II	32.75	33.0	34.75

APPENDIX 4

ANALYSIS OF MILK YIELD DATACovariance Analysis of Milk Yield

X - Pretrial yield (litres)

Y - Experimental yield (litres)

(mean of weeks 2,3,4 and 5)

Control Group				Maize Group			
Cow	No.	X	Y	Cow	No.	X	Y
10		12.3	8.7	5		13.5	10.5
21		17.2	15.2	19		16.4	11.2
39		12.9	10.5	37		13.1	10.3
56		11.0	8.8	48		13.2	12.5
58		15.3	12.1	70		10.3	11.1
67		12.1	9.6	80		11.2	11.0
77		11.3	8.8	93		13.1	11.8
85		15.7	13.0	95		14.3	11.5
87		11.6	8.8	99		17.5	12.8
110		13.9	10.4	123		14.0	10.8
111		14.2	9.7	124		14.4	10.6
112		12.9	10.5	129		13.9	10.7
117		14.9	12.4	154		12.6	9.6
120		14.9	13.0	159		11.5	9.1
127		14.9	11.4	160		15.5	12.9
149		15.9	12.7	165		16.8	14.4
158		12.7	10.4	166		12.6	10.3
180		14.5	11.8	177		5.5	9.7
192		12.5	11.0	186		13.1	8.8
				225		10.9	9.3
SX	260.7					263.4	
SY			208.8				218.9
X,Y	13.7	11.0				13.2	10.9
SX ²	3631.7					3600.4	
SY ²			2351.8				2433.9
SXY	2916.3					2925.8	

OVERALL TOTALS

	$SX = 524.1,$	$SY = 427.7,$	$n = 39$
	$SX^2 = 7232.1$	$SY^2 = 4785.7$	$SXY = 5842.1$
Less	$C = 7043.1$	$C = 4690.4$	$C = 5747.6$
	$Sx^2 = 189$	$Sy^2 = 95.3$	$Sxy = 94.5$

INDIVIDUAL GROUPS

	CONTROL	MAIZE
Sx^2	54.6	131.4
Sy^2	57.2	38.0
Sxy	51.3	42.9
$\frac{Sxy}{Sx^2} = b$	0.94	0.33
$Sy^2 - \frac{(Sxy)^2}{Sx^2}$	9.0	24.0

ANALYSIS OF VARIANCE

(1) OF X the PRETRIAL YIELDS

Source of variance	d.f.	s.s.	m.s.
TOTAL	38	189	4.97
BETWEEN TREATMENT GROUP MEANS	1	2.4	2.4
WITHIN TREATMENT GROUPS	37	186.6	5.04

$$F = \frac{2.4}{5.04} = 0.48$$

$$F_{0.05} 37, 1 \text{ d.f.} = 250$$

difference between pretrial milk yields not significant

(II) OF Y the experimental yields

Source of variance	d.f.	s.s.	m.s.
Total	38	95.3	2.5
BETWEEN TREATMENT GROUPS MEANS	1	0.0975	0.0975
WITHIN TREATMENT GROUPS	37	95.2025	2.5730

$$F = \frac{0.0975}{2.5730} = 0.04$$

$$F_{0.05} \quad 37, 1 \text{ df} = 250$$

differences between experimental milk yields not significant

COMPARISONS OF THE REGRESSION LINES

Group	d.f.	S_x^2	S_{xy}	S_y^2	b	Deviations from Regression		
						d.f.	s.s.	m.s.
Control	18	54.6	51.3	57.2	0.94	17	9.0	0.53
Maize	19	131.4	42.9	38.0	0.33	18	24.0	1.33
Deviations from Individual Regressions						35	33.0	0.94
Total	37	186.0	94.2	95.2	0.51			
Deviations from Common Regression						36	47.49	1.32
Differences among groups						1	14.49	14.49

$$F = \frac{14.49}{0.94} = 15.4$$

$$F_{0.05} \quad 1, 35 \text{ d.f.} = 4.12$$

$$F_{0.01} \quad 1, 35 \text{ d.f.} = 7.39$$

significant differences between the slopes of the regression lines $P < 0.01$

Adjusted means - \hat{y}

Original means	\bar{x}	\bar{y}
Control Group	13.7	11.0
Maize Group	13.2	10.9

Overall means 13.45 10.95

Adjusted mean $\hat{y} = \bar{y} - (x - \bar{x})$

$$\text{Control Group } \hat{y} = 11.0 - 0.51 (13.7 - 13.45) \\ = 11.0 - 0.13 = 10.87$$

$$\text{Maize Group : } \hat{y} = 10.9 - 0.51 (13.2 - 13.45) \\ = 10.9 + 0.13 = 11.03$$

Adjusted means then for control group = 10.9
and for maize group 11.0

Analysis of Covariance of Groups Using Adjusted Means

Source	d.f.	Sx^2	Sxy	Sy^2	Deviations from Regression			
					d.f.	s.s.	m.s.	
Total	38	189.0	94.5	95.3	37	48.05	1.30	
Between Treatment means	1	3.0	0.3	0.1				
Within groups	37	186.0	94.2	95.2	36	47.49	1.32	
					Between Groups	1	0.56	0.56

$$F = \frac{0.56}{1.32} = 0.42$$

$$F_{0.05} 36, 1 \text{ d.f.} = 250$$

Difference between adjusted means not significant

LINEAR REGRESSION OF EXPERIMENTAL MILK YIELD AGAINST TIMECONTROL GROUP

x	y	$y = a + bx$
1	13.3	$a = 13.85$
2	12.4	$b = -0.81$
3	10.8	$r = -0.94$
4	10.3	$t = -4.772, \quad t_{0.05} \quad 3 \text{ d.f.} = 3.182$
5	10.3	\therefore correlation significant
$y = 13.85 - 0.81 x$		

Maize Group

x	y	$y = a + b x$
1	12.0	$a = 12.3$
2	11.6	$b = -0.38$
3	11.1	$r = -0.92$
4	10.4	$t = -4.179 \quad t_{0.05} \quad 3 \text{ d.f.} = 3.182$
5	10.7	\therefore correlation significant
$y = 12.3 - 0.38 x$		

Analysis of Variance

Group	d.f.	Sx^2	Sxy	Sy^2	b	Deviations from Regression		
						d.f.	s.s.	m.s.
Control	4	10	-8.1	7.4	-0.81	3	0.84	0.28
Maize	4	10	-3.8	1.7	-0.38	3	0.26	0.087
Deviations from Individual Regressions						6	1.10	0.18
Total	8	20	-11.9	9.1	-0.60			
Deviations due to Common Regressions						7	2.02	0.29
Differences Among group Regression lines						1	0.92	0.92

$$F = \frac{0.92}{0.18} = 5.1$$

$$F_{0.05} \quad 1,6 \text{ d.f.} = 5.99$$

$$F_{0.10} \quad 1,6 \text{ d.f.} = 3.78$$

significant differences between regression lines ($P < 0.10$)

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