Chapter 3

# EXPERIMENTAL

## 3.1 INTRODUCTION

Tropical ruminants generally depend on natural permanent pastures for their maintenance and production. However, both the quantity and quality of natural grasslands available in tropical areas set a limit to their productivity. Unsatisfactory growth of cattle grazing natural pasture in the wet tropics has been recorded on many occasions. For example, Vilela et al. (1977) have shown that liveweight gains of only 0.049 kg $hd^{-1}$ $day^{-1}$ were produced from native highland pastures of Thailand during the 1976/1977 grazing season. By comparison, it was shown that improved pastures produced liveweight gains of 0.203 kg $hd^{-1}$. Such results are typical of those reported in the literature.

The review of literature led to the proposal of several hypotheses outlined at the end of the previous chapter (Section 2.3). Briefly, it was suggested that animal production could be increased by the use of appropriate fertilizers, to increase both the quality and quantity of pasture, and that by use of suitable stocking rates pasture utilisation could be optimised. The method of testing these hypotheses was to design an experiment in which native and oversown pastures were grazed by beef cattle at Siwa in South Sulawesi, Indonesia. Since stocking rate is a significant factor determining both plant and animal productivity, this was included as a major experimental variable.

Earlier studies conducted by Blair et al. (1979) showed the area to be deficient in the plant nutrient sulfur (S). In addition, no information existed for the region on the effect of stocking rate on animal productivity, pasture productivity and stability. A series of experiments was therefore designed to provide information on the effects of the stocking rate and sulfur application on animal, plant and soil performance.

Local cattle (Bali cattle) which were purchased from smallholders in Bali and transferred to South Sulawesi (Reksohadiprodjo, 1980), do not handle well in cattle yards needed in extensive ranching conditions. High calf mortality has been found when Bali calves were weaned and postnatal calf losses are also high (25-30%). Since the Bali cattle are more adapted to the area than the Brahman cross cattle, it was suspected that the latter breed is more responsive to the experimental treatments. It was therefore considered appropriate to use weaner Brahman cross heifers as the experimental animals since these have a greater productivity than local cattle and are also available in the area.

## 3.2 MATERIALS AND METHODS

### 3.2.1 Location and Climate

The experiments were conducted on the Siwa ranch of the Indonesian Livestock Company (P.T. Bina Mulya Ternak) in S. Sulawesi, Indonesia. The ranch is located on the East coast of S. Sulawesi some 60 km north of Sengkang (Figure 3.1), latitude 4°7'54" S, longitude 120°2'42".

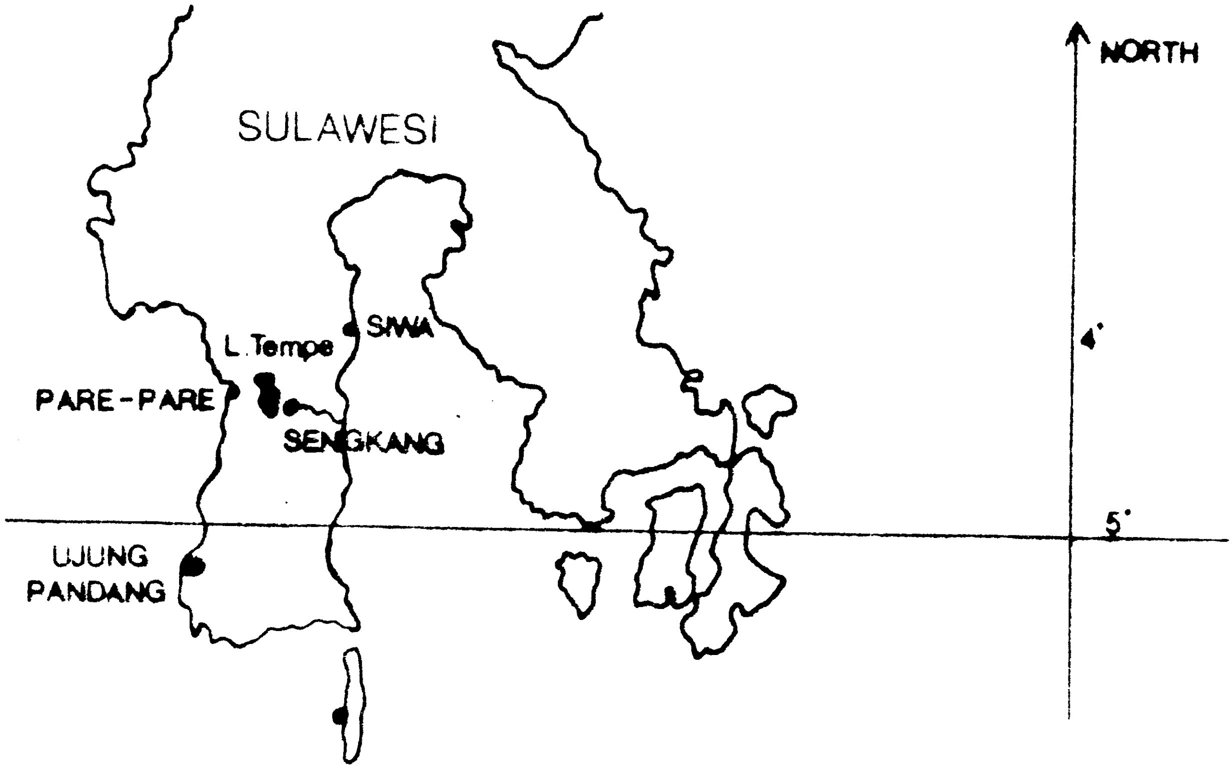



Figure 3.1. Map of S. Sulawesi showing experimental location.

The country is gently undulating and the ranch area occupies land that stretches from the coastal plain to the foothills of the central mountain chain.

Two experimental sites were selected on land that was representative of native and oversown pastures. The soil at both sites is classified as red yellow podsolic (Anon., 1969).

Being located on the East coast of S. Sulawesi means that the wettest months are in the April-June period when the rain comes from the S.E. trade winds that blow across the Arafura Sea. When these winds swing to the north-west to bring rain to the West coast in November to February, the Siwa site is in the rainshadow of the central mountain chain. The rainfall recorded at the Siwa ranch headquarters during the experimental period, together with the mean monthly rainfall at the nearest recording station, Sengkang, is presented in Table 3.1.

The average rainfall during the three year experimental period was 2838 mm of which 70% fell between March and August. This distribution was similar to the long term average for Sengkang but the annual total is higher.

### 3.2.2 Experimental Design and Statistical Analysis

The sites were selected so that they were representative of the native pastures of the area and also the native pastures that had been oversown with the legumes *Stylosanthos guianensis* cv. Cook and Schoffield (Stylo). Plots were then fenced to accommodate the treatments shown in Table 3.2. Plot size was varied to establish the required stocking rates so that there were three animals per plot.

Table 3.1 Rainfall recorded at Siwa Ranch during the experimental period (mm/month) and number of wet days/month together with the long term average (10 years) at Sengkang some 60 km from the site.

| | Experimental Site | | | | | | Sengkang av. for 10 years | |
|---|---|---|---|---|---|---|---|---|
| | 1979/80 | | 1980/81 | | 1981/82 | | | |
| Month | mm | w.d. | mm | w.d. | mm | w.d. | mm | w.d |
| September | 182.5 | 9 | 31 | 2 | 222 | 10 | 175 | 8 |
| October | 99 | 5 | 110.5 | 8 | 388 | 14 | 128 | 8 |
| November | 213 | 5 | 79.5 | 5 | 85 | 6 | 93 | 6 |
| December | 135.5 | 10 | 126.5 | 6 | 33 | 2 | 66 | 5 |
| January | 34.5 | 4 | 18.5 | 1 | 8 | 2 | 51 | 5 |
| February | 75.5 | 6 | 75.5 | 7 | 115.5 | 8 | 35 | 3 |
| March | 160.5 | 8 | 383.5 | 16 | 257 | 11 | 122 | 7 |
| April | 574.5 | 17 | 564 | 13 | 356 | 16 | 232 | 11 |
| May | 321 | 17 | 835.5 | 19 | 493.5 | 12 | 297 | 11 |
| June | 389 | 11 | 567.5 | 11 | 300.5 | 8 | 223 | 11 |
| July | 114 | 3 | 515 | 16 | 0 | 0 | 255 | 11 |
| August | 394 | 14 | 208.5 | 6 | 45.5 | 4 | 100 | 5 |
| Total | 2693 | 109 | 3515.5 | 110 | 2304 | 93 | 1777 | 91 |
| Average | 194 | 9 | 293 | 9 | 192 | 8 | 148 | 8 |

Stocking rates were chosen on the basis of local ranch experience to give what was anticipated to be moderate and high levels of pasture utilization. This was done to achieve different nutrient recycling rates and to subject the various pasture components to different selection pressures.

Fertilizers were hand broadcast onto the surface of the pasture at the start of each grazing year. A basal application of P as TSP was made at the beginning of the 1981/82 grazing year (October 1981) when the P levels of soil and plant were considered low.

Table 3.2. Fertilizer and stocking rates used on two grazing experiments conducted at Siwa Ranch, S. Sulawesi.

| Pasture Type | Treatment | Rate |
|---|---|---|
| Native | Fertilizer | 0 or 30 kg S $ha^{-1}$ $year^{-1}$ applied as elemental S ($S_0$ and $S_1$) |
| | Stocking Rate | 0.5 or 1.0 A.U.* $ha^{-1}$ |
| Oversown | Fertilizer | Year of Application: 1, 2, 3 (kg S $ha^{-1}$ $year^{-1}$) |
| | | $S_0$: 0, 0, 0 |
| | | $S_1$: 15, 15, 15 |
| | | $S_2$: 30, 15, 15 |
| | | $S_3$: 30, 30, 30 |
| | Stocking Rate | 1.0 or 2.0 A.U.* ha |

* A.U. = Animal unit. In this thesis this represents a heifer approximately 110-150 kg body weight at the start of each grazing year.

The various fertilizer and stocking rates were studied in a factorial combination with the plots arranged in a completely randomized block design with two replicates. Plot layouts for each site are presented in Appendix 1.

The lack of availability of land to conduct the grazing experiments meant that the two sites were separated by a distance of some 10 km. For this reason no statistical comparisons have been attempted between sites.

Liveweight data have been analyzed as a split-plot in time with the individual animals as sub-samples within each plot.

### 3.2.3 Sampling Schedule

Soil and pasture samples were collected in each grazing year and animal liveweights recorded in one day at intervals of approximately 3 month A schedule of samplings is shown in Table 3.3.

Table 3.3. Sampling schedule used throughout the experiment.

| Date | Pasture Estimation and Soil Sampling | Animal Livewieght |
|---|---|---|
| 1979/1980 | 15.9.1979 and 14.10.1980 | 17.9.1979, 12.5.1980 and 17.9.1980 |
| 1980/1981 | 14.9.1980 and 29.8.1981 | 19.9.1980, 19.12.1980, 27.3.1981, 25.6.1981 and 14.10.1981 |
| 1981/1982 | 29.8.1981 and 14.10.1982 | 15.10.1981, 22.1.1982, 21.4.1982, 19.7.1982 and 12.10.1982 |

At each weighing the cattle were removed from the plots to small yards adjacent to the trial area and weighed on portable electronic scales that were developed for the purpose by A.R. Till, C.S.I.R.O., Division of Animal Production, Armidale. The cattle were weighed in a non fasted condition. At the end of each grazing year a new group of heifers was introduced to the plots.

### 3.2.4 Pastures

Native Site. At the commencement of the experiment the pasture at this site was dominated (73.4%) by native grasses (see Results Section - Table 3.9), the major species present being *Heteropogon* spp. In addition, the pasture was estimated to contain 24.6% *Imperata cylindrica*. There was also a small (2%) native legume component which was primarily *Desmodium* species.

The area had been fenced as a Ranch paddock for eight years and had not received fertilizer or been sown with introduced species during that time.

Oversown Site. This area had been sown on a prepared seedbed and fertilized with 50 kg TSP $ha^{-1}$ in 1975. This pasture was destroyed by fire in 1976. The area was then oversown in 1977 to a pasture mix consisting of Cook and Schofield stylo and fertilized with 50 kg TSP $ha^{-1}$. There was no further treatment to maintain pasture productivity on this area until the experiment commenced in September 1979.

The area was used as a normal Ranch paddock up to the time of fencing the plot areas in 1979.

At the pasture estimation made in October 1979, the average botanical composition of the pasture was found to be 26% legume (Results Section - Table 3.10), which was made up of 10% native *Desmodium* spp. and 16% introduced legumes such as Stylo. A further 55% of the feed on offer was natural grass (*Heteropogon* spp.), and the remaining 19% *Imperata cylindrica*.

### 3.2.5 Physical Facilities

The plots were located on undulating topography which was dissected by deep creeks. This meant that the plots were of irregular shape (Appendix 1) and that about 20 km of fencing was required. The fences consisted of 4 barbed wires strained between a mixture of steel and living posts. A set of cattle handling yards were constructed adjacent to each plot site. These yards were used to undertake routine animal health measures and weighing.

An animal shelter, 2.4 x 4m in size was constructed in each plot. This afforded shelter for the animals and as it was located adjacent to the water trough served as a congregation area where daily observations could be made.

Water was provided to each plot through a reticulation system. The water was pumped from a dam that had been constructed adjacent to each site and held in concrete tanks with a capacity of 5 and 10 $m^3$, located at the highest point of the site. The water then gravitated to concrete water troughs constructed in each plot. The siting of the various plots meant that some 3.5 km of polythene pipe had to be installed.

3.2.6 Cattle

All cattle used in the experiments were Brahman cross that had been made available from the commercial herd belonging to the Indonesian Government owned livestock company (P.T. Bina Mulya Ternak). The animals were from 1.5 to 2 years of age when selected for the experiment and weighed between 140 and 150 kg liveweight.

The animals selected for the experiment were first ear tagged and weighed. The weights were then listed in descending order and divided into three equal size groups. One animal was then selected at random from each group and assigned to a plot. A new set of animals was selected at the start of each grazing year.

Cattle were drenched for internal parasites and sprayed for ticks at approximately monthly intervals throughout the experiment. The animals were weighed at the times shown in Table 3.3. Salt was supplemented daily at the rate of 30 grams $hd^{-1}$ throughout the period to prevent Na deficiency.

At the end of each grazing year the heifers were removed from the plots, weighed and mob mated with chin harnessed bulls. There was 1 bull for each 30 heifers. The number of marked heifers was recorded daily.

### 3.2.7 Pasture Estimation

The pasture quantity and composition were estimated at six monthly intervals by three observers using a MODIFIED DRY-WEIGHT RANK method ('t Mannetje and Haydock, 1963). Due to technical difficulties, pasture estimation and soil sampling were made annually. For each pasture type the observers selected five standard quadrats and these were photographed from above and the side using a Polaroid camera. The botanical composition of each quadrat was assessed and the pasture in the quadrat cut, separated into the various components (native and introduced legume, native and introduced grass, Imperata, weed) and weighed fresh. Lack of drying facilities prevented the determination of dry weights and thus fresh weight was used throughout. The three observers carried a set of prints and each made an independent assessment of the pasture score and composition. Each observer made an assessment of 10 quadrats per plot. At the same time as the pasture was being scored, plant and soil samples were collected from the quadrats for chemical analysis.

### 3.2.8 Soil and Plant Sampling and Analysis

Soil samples (0-7.5 cm) were collected at the commencement and again at the end of each grazing year. Three sets of 10 cores were collected from each plot. The samples were air dried, crushed and mixed thoroughly before analysis. The samples were transported to Australia for analysis. The methods used are as shown in the Consolidated Fertilizers Ltd. Soil Interpretation Manual.

| Extractant | Soil/ solution ratio | Property determined |
|---|---|---|
| Water | 1: 5 | $NO_3$-N |
| $NaHCO_3$ | 1:100 | Bicarb P |
| Ammonium acetate | 1:100 | Exchangeable K |
| Ammonium acetate | 1:100 | Exchangeable Ca |
| Ammonium acetate | 1:100 | Exchangeable Mg |
| Ammonium acetate | 1:100 | Exchangeable Na |
| DTPA + Triethanolamine + $CaCl_2$ | 1: 10 | DTPA Fe |
| DTAP + Triethanolamine + $CaCl_2$ | 1: 10 | Cu |
| DTPA + Triethanolamine + $CaCl_2$ | 1: 10 | Mn |
| DTPA + Triethanolamine + $CaCl_2$ | 1:10 | Zn |
| Water | 1: 5 | Cl |
| $Ca(H_2PO_4)_2$ | 1:200 | $SO_4$-S |
| Water | 1: 5 | pH |
| $K_2Cr_2O_7 + H_2SO_4$ | 1:100 | Organic carbon |
| Water | 1: 5 | Conductivity |

Reference: Consolidated Fertilizers Ltd. Soil Interpretation Manual.

Plant samples were collected annually by the pluck sample method. The herbage sampled was as similar as possible to that being selected by the animals. The plant samples were sundried before being ground to pass a 1 mm sieve prior to digestion. Samples digested in $HNO_3/HClO_4$ acid were analyzed for P, S, K, Ca, Mg, Na and those digested in $H_2SO_4/H_2O_2$ for N.

The mineral analyses of the soil and plant samples was carried out at the University of New England, Armidale, N.S.W. Australia, by standard chemical methods using the autoanalyser for N, P and S, the flame photometer for Na and K and by atomic absorption spectroscopy for Ca and Mg.

## 3.3 RESULTS

### 3.3.1 Soil

The chemical composition of soil samples showed that phosphorus (7.4 ppm at the native site and 7.5 ppm at the oversown site) and the nitrogen values of 0.4 ppm (native) and of 0.6 ppm (oversown) were lower than the suggested CFL adequacy levels at the commencement of the experiment (Table 3.4).

Table 3.4 Chemical properties of samples collected from the 0.75 cm soil layer at each site.

| Soil Parameter | September 1979 | | September 1982 | | CFL Adequacy Level* |
|---|---|---|---|---|---|
| | Native | Oversown | Native | Oversown | |
| Nitrate N (ppm) | 0.4 | 0.6 | 17.1 | 22.0 | 5 low |
| Bicarb P (ppm) | 7.4 | 7.5 | 24.4 | 26.3 | 15-20 |
| Exchangeable K (ppm) | 323 | 196 | 147 | 94 | 80 |
| Exchangeable Ca (ppm) | 1995 | 2114 | 1164 | 916 | 500 |
| Exchangeable Mg (ppm) | 1124 | 1202 | 1040 | 950 | 50 |
| DTPA Fe (ppm) | 92 | 70 | 104 | 91 | 2.0 |
| Cu (ppm) | 1.8 | 2.0 | 2.8 | 2.3 | 0.3 |
| Mn (ppm) | 53 | 47 | 86 | 71 | 1-50 |
| Zn (ppm) | 1.7 | 1.4 | 10.3 | 2.0 | 0.3 |
| Na (ppm) | 39.5 | 35.6 | 18.9 | 15.6 | - |
| Cl (ppm) | 15.6 | 13.1 | 8.1 | 15.9 | - |
| $SO_4$-S (ppm) | 6.4 | 6.4 | 6.8 | 6.7 | 5 low |
| pH | 5.1 | 5.4 | 5.0 | 5.2 | - |
| Organic Carbon (% C) | 3.5 | 2.2 | 3.3 | 2.8 | 2.0 low |
| Conductivity (mmho/cm) | 0.03 | 0.03 | 0.07 | 0.09 | - |

* Level below which a fertilizer response is likely based on soil interpretation charts. Consolidated Fertilizers Ltd., Brisbane.

Other soil parameters, such as organic carbon, potassium and the trace elements were adequate at both the native and oversown site (Table 3.4). Sulfur levels also appeared satisfactory at the commencement of the experiment.

The soil chemical analysis of the samples collected at the end of the third grazing year (September 1982) revealed that all soil nutrients at both experimental sites were adequate. The phosphorus value of the native site had increased from 7.4 up to 24.4 ppm and at the oversown site from 7.5 up to 26.3 ppm. The nitrogen values were greatly increased from 0.4 up to 17.1 ppm (native) and from 0.6 up to 22.0 ppm (oversown), while only slight increases in $SO_4$-S values were recorded at both sites (Table 3.4).

Compared to the initial sampling, the mean K, Ca, Mg, Na, Cl values at both sites had decreased but were still at an adequate level. The mean pH values of the native and oversown soils remained stable, while organic carbon at the native soils were similar (3.5 percent down to 3.3 percent). At this stage, levels of other nutrients had increased.

Phosphorus. Phosphorus values of 7.0 ppm (control) and 8.5 ppm (fertilizer treatment) were recorded at the native site at the initial soil sampling (September 1979) (Table 3.5). At the oversown site, the phosphorus values of the $S_1$, $S_2$ and $S_3$ treatments were 8.3, 8.0 and 5.5 ppm respectively, while no data was available for the $F_4$ treatment. By the end of the first grazing year (September 1980), levels of all treatments at both sites had increased (Table 3.5) although no fertilizer P had been applied. The values were higher at the oversown site.

Table 3.5 Phosphorus values (ppm) of soil samples collected from 0-7.5 cm layer at each site during the grazing year.

| Pasture Type | Sulfur Treatment | ppm P Sampling Dates Sept. 79 | Sept. 80 | Sept. 81 | Sept. 82 |
|---|---|---|---|---|---|
| Native | $S_o$ | 7.0 | 11.0 | 15.8 | 27.8 |
| | $S_1$ | 8.5 | 11.3 | 19.3 | 21.0 |
| Oversown | $S_o$ | 8.3 | 16.9 | 11.3 | 34.8 |
| | $S_1$ | 8.0 | 16.3 | 12.0 | 33.5 |
| | $S_2$ | 5.5 | 17.1 | 16.5 | 17.8 |
| | $S_3$ | n.a. | 17.1 | 15.0 | 19.0 |

There was an increase in the phosphorus values at the native site by the end of the second grazing year (September 1981) compared to September 1980. However, the phosphorus levels of the oversown site were similar to the September 1980 value. By the end of the third grazing year (September 1982), values were similar at both experimental sites and compared to September 1981, were much higher. This was largely due to the phosphorus applied at the beginning of the third grazing year (October 1981).

Potassium. Potassium levels were generally higher in the native soils during the whole of the experiment. There was an increase in both soils by the end of the first grazing year (Table 3.6) and further increases were recorded during the second year. By this stage, values were similar between the $S_2$ (301 ppm) and $S_3$ (297 ppm) treatments of the oversown site while the value of the $S_1$ (333 ppm) was similar to the $S_4$ (347 ppm). At the native site, the $S_1$ treatment (441 ppm) was similar to the $S_o$ (438 ppm) treatment and both were higher than that of oversown soils.

The potassium values of both soils decreased markedly over the period September 1981 to September 1982 (the third grazing year) but levels were generally still adequate.

Table 3.6 Potassium values (ppm) of soil samples collected from 0-7.5 cm soil layer at each site during the grazing year.

| Pasture Type | Sulfur Treatment | ppm K Sampling Dates Sept. 79 | Sept. 80 | Sept. 81 | Sept. 82 |
|---|---|---|---|---|---|
| Native | $S_0$ | 337 | 365 | 441 | 203 |
| | $S_1$ | 284 | 410 | 438 | 90 |
| Oversown | $S_0$ | 219 | 240 | 333 | 97 |
| | $S_1$ | 150 | 256 | 301 | 116 |
| | $S_2$ | 199 | 300 | 297 | 74 |
| | $S_3$ | n.a. | 308 | 347 | 89 |

<u>Sulfur</u>. The chemical analysis of soil samples from the native and oversown sites revealed that the $SO_4$-S values ranged from 5.0 to 7.0 ppm at the commencement of the experiment (Table 3.7).

By the end of the first grazing year, the mean $SO_4$-S values of all treatments had decreased slightly with little difference between the native and oversown sites. There was an increase in the soil sulfur levels of the native site by the end of the second grazing year. At this stage, the soil sulfur level of the $S_1$ treatment (6.4 ppm) appeared adequate, while the sulfur levels in the oversown soils were generally lower than 5.0 ppm. The $S_1$ treatment of native soil resulted in 8.5 ppm $SO_4$-S by the end of the third grazing year while the $S_0$ treatment still contained 5.0 ppm. By this stage, the soil sulfur levels of the oversown site were above 5.0 ppm. Although the soil chemical analyses showed that sulfur treatments tended to give higher values, differences were not significant at either site.

Table 3.7 Sulfur values (ppm) of soil samples collected from 0-7.5 cm soil layer at each site during the grazing year.

| Pasture Type | Sulfur Treatment | $SO_4$-S (ppm) Sampling Dates Sept. 79 | Sept. 80 | Sept. 81 | Sept. 82 |
|---|---|---|---|---|---|
| Native | $S_o$ | 6.0 | 3.7 | 5.0 | 5.0 |
| | $S_1$ | 7.0 | 4.6 | 6.4 | 8.5 |
| Oversown | $S_o$ | 7.0 | 4.3 | 2.4 | 5.3 |
| | $S_1$ | 7.0 | 4.9 | 4.1 | 6.3 |
| | $S_2$ | 5.0 | 4.9 | 3.5 | 6.0 |
| | $S_3$ | n.a. | 3.9 | 2.7 | 9.3 |

pH. The analysis showed that the soil pH of the experimental sites initially ranged from 5.1 to 5.5 and only slight changes occurred during the experimental period (Table 3.8).

Table 3.8 Soil pH values (ppm) of soil samples collected from 0-7.5 cm soil layer at each site during the grazing year.

| Pasture Type | Sulfur Treatment | pH values Sampling Dates Sept. 79 | Sept. 80 | Sept. 81 | Sept. 82 |
|---|---|---|---|---|---|
| Native | $S_o$ | 5.1 | 5.1 | 5.3 | 5.2 |
| | $S_1$ | 5.2 | 5.2 | 5.2 | 4.8 |
| Oversown | $S_o$ | 5.4 | 5.3 | 5.6 | 5.3 |
| | $S_1$ | 5.5 | 5.2 | 5.5 | 5.3 |
| | $S_2$ | 5.5 | 5.3 | 5.7 | 5.1 |
| | $S_3$ | n.a. | 5.1 | 5.7 | 5.2 |

### 3.3.2 Pastures

Yield and botanical composition.

Native Site. The total feed on offer at the native site was 14.88 tonnes fresh weight (tf.wt.) ha$^{-1}$ at the commencement of the experiment. The pasture was dominated by native grasses (*Heteropogon* spp. 73.4%) with 24.6% of the available feed as *Imperata* and only 2% as native legumes (*Desmodium* spp.) (Table 3.9). By the end of the first grazing year (September 1980) the quantity of native grasses on offer had been reduced to almost half the original amount at both stocking rates. This reduction led to an increase in the proportion of *Imperata* and weeds in the pasture. In the first year there was no effect of fertilizer on the quantity of feed on offer or botanical composition. The reduction in the quantity of grass on offer led to an opening up of the pasture and weeds were evident at the end of the first year.

Table 3.9 Feed on offer (tonnes fresh weight ha$^{-1}$) and the botanical composition (%) of the pastures at the native site as measured throughout the grazing years.

| | Sampling Dates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Stocking Rate | Oct. 79 | Sept. 80 | | Aug. 81 | | March 82 | | Oct. 82 | |
| (beasts ha$^{-1}$) | 0.5 & 1.0 | 0.5 | 1.0 | 0.5 | 1.0 | 0.5 | 1.0 | 0.5 | 1.0 |
| **Yield (tonnes fresh weight ha$^{-1}$)** | | | | | | | | | |
| **Pasture Components** | | | | | | | | | |
| Legume | 0.30 | 0.03 | 0.30 | 0.10 | 0.37 | 0.41 | 0.69 | 0.13 | 0.09 |
| Grass | 10.92 | 5.04 | 4.68 | 8.92 | 5.65 | 6.10 | 3.98 | 4.36 | 3.09 |
| Imperata | 3.66 | 5.04 | 4.37 | 4.96 | 5.20 | 7.76 | 11.35 | 3.69 | 2.58 |
| Other species | 0 | 0.97 | 0.73 | 2.07 | 2.14 | 1.79 | 2.07 | 12.70 | 8.10 |
| TOTAL | 14.88 | 11.08 | 10.08 | 16.05 | 13.36 | 16.06 | 18.09 | 12.70 | 8.10 |
| **Botanical Composition (%)** | | | | | | | | | |
| Legume | 2.0 | 0.2 | 3.0 | 0.6 | 2.8 | 2.5 | 3.9 | 1.0 | 1.1 |
| Grass | 73.4 | 45.5 | 46.4 | 55.6 | 42.3 | 37.9 | 22.1 | 34.3 | 38.2 |
| Imperata | 24.6 | 45.5 | 43.4 | 30.9 | 38.9 | 48.4 | 62.4 | 29.1 | 31.8 |
| Other species | 0 | 8.9 | 7.2 | 12.9 | 16.0 | 11.2 | 11.6 | 35.6 | 28.9 |

The stocking rates of 0.5 and 1.0 beast $ha^{-1}$ were maintained in the second year and feed on offer accumulated in both treatments, although there was a greater accumulation at the lower stocking rate. There was a continual increase in the weed component at both stocking rates so that by August 1981, 13-16% of the feed on offer was weed.

Sampling carried out in March 1982 showed a large rise in the amount of feed on offer at the higher stocking rate. This was mainly due to an increase in the amount of Imperata present. Feed on offer remained stable at the low stocking rate although the composition of the pasture changed with native grasses decreasing and Imperata increasing.

By the end of the third grazing year (October 1982), there was a reduction in the quantity of feed on offer and this was particularly marked in the native grass component. The total feed on offer at the lower stocking rate was greater ($P < 0.05$) than that of the higher stocking rate.

Oversown Site. At the oversown site, 26% of the 12.86 tonnes f.wt. $ha^{-1}$ total feed on offer at the start of the experiment was present as improved legumes (Stylosanthes guianensis cv. Schofield). The pasture was dominated by native grasses (Heteropogon spp. and Themeda spp.) with 19% of the available feed as Imperata (Table 3.10). The reduction in the quantity of native grasses to almost half the initial amount by the end of the first grazing year (September 1980) resulted in a decrease of the total feed on offer, whilst Imperata remained stable. An analysis of variance showed that there was little effect of stocking rate on the quantity of feed on offer or its botanical composition (Table 3.10). The legumes also decreased markedly in quantity suggesting that the experimental cattle selected the higher quality feed available from this oversown pasture. The reduction in the quantity of grass and legumes on offer again led to an opening up of the pasture, and the weed component increased by the end of the first grazing year.

Table 3.10 Feed on offer (tonnes fresh weight $ha^{-1}$) and the botanical composition (%) of the oversown pasture.

| | Sampling Dates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Stocking Rate | Oct. 79 | Sept. 80 | | Aug. 81 | | March 82 | | Oct. 82 | |
| (beasts $ha^{-1}$) | 1.0 & 2.0 | 1.0 | 2.0 | 1.0 | 2.0 | 1.0 | 2.0 | 1.0 | 2.0 |
| Yield (tonnes fresh weight $ha^{-1}$) | | | | | | | | | |
| Pasture Components | | | | | | | | | |
| Legume | 3.35 | 0.40 | 0.24 | 0.66 | 0.84 | 1.18 | 0.87 | 0.20 | 0.10 |
| Grass | 7.07 | 3.90 | 3.27 | 10.15 | 7.84 | 6.26 | 4.48 | 3.70 | 3.40 |
| Imperata | 2.44 | 2.48 | 1.22 | 6.83 | 5.33 | 10.34 | 7.43 | 2.80 | 2.60 |
| Other species | 0 | 0.74 | 0.47 | 2.84 | 1.60 | 2.57 | 1.64 | 3.70 | 2.20 |
| TOTAL | 12.86 | 7.52 | 5.20 | 20.48 | 15.61 | 20.35 | 14.42 | 10.40 | 8.30 |
| Botanical Composition (%) | | | | | | | | | |
| Legume | 26.0 | 5.3 | 4.6 | 3.2 | 5.4 | 5.4 | 6.3 | 1.9 | 1.2 |
| Grass | 55.0 | 51.8 | 63.0 | 49.6 | 50.2 | 31.0 | 31.3 | 35.6 | 41.0 |
| Imperata | 19.0 | 33.0 | 23.4 | 33.4 | 34.1 | 12.8 | 11.1 | 26.9 | 31.3 |
| Other species | 0 | 9.9 | 9.0 | 13.9 | 10.3 | 12.8 | 11.1 | 35.6 | 26.5 |

As at the native site, feed on offer accumulated at both stocking rates in the second grazing year (August 1981), there being a greater accumulation at the lower stocking rate. This increase in the bulk of feed on offer was largely in the native grasses, weeds and Imperata components, with legumes remaining constant.

Between August 1981 and March 1982 the amount of feed on offer remained stable at both stocking rates although changes in composition occurred. The legume and weed component showed little or no change but there was a marked rise in the Imperata component and a decrease in the amount of native grasses.

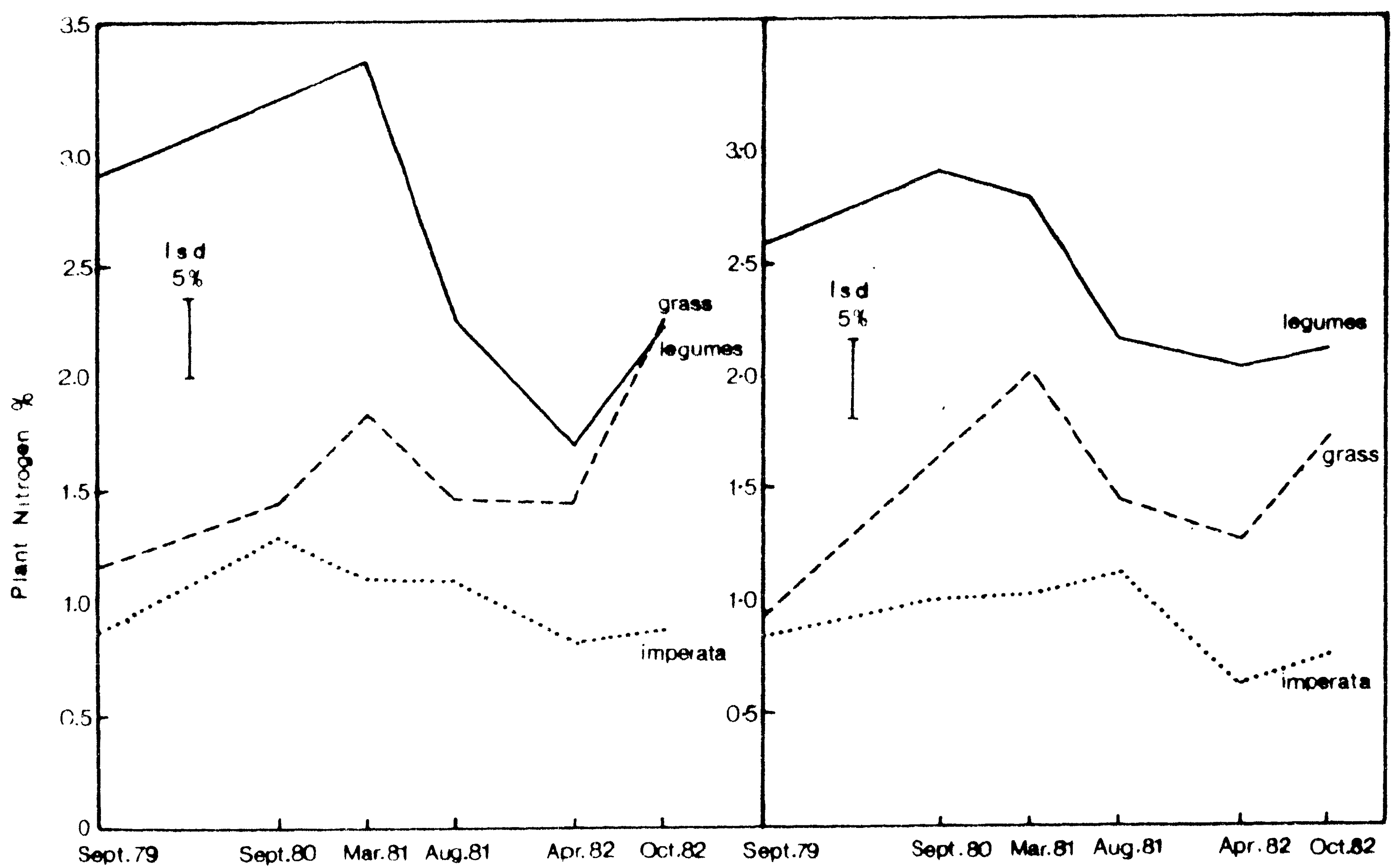
By the end of the third grazing year (October 1982), the reduction of native grasses, Imperata and legumes resulted in a reduction in the bulk of feed on offer while the weed component increased by 75% from that present in August 1981. The total feed on offer at the lower stocking rate was greater ($P < 0.05$) than that at the higher stocking rate.

Chemical Composition

Nitrogen. At the native site there was a significant interaction ($P < 0.001$) between time and pasture components (Table 3.11). The nitrogen content of the Imperata was not statistically or significantly different throughout the experimental period while that of the native grass generally increased with time. Marked differences in nitrogen concentration were observed between the two components in the 1982 grazing year. The legume at the native site usually contained higher nitrogen levels than either the grass or Imperata components although these values were not statistically analysed.

There was a significant time x pasture interaction at the oversown site (Table 3.11), as well as stocking rate x time x pasture component (Fig. 3.2 (a) (b)). In the former, nitrogen concentration of the legumes tended to decrease as the experiment progressed while that of the grasses was extremely variable. The nitrogen content of

Figure 3.2 (a)(b) Changes in plant nitrogen (%) of oversown pasture at (a) 2.0 AU $ha^{-1}$ and (b) 1.0 AU $ha^{-1}$ during the three experimental years.



3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Plant Nitrogen %
l s d
5%
grass
legumes
imperata
Sept.79
Sept.80
Mar.81
Aug.81
Apr.82
Oct.82
3·0
2·5
2·0
1·5
1·0
0·5
l s d
5%
legumes
grass
imperata
Sept.79
Sept.80
Mar.81
Aug.81
Apr.82
Oct.82

Imperata changed only slightly during the course of the experiment. There was little effect of stocking rate although at October 1982 the nitrogen content of the native grasses was higher at 2 than 1 A.U. $ha^{-1}$. At neither site was there an effect of sulfur application.

Table 3.11 Nitrogen concentration in pasture component (%) of plucked samples from the experimental sites during the grazing year. Comparisons are between sampling times and grass and Imperata components at the native site and between times and all pasture components at the oversown site. Duncan's Multiple Range Test P <0.05).

| Pasture | SAMPLING DATES | | | | | |
|---|---|---|---|---|---|---|
| Species | Sept. 79 | Sept. 80 | March 81 | Aug. 81 | April 82 | Oct. 82 |
| Native: | | | | | | |
| Legumes | n.a. | n.a. | n.a. | 2.031 | 1.832 | 2.027 |
| Grasses | 0.777a | 1.398d | 1.514e | 1.212cd | 1.435d | 1.739f |
| Imperata | 0.832ab | 1.152bcd | 0.976abc | 1.018abc | 0.906abc | 0.799a |
| Oversown: | | | | | | |
| Legumes | 2.945h | 3.081h | 3.106h | 2.202g | 1.859f | 2.169g |
| Grasses | 1.034bc | 1.513e | 1.927fg | 1.452e | 1.346de | 1.992fg |
| Imperata | 0.864abc | 1.136cd | 1.058bcd | 1.108bcd | 0.717a | 0.819ab |

Phosphorus. Table 3.12 shows the percentage phosphorus concentration in the pasture components during the three experimental years. Sulfur application had no effect on the phosphorus concentration of either pasture, but significant differences in the P concentration between pasture components occurred at both sites (Table 3.12). The grass at the native site contained higher ($P < 0.01$) P levels than the Imperata component. Similarly, the legume was generally higher than Imperata although these values were not statistically analysed.

There was a significant time x stocking rate x pasture component interaction at the oversown site. The P concentration of the legume and grass components tended to increase as the experiment progressed while that of the Imperata changed only slightly during the whole of the experiment (Table 3.12). The great increase in P levels in pasture components at both sites occurred in the third grazing year (1981/82) and was mostly due to the result of fertilizer P application at the beginning of this grazing year (October 1981).

Table 3.12 Phosphorus concentration in pasture component (%) of plucked samples from the experimental areas during the grazing years. (Comparisons are between sampling times and grass and Imperata components at the native site and between times and all pasture components at the oversown site. Duncan's Multiple Range Test $P < 0.05$).

| Pasture | SAMPLING DATES | | | | | |
|---|---|---|---|---|---|---|
| Species | Sept. 79 | Sept. 80 | March 81 | Aug. 81 | April 82 | Oct. 82 |
| Native: | | | | | | |
| Legumes | n.a. | n.a. | n.a. | 0.121 | 0.202 | 0.219 |
| Grasses | 0.097abc | 0.094abc | 0.136c | 0.110abc | 0.267e | 0.273e |
| Imperata | 0.099abc | 0.086ab | 0.082ab | 0.065a | 0.220d | 0.124bc |
| Oversown: | | | | | | |
| Legumes | 0.116bcd | 0.113abcd | 0.227e | 0.144d | 0.224e | 0.211e |
| Grasses | 0.092ab | 0.117bcd | 0.200e | 0.133cd | 0.307f | 0.228e |
| Imperata | 0.088ab | 0.101abc | 0.074a | 0.104abc | 0.145d | 0.115bcd |

Potassium. The potassium values of the grass and Imperata components were higher in the native pasture (0.885 and 0.753%) compared to the oversown pasture (0.704 and 0.539%) at the commencement of the first grazing year (Table 3.13). The highest value was recorded in the legume component of the oversown pasture.

Table 3.13 Potassium concentration in pasture component (%) of plucked samples from the experimental areas during the grazing years. (Comparisons are between sampling times and grass and Imperata components at the native site and between times and all pasture components at the oversown site. Duncan's Multiple Range Test $P < 0.05$).

| Pasture Species | Sept. 79 | Sept. 80 | March 81 | Aug. 81 | April 82 | Oct. 82 |
|---|---|---|---|---|---|---|
| Native: | | | | | | |
| Legumes | n.a. | n.a. | n.a. | 1.246 | 1.218 | 1.068 |
| Grasses | 0.885ab | 1.446c | 1.376c | 1.479c | 1.499c | 2.192d |
| Imperata | 0.753ab | 0.914ab | 0.614a | 0.813ab | 1.348c | 1.049b |
| Oversown: | | | | | | |
| Legumes | 1.435de | 1.764f | 2.263g | 1.704ef | 1.380d | 1.584def |
| Grasses | 0.701ab | 1.553def | 1.603def | 1.672ef | 1.596def | 1.748f |
| Imperata | 0.539a | 0.818bc | 0.751abc | 0.910bc | 0.967bc | 1.001c |

Sulfur application had no effect on the K concentration of any of the pasture components of both pastures, but a significant difference in the potassium concentration between the pasture components occurred at both sites.

There was a significant time x pasture component interaction at the native site. Marked differences in potassium concentration were observed between the grass and Imperata components in the 1980/81 grazing year. The native legume at this site generally contained lower K levels than the grass component but was still higher than the potassium concentration of Imperata although these values were not statistically analysed.

The legume at the oversown site usually contained higher ($P < 0.01$) K levels than that of the Imperata and appeared similar to the grass component. There was a significant time x stocking rate x pasture components interaction. The K levels of the grass and Imperata tended to increase as the experiment progressed while that of the legumes remained stable. There was only a small effect of stocking rate. In April 1982 the K content of the grass and Imperata was greater at the higher stocking rate.

Sulfur. The sulfur concentrations of the pasture components were a little higher at the oversown pasture at the commencement of the experiment (Table 3.14). From the end of the first grazing year (September 1980) until the middle of the second year (March 1981), the data show that components from oversown pasture contained a higher percentage of sulfur than those from native pasture.

Table 3.14 Sulfur concentration in pasture component (%) of plucked samples from the experimental areas during the grazing years. (Comparisons are between sampling times and grass and Imperata components at the native site and between times and all pasture components at the oversown site. Duncan's Multiple Range Test $P < 0.05$).

| Pasture | SAMPLING DATES | | | | | |
|---|---|---|---|---|---|---|
| Species | Sept. 79 | Sept. 80 | March 81 | Aug. 81 | April 82 | Oct. 82 |
| Native: | | | | | | |
| Legumes | n.a. | n.a. | n.a. | 0.219 | 0.129 | 0.161 |
| Grasses | 0.060a | 0.093ab | 0.139bc | 0.213e | 0.151cd | 0.253e |
| Imperata | 0.064a | 0.083ab | 0.083ab | 0.201de | 0.104abc | 0.074a |
| Oversown: | | | | | | |
| Legumes | 0.106b | 0.136de | 0.304h | 0.131cde | 0.131cde | 0.186f |
| Grasses | 0.080a | 0.119bcd | 0.195f | 0.149e | 0.174f | 0.234g |
| Imperata | 0.075a | 0.108bc | 0.132cde | 0.073a | 0.068a | 0.077a |

There was a reduction in the sulfur concentration of all pasture components at the oversown site when plucked samples were taken in August 1981, while the sulfur concentration of the grass and Imperata components at the native pasture increased by 53 and 142%

compared to the March 1981 values. At this stage, the average S concentration of pasture components from the native site was higher than that from the oversown site.

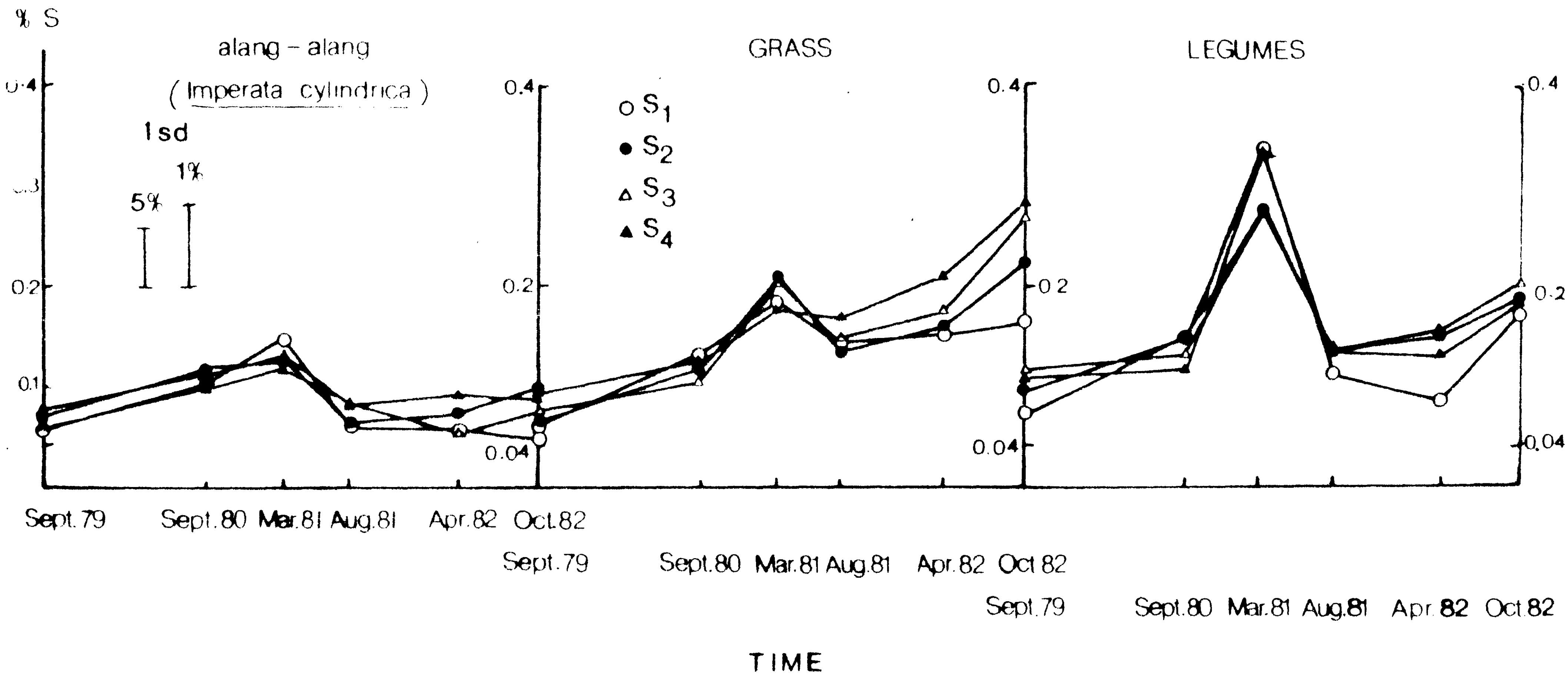
The S concentration of all pasture components of the oversown pasture had increased by 30% (range from 15 to 43%) by the end of the third grazing year compared to the April 1982 figures. The legume and grass components of the native pasture also showed an increase in their sulfur contents while Imperata increased by 30%. The average sulfur concentration of the oversown pasture was higher than that of the native pasture.

There was an effect of sulfur fertilizer on sulfur concentration of pasture components of the oversown pasture. A significant interaction between S content of the various pasture components with time and fertilizer treatments occurred. A trend of increasing S content of the grass and legume components was observed while the S content of Imperata remained stable throughout the experiment. The sulfur content of the grass component of the $S_3$ treatment was similar to the $S_2$ treatment and was higher ($P< 0.05$) than the $S_1$ treatment. All of the fertilizer treatments ($S_1$, $S_2$ and $S_3$) resulted in higher ($P< 0.01$) grass sulfur contents than the control ($S_0$) by the end of the third grazing year (Fig. 3.3).

The legume sulfur contents of oversown pasture for the fertilizer treatments were higher ($P < 0.05$) than the control ($S_0$) by the middle of the third grazing year (April 1982), with no differences occurring between fertilizer treatments.

Sodium. The sodium concentration of all pasture components of the oversown pasture was similar to native pasture at the commencement

Figure 3.3. Changes in plant sulfur (%) of oversown pasture in relation to applied sulfur during three experimental years.



% S
alang - alang
( Imperata cylindrica )
GRASS
LEGUMES
1sd
5%
1%
0.4
0.3
0.2
0.1
0.04
$S_1$
$S_2$
$S_3$
$S_4$
Sept.79 Sept.80 Mar.81 Aug.81 Apr.82 Oct.82
TIME

of the experiment Table 3.15). At this stage, the sodium contents of all pasture components were similar.

By the end of the first grazing year (September 1980) there was an increase of 21% (oversown) and of 31% (native) in the sodium concentration of all pasture components compared to the original amount. The sodium contents of all pasture components appeared stable and similar until August 1981.

There was a marked decrease in Na concentration of all pasture components at both sites during the period of August 1981 to October 1982(the third grazing year). In the middle of the third year (April 1982) the Na concentrations of all pasture components at both sites were similar. The Imperata component gave the lowest value at the end of the third grazing year, while the legume and grass components contained a similar concentration of sodium.

Table 3.15 Sodium concentration in pasture component (%) of plucked samples from the experimental areas during the grazing years. (Comparisons are between sampling times and grass and Imperata components at the native site and between times and all pasture components at the oversown site. Duncan's Multiple Range Test P< 0.05).

| Pasture | SAMPLING DATES | | | | | |
|---|---|---|---|---|---|---|
| Species | Sept. 79 | Sept. 80 | March 81 | Aug. 81 | April 82 | Oct. 82 |
| Native: | | | | | | |
| Legumes | n.a. | n.a. | n.a. | 0.079 | 0.037 | 0.011 |
| Grasses | 0.072cd | 0.102f | 0.079d | 0.068c | 0.032b | 0.013a |
| Imperata | 0.078cd | 0.092eb | 0.082d | 0.080d | 0.031b | 0.005a |
| Oversown: | | | | | | |
| Legumes | 0.079 | 0.099 | 0.087 | 0.081 | 0.038 | 0.010 |
| Grasses | 0.075 | 0.097 | 0.080 | 0.079 | 0.040 | 0.012 |
| Imperata | 0.081 | 0.090 | 0.081 | 0.079 | 0.036 | 0.005 |

Calcium. There was a marked increase in the Ca concentration of all pasture components at the oversown pasture during the first grazing year (September 1979 to September 1980). In this period, the calcium concentration of the grass component of the native pasture increased by 36% while the *Imperata* calcium decreased by 20%.

By the middle of the second grazing year (March 1981), the calcium concentration of all pasture components at both sites had increased. At this stage, the Ca content ranged from 0.190 to 0.258% at the native pasture and from 0.271 to 1.573% at the oversown pasture (Table 3.16).

Whilst the Ca content in pasture components at the oversown site decreased during the period of March 1981 to August 1981, the native pasture showed little change.

Table 3.16 Calcium concentration in pasture component (%) of plucked samples from the experimental areas during the grazing years. (Comparisons are between sampling times and grass and *Imperata* components at the native site and between times and all pasture components at the oversown site. Duncan's Multiple Range Test $P < 0.05$).

| Pasture | SAMPLING DATES | | | | | |
|---|---|---|---|---|---|---|
| Species | Sept. 79 | Sept. 80 | March 81 | Aug. 81 | April 82 | Oct. 82 |
| Native: | | | | | | |
| Legumes | n.a. | n.a. | n.a. | 1.163 | 1.039 | 1.427 |
| Grasses | 0.139bc | 0.188cd | 0.258de | 0.253d | 0.324e | 0.256d |
| Imperata | 0.147bc | 0.108ab | 0.190cd | 0.209cd | 0.157bc | 0.067a |
| Oversown: | | | | | | |
| Legumes | 0.679dcd | 1.503f | 1.573f | 1.173e | 1.132e | 1.125e |
| Grasses | 0.081a | 0.250abc | 0.317c | 0.234abc | 0.341c | 0.615d |
| Imperata | 0.092ab | 0.176abc | 0.271bc | 0.189abc | 0.178abc | 0.164abc |

The grass calcium content of the oversown pasture increased ($P < 0.01$) by the end of the third grazing year (Octoer 1982) compared to the April 1982 values. The legume and Imperata calcium levels appeared stable.

At the oversown pasture, the legume calcium was consistently higher ($P < 0.01$) than the grass and Imperata throughout the experiment, while the grass calcium was found to be higher ($P < 0.01$) than Imperata by the end of the third grazing year. A trend of increasing Ca content of the grass component was observed at the native pasture, while the Ca content of the Imperata tended to decline. A significant difference ($P < 0.01$) in Ca content between grass and Imperata components occurred in April 1982 and October 1982.

Magnesium

Table 3.17 Magnesium concentration in pasture component (%) of plucked samples from the experimental areas during the grazing years. (Comparisons are between sampling times and grass and Imperata components at the native site and between times and all pasture components at the oversown site. Duncan's Multiple Range Test $P < 0.05$).

| Pasture | SAMPLING DATES | | | | | |
|---|---|---|---|---|---|---|
| Species | Sept. 79 | Sept. 80 | March 81 | Aug. 81 | April 82 | Oct. 82 |
| Native: | | | | | | |
| Legumes | n.a. | n.a. | n.a. | 0.305 | n.a. | 0.236 |
| Grasses | 0.206cde | 0.231de | 0.253e | 0.213cde | 0.123ab | 0.222de |
| Imperata | 0.136abc | 0.087a | 0.138ab | 0.205cd | 0.123ab | 0.170bc |
| Oversown: | | | | | | |
| Legumes | 0.441g | 0.325ef | 0.258d | 0.129abc | 0.246d | 0.258d |
| Grasses | 0.241d | 0.271d | 0.289def | 0.247d | 0.274d | 0.334f |
| Imperata | 0.109ab | 0.160c | 0.161c | 0.156bc | 0.129abc | 0.104a |

No trend was apparent in magnesium concentration at the native site (Table 3.17). There was a significant ($P < 0.001$) time x pasture component interaction with generally the levels of magnesium in grass being higher than those of <u>Imperata</u> except at the August 1981 and April 1982 harvests.

There was also a significant ($P < 0.001$) time x pasture component effect at the oversown site. Levels of magnesium in the grass component were stable for most of the experiment while those in legume decreased markedly during the first two years. <u>Imperata</u> possessed much lower levels of magnesium than either of the other components at most stages of the experiment.

### 3.3.3 Animal Performance

<u>Native Pasture 1979-80</u>. The patterns of liveweight change of all treatments appeared similar (Appendix 2.1) and there was no liveweight response to fertilizer or stocking rate.

Although the initial weight of the experimental animals differed between treatments, the analysis of variance with the initial weight as a covariate showed that there was no effect of the initial weight on the liveweight changes (Appendix 3.1). During this first grazing year, the final liveweight of the lower stocking rate treatment was significantly higher ($P < 0.01$) than the higher stocking rate treatments (Figure 3.4) but this was probably due to a higher initial weight in the treatment of 0.5 A.U. $ha^{-1}$ with $S_1$ (128.3 kg) compared to 1.0 A.U. $ha^{-1}$ with $S_1$ (107.0 kg).

During the first year of the experiment, slightly higher liveweight gains (lwg) were obtained from the lower stocking rates at the native pasture in both weighing periods (Table 3.18), although the differences were not statistically significant. There was no difference in lwg $head^{-1}$ $day^{-1}$ between treatments within weighing periods.

Figure 3.4. Actual liveweight changes of cattle grazing native pasture during the 1979/80 grazing year.

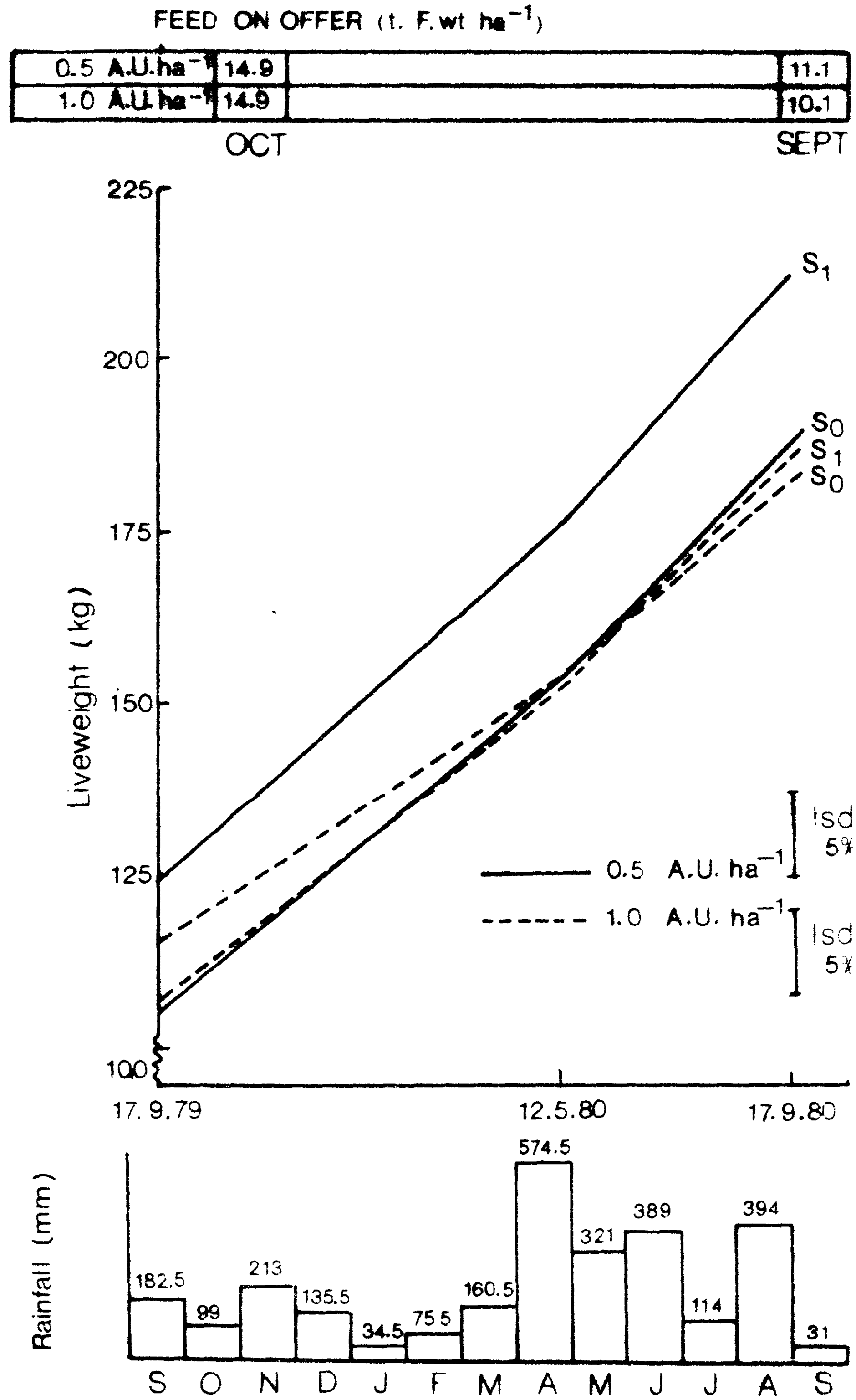

FEED ON OFFER (t. F.wt ha⁻¹)
0.5 A.U.ha⁻¹ 14.9 11.1
1.0 A.U.ha⁻¹ 14.9 10.1
OCT
SEPT
Liveweight (kg)
225
200
175
150
125
100
S1
S0
S1
S0
lsd 5%
0.5 A.U. ha⁻¹
1.0 A.U. ha⁻¹
lsd 5%
17.9.79
12.5.80
17.9.80
Rainfall (mm)
182.5
99
213
135.5
34.5
75.5
160.5
574.5
321
389
114
394
31
S O N D J F M A M J J A S

Table 3.18 Liveweight gain head$^{-1}$ day$^{-1}$ of cattle grazing native pasture during the 1979/80 experimental year.

| Treatment | | Lwg head$^{-1}$ day$^{-1}$ (kg) Weighing Period | |
|---|---|---|---|
| Stocking Rate A.U. ha$^{-1}$ | Sulfur Fertilizer | 17.9.79-12.5.80 (238 days) | 12.5.80-17.9.80 (128 days) |
| 0.5 | $S_o$ | 0.206 | 0.282 |
| | $S_1$ | 0.218 | 0.295 |
| 1.0 | $S_o$ | 0.165 | 0.283 |
| | $S_1$ | 0.196 | 0.254 |

In general, the daily liveweight gain in the second period was 40% (range from 30 to 55%) higher than the first period. Unfortunately, due to the technical difficulties in the field, no liveweight gain was recorded between these two weighings and thus no information is available from the initial grazing experiment regarding seasonal fluctuations in the liveweight changes.

The daily and annual liveweight gain presented in Table 3.19 show that fertilizer and stocking rate had no significant effect on lwg hd$^{-1}$ day$^{-1}$ or lwg hd$^{-1}$ yr$^{-1}$. Increasing the stocking rate from 0.5 to 1.0 increased lwg ha$^{-1}$ yr$^{-1}$ significantly.

Table 3.19 Liveweight gain parameters of cattle grazing native pasture during the 1979/80 experimental year. (Comparisons are between stocking rate and fertilizer treatments within each parameter DMRT $P < 0.05$).

| Treatment | | Liveweight gain (g) | | |
|---|---|---|---|---|
| Stocking Rate A.U. ha$^{-1}$ | Sulfur Fertilizer | lwg hd$^{-1}$day$^{-1}$ | lwg hd$^{-1}$yr$^{-1}$ | lwg ha$^{-1}$ yr$^{-1}$ |
| 0.5 | $S_o$ | 0.233$^a$ | 85.0$^a$ | 42.5$^a$ |
| | $S_1$ | 0.245$^a$ | 89.4$^a$ | 44.7$^a$ |
| 1.0 | $S_o$ | 0.206$^a$ | 75.2$^a$ | 75.2$^a$ |
| | $S_1$ | 0.216$^a$ | 78.8$^a$ | 78.8$^a$ |

* Calculation based on 365 days

<u>Oversown Pasture 1979/80</u>. The trends of liveweight changes at the oversown site were similar between treatments during the first year of the experiment (Figure 3.5 (a) (b) and Appendix 2.2).

Although most of the experimental cattle at the lower stocking rates reached a higher liveweight than at the higher stocking rates by the end of the first grazing year, there was no significant liveweight response recorded to the treatments.

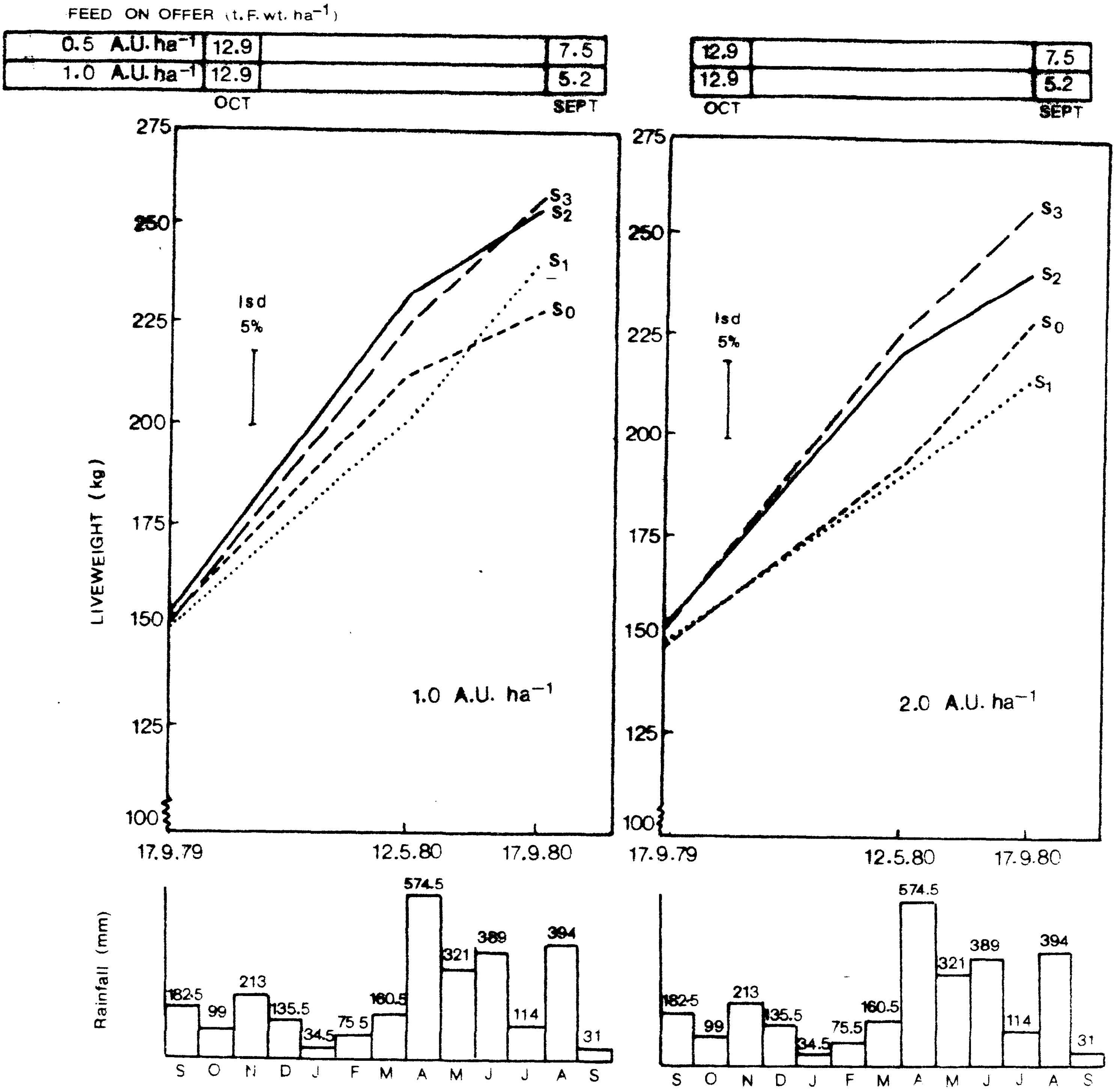
Table 3.20 presents the mean liveweight gain of cattle grazing oversown pasture within each weighing period during the first grazing year. There was a lower liveweight gain recorded in the second period than the first, although differences were not statistically significant. Similarly, there was no effect of fertiliser treatment.

Although the liveweight gain head$^{-1}$ day$^{-1}$ of the lower stocking rate was significantly higher ($P < 0.05$) than that of the higher stocking rate during the whole experimental period, there was no interaction between weighing period, stocking rate and fertilizer in the 1979/80 grazing year.

Table 3.20 Liveweight gain head$^{-1}$ day$^{-1}$ of cattle grazing oversown pasture during the 1979/80 experimental year.

| Treatment | | Lwg head$^{-1}$ day$^{-1}$ (kg) | |
|---|---|---|---|
| Stocking Rate | Sulfur | Weighing Period | |
| A.U. ha$^{-1}$ | Fertilizer | 17.9.79-12.5.80 | 12.5.80-17.9.80 |
| 1.0 | $S_o$ | 0.261 | 0.122 |
| | $S_1$ | 0.223 | 0.280 |
| | $S_2$ | 0.317 | 0.202 |
| | $S_3$ | 0.320 | 0.241 |
| 2.0 | $S_o$ | 0.200 | 0.273 |
| | $S_1$ | 0.183 | 0.189 |
| | $S_2$ | 0.290 | 0.117 |
| | $S_3$ | 0.144 | 0.208 |

Figure 3.5 (a) (b). Actual liveweight changes of cattle grazing oversown pastures at (a) 1.0 AU $ha^{-1}$ and (b) 2.0 AU $ha^{-1}$ during the 1979/80 grazing year.



FEED ON OFFER (t. F. wt. ha⁻¹)
0.5 A.U. ha⁻¹
1.0 A.U. ha⁻¹
12.9
12.9
7.5
5.2
OCT
SEPT
LIVEWEIGHT (kg)
lsd 5%
S3
S2
S1
S0
1.0 A.U. ha⁻¹
2.0 A.U. ha⁻¹
17.9.79
12.5.80
17.9.80
Rainfall (mm)
182.5
99
213
135.5
34.5
75.5
160.5
574.5
321
389
114
394
31
S O N D J F M A M J J A S

There was a slight but significant decrease ($P < 0.05$) in lwg $hd^{-1}$ $day^{-1}$ and lwg $hd^{-1}$ $year^{-1}$ when the stocking rate was increased from 1.0 to 2.0 A.U. $ha^{-1}$. The increase in stocking rate also resulted in a significant ($P < 0.01$) increase in lwg $ha^{-1}$ $yr^{-1}$ (Table 3.21).

Table 3.21 Liveweight gain parameters of cattle grazing oversown pasture during the 1979/80 grazing year. (Comparisons are between stocking rate and fertilizer treatments within each parameter DMRT $P < 0.05$).

| Treatment | | Liveweight gain (g) | | |
|---|---|---|---|---|
| Stocking Rate A.U. $ha^{-1}$ | Sulfur Fertilizer | lwg $hd^{-1}$ $day^{-1}$ (kg) | lwg $hd^{-1}yr^{-1}$ (kg) | lwg $ha^{-1}yr^{-1}$ (kg) |
| 1.0 | $S_o$ | $0.212^{ab}$ | $77.4^{abc}$ | $77.4^{a}$ |
| | $S_1$ | $0.242^{ab}$ | $88.3^{abc}$ | $88.3^{ab}$ |
| | $S_2$ | $0.193^{ab}$ | $70.4^{bc}$ | $70.4^{ab}$ |
| | $S_3$ | $0.292^{b}$ | $106.6^{c}$ | $106.6^{ab}$ |
| 2.0 | $S_o$ | $0.225^{ab}$ | $82.1^{abc}$ | $164.2^{d}$ |
| | $S_1$ | $0.184^{ab}$ | $67.2^{ab}$ | $134.4^{bd}$ |
| | $S_2$ | $0.229^{ab}$ | $83.6^{abc}$ | $167.2^{cd}$ |
| | $S_3$ | $0.166^{a}$ | $60.6^{a}$ | $121.2^{ab}$ |

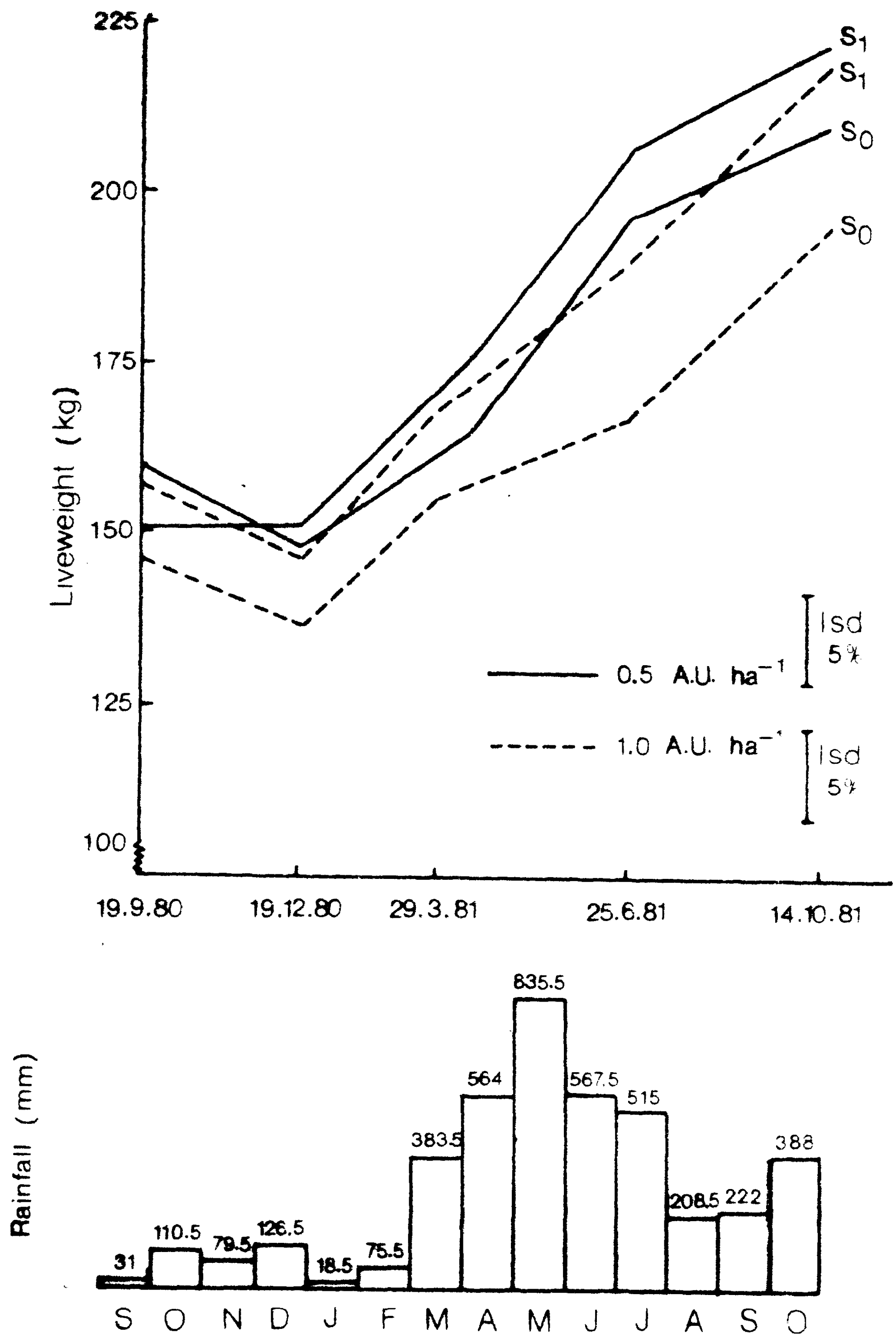
<u>Native Pasture 1980/81</u>. All of the experimental animals lost weight during the first weighing period of the second grazing year at the native site (Figure 3.6 and Appendix 2.3). However, the differences between treatments were not significant. This loss in liveweight was probably due to the dry period which occurred at the beginning of the second grazing year and resulted in lower feed availability.

The patterns of liveweight changes were similar between treatments (Figure 3.6). The differences ($P < 0.05$) in initial weight had no effect on liveweight changes (Appendix 3.2).

Figure 3.6. Actual liveweight changes of cattle grazing native pasture during the 1980/81 grazing year.

FEED ON OFFER (t. F. wt ha$^{-1}$)

| | SEPT | | AUG |
|---|---|---|---|
| 0.5 A.U.ha$^{-1}$ | 11.1 | | 16.1 |
| 1.0 A.U.ha$^{-1}$ | 10.1 | | 13.4 |



A significant interaction between time and stocking rate was observed during the 1980/81 grazing year. There was a higher ($P < 0.05$) lwg $hd^{-1}$ $day^{-1}$ obtained at the lower stocking rate in the third weighing period (Table 3.22). Fertilizer had no effect on animal performance at this site.

Table 3.22 Liveweight gain $head^{-1}$ $day^{-1}$ of cattle grazing native pasture during the 1980/81 grazing year.

| Treatment | | Lwg $head^{-1}$ $day^{-1}$ (kg) Weighing Period | | | |
|---|---|---|---|---|---|
| Stocking Rate A.U. $ha^{-1}$ | Sulfur Fertilizer | 19.9.80- 19.12.80 (92 days) | 19.12.80- 27.3.81 (98 days) | 27.3.81- 25.6.81 (90 days) | 25.6.81- 14.10.81 (111 days) |
| 0.5 | $S_o$ | -0.130 | 0.173 | 0.302 | 0.161 |
| | $S_1$ | -0.002 | 0.260 | 0.345 | 0.134 |
| 1.0 | $S_o$ | -0.109 | 0.192 | 0.131 | 0.248 |
| | $S_1$ | -0.119 | 0.232 | 0.247 | 0.259 |

Table 3.23 showed that $S_1$ caused 32.9 - 46.1 % higher lightweight gain than So, even though it was not significant statistically. There was a significant increase ($P < 0.05$) in lightweight gain ha $yr^{-1}$ when stocking rate was increased from 0.5 to 1.0 A.U. $ha^{-1}$.

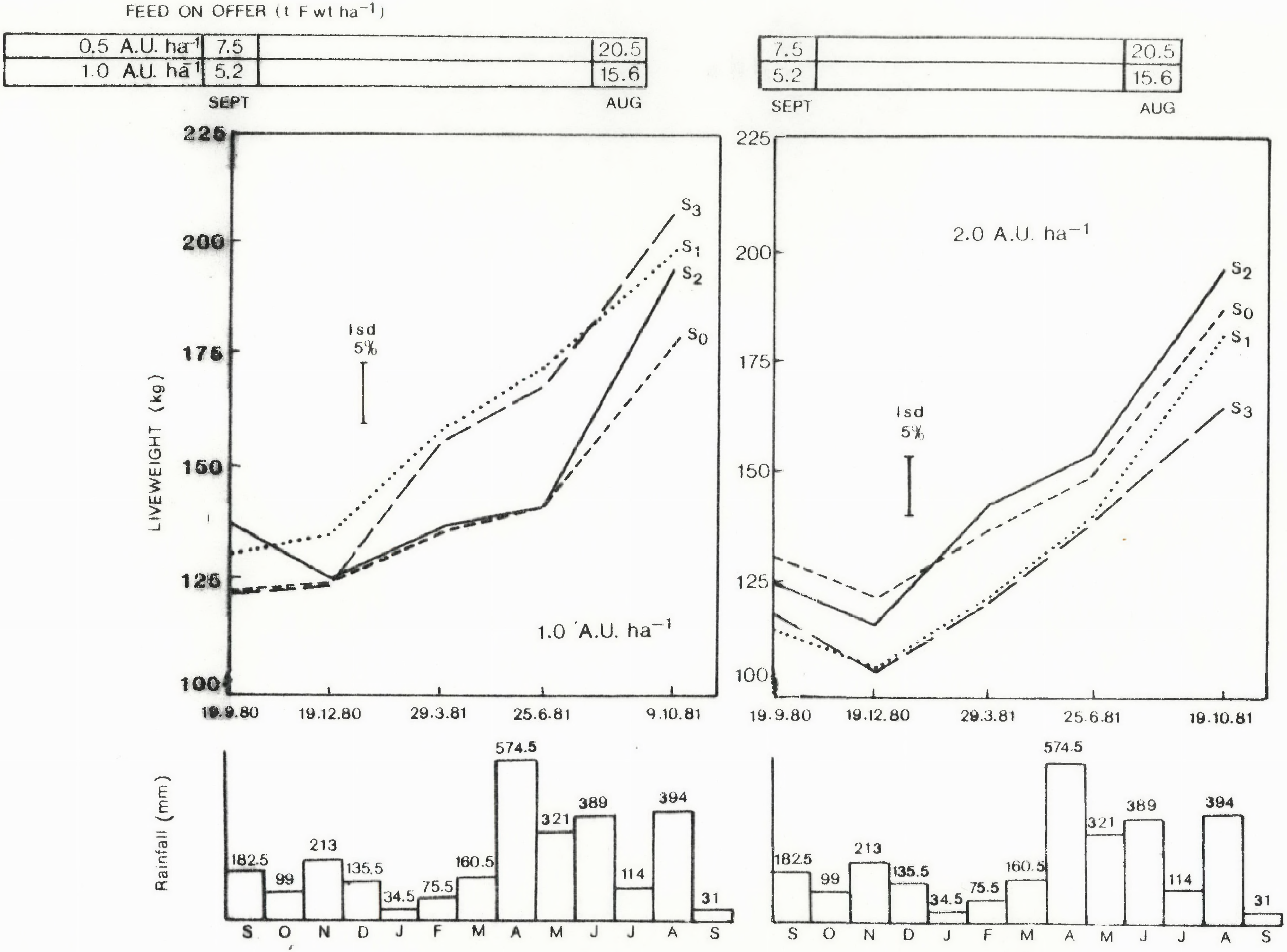
Table 3.23 Liveweight gain parameters of cattle grazing native pasture during the 1980/81 grazing year.

| Treatment | | Liveweight gain (kg) | | |
|---|---|---|---|---|
| Stocking Rate A.U. $ha^{-1}$ | Sulfur Fertilizer | lwg $hd^{-1}day^{-1}$ (kg) | lwg $hd^{-1}yr^{-1}$ (kg) | lwg $ha^{-1}yr^{-1}$ (kg) |
| 0.5 | $S_o$ | 0.128 | 46.7 | 23.4 |
| | $S_1$ | 0.182 | 66.4 | 33.2 |
| 1.0 | $S_o$ | 0.124 | 45.3 | 45.3 |
| | $S_1$ | 0.161 | 58.8 | 58.8 |

<u>Oversown Pasture 1980/81</u>. As at the native site, most of the experimental cattle grazed on the oversown pastures lost weight in the first period of weighing during the 1980/81 grazing year (Figure 3.7 (a) (b), Appendix 2.4). There was a significant interaction between liveweight of the various sulfur fertilizer and stocking rate treatments with time. A trend of decreasing liveweight of cattle during the first weighing period was observed at most treatments. The liveweight of the sulfur treatments ($S_1$, $S_2$ and $S_3$) were higher ($P < 0.05$) than that from the no sulfur treatment ($S_o$) at 1.0 A.U. $ha^{-1}$ stocking rate during the last three periods of weighing. At the higher stocking rate, there was no consistent pattern of differences in liveweight between treatments. Although there was a difference in the initial weight between treatments at the commencement of this second grazing year (Appendix 2.4), the analysis of variance with initial weight as a covariate showed no effect of initial weight in liveweight changes (Appendix 3.3).

There was no consistent sulfur fertilizer or stocking rate effect in lwg $hd^{-1}$ $day^{-1}$ in any of the four weighing periods (Table 3.24).

Figure 3.7 (a) (b). Actual liveweight changes of cattle grazing oversown pasture at (a) 1.0 AU $ha^{-1}$ and (b) 2.0 AU $ha^{-1}$ during the 1980/81 grazing year.



FEED ON OFFER (t F wt ha$^{-1}$)
0.5 A.U. ha$^{-1}$
1.0 A.U. ha$^{-1}$
7.5
5.2
20.5
15.6
SEPT
AUG
LIVEWEIGHT (kg)
225
200
175
150
125
100
lsd 5%
S3
S1
S2
S0
1.0 A.U. ha$^{-1}$
19.9.80
19.12.80
29.3.81
25.6.81
9.10.81
Rainfall (mm)
182.5
99
213
135.5
34.5
75.5
160.5
574.5
321
389
114
394
31
S O N D J F M A M J J A S
2.0 A.U. ha$^{-1}$
19.10.81

Table 3.24 Liveweight gain head$^{-1}$ day$^{-1}$ of cattle grazing oversown pasture within each of the weighing periods during 1980/81 grazing year.

| Treatment | | Lwg head$^{-1}$ day$^{-1}$ (kg) Weighing Period | | | |
|---|---|---|---|---|---|
| Stocking Rate A.U. ha$^{-1}$ | Sulfur Fertilizer | 19.9.80- 19.12.80 (92 days) | 19.12.80- 27.3.81 (98 days) | 27.3.81- 25.6.81 (90 days) | 25.6.81- 14.10.81 (111 days) |
| 1.0 | $S_o$ | 0.020 | 0.112 | 0.072 | 0.330 |
| | $S_1$ | 0.053 | 0.237 | 0.154 | 0.243 |
| | $S_2$ | 0.125 | 0.116 | 0.050 | 0.467 |
| | $S_3$ | 0.020 | 0.318 | 0.143 | 0.349 |
| 2.0 | $S_o$ | -0.098 | 0.155 | 0.145 | 0.336 |
| | $S_1$ | -0.082 | 0.151 | 0.196 | 0.368 |
| | $S_2$ | -0.096 | 0.274 | 0.119 | 0.375 |
| | $S_3$ | -0.130 | 0.151 | 0.193 | 0.237 |

The mean annual liveweight gain ranged from 0.113 to 0.207 kg hd$^{-1}$ day$^{-1}$ with significant difference between stocking rate or sulfur fertilizer treatments. Production on an area basis (kg ha$^{-1}$ year$^{-1}$) was significantly higher ($P < 0.05$) at the high stocking rate at $S_o$, $S_1$ and $S_2$ and also higher but not significantly at $S_3$ treatment (Table 3.25).

Table 3.25 Liveweight gain parameters of cattle grazing oversown pasture during the 1980/81 grazing year. (Comparisons are between stocking rate and fertilizer treatments within each parameter DMRT $P < 0.05$).

| Treatment | | Liveweight gain (kg) | | |
|---|---|---|---|---|
| Stocking Rate A.U. ha$^{-1}$ | Sulfur Fertilizer | lwg hd$^{-1}$day$^{-1}$ (kg) | lwg hd$^{-1}$yr$^{-1}$ (kg) | lwg ha$^{-1}$yr$^{-1}$ (kg) |
| 1.0 | $S_o$ | 0.144$^{ab}$ | 52.6$^{ab}$ | 52.6$^{a}$ |
| | $S_1$ | 0.176$^{ab}$ | 64.2$^{ab}$ | 64.2$^{a}$ |
| | $S_2$ | 0.145$^{a}$ | 52.9$^{ab}$ | 52.9 |
| | $S_3$ | 0.217$^{b}$ | 79.2$^{b}$ | 79.2 |
| 2.0 | $S_o$ | 0.145$^{ab}$ | 52.9$^{ab}$ | 105.8 |
| | $S_1$ | 0.169$^{ab}$ | 61.7$^{ab}$ | 123.4 |
| | $S_2$ | 0.181$^{ab}$ | 66.1$^{ab}$ | 132.2 |
| | $S_3$ | 0.118$^{a}$ | 43.1$^{a}$ | 86.2 |

* Calculation based on 365 days

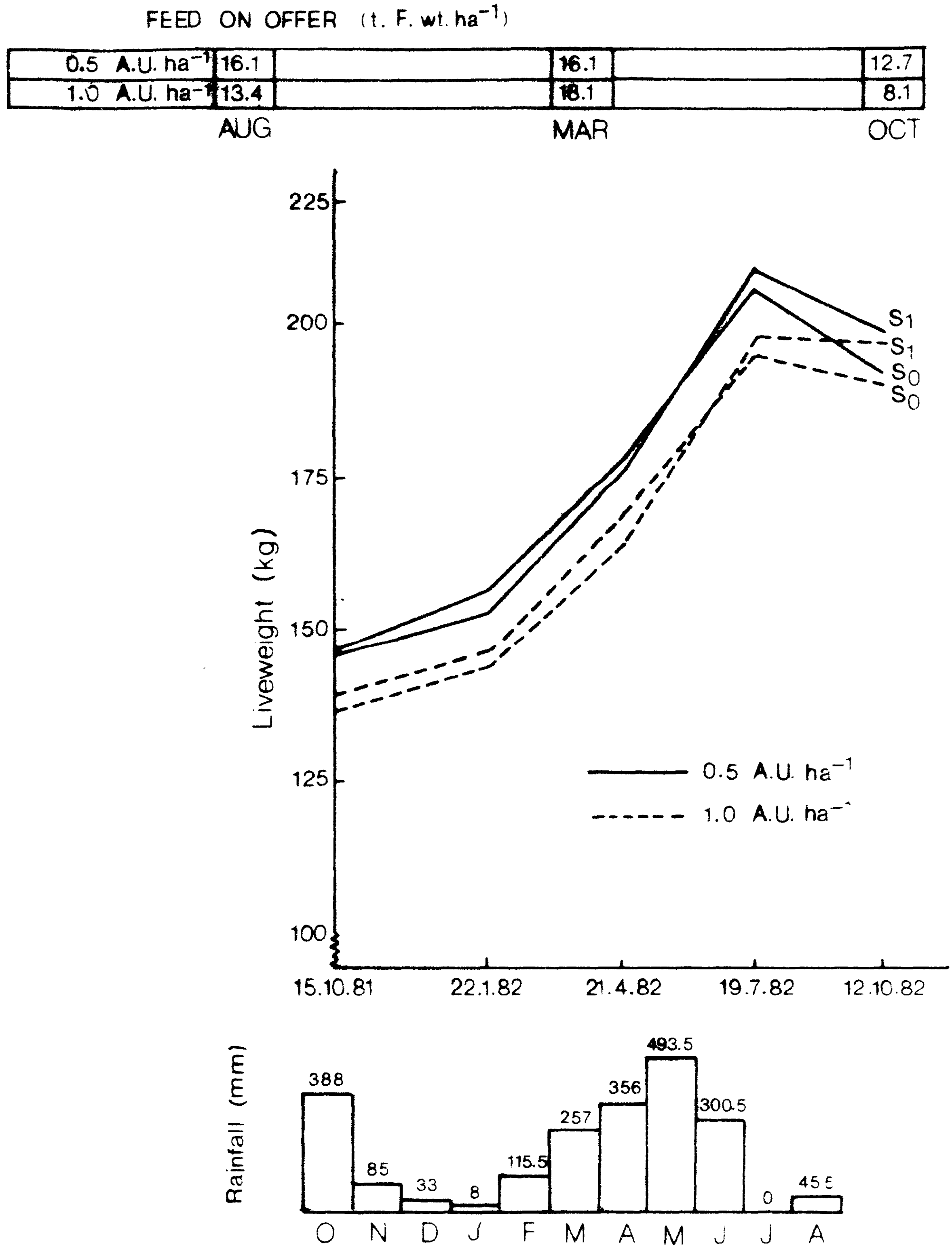
<u>Native Pasture 1981/1982</u>. Unlike the previous two experimental years, all experimental animals on the native pasture lost weight during the last period of the third grazing year (Figure 3.8). This was probably due to the low rainfall received which resulted in a lower percentage of green feed available on the pasture. There was no liveweight response to sulfur fertilizer and stocking rate treatments recorded at the native site during the 1981/82 grazing year (Appendix 2.5). The patterns of liveweight changes between treatments appeared similar; a trend of increasing liveweight was observed until the fourth weighing date (19.7.82) followed by a decrease during the last period.

There was no interaction between liveweight gain head$^{-1}$ day$^{-1}$ of the various sulfur fertilizer and stocking rate treatments with time at this site during the 1981/1982 grazing year (Table 3.26). The higher gains produced in the third period of weighing (April to July 1982) compared to other periods was probably due to the greater rainfall received in this period. Sulfur fertilizer and stocking rate had no effect on lwg hd$^{-1}$ day$^{-1}$.

Table 3.26 Liveweight gain head$^{-1}$ day$^{-1}$ of cattle grazing native pasture within each of the weighing periods during 1981/82 grazing year.

| Treatment | | Lwg head$^{-1}$ day$^{-1}$ (kg) Weighing Period | | | |
|---|---|---|---|---|---|
| Stocking Rate A.U. ha$^{-1}$ | Sulfur Fertilizer | 15.10.81- 22.1.82 (100 days) | 22.1.82- 21.4.82 (89 days) | 21.4.82- 19.7.82 (89 days) | 19.7.82- 12.10.82 (85 days) |
| 0.5 | $S_0$ | 0.110 | 0.240 | 0.328 | -0.159 |
| | $S_1$ | 0.072 | 0.257 | 0.322 | -0.063 |
| 1.0 | $S_0$ | 0.067 | 0.260 | 0.296 | -0.061 |
| | $S_1$ | 0.082 | 0.221 | 0.382 | 0.010 |

Figure 3.8. Actual liveweight changes of cattle grazing native pasture during the 1981/82 grazing year.



FEED ON OFFER (t. F. wt. ha-1)
0.5 A.U. ha-1
1.0 A.U. ha-1
16.1
13.4
16.1
18.1
12.7
8.1
AUG
MAR
OCT
Liveweight (kg)
225
200
175
150
125
100
S1
S1
S0
S0
0.5 A.U. ha-1
1.0 A.U. ha-1
15.10.81
22.1.82
21.4.82
19.7.82
12.10.82
Rainfall (mm)
388
85
33
8
115.5
257
356
493.5
300.5
0
45.5
O
N
D
J
F
M
A
M
J
J
A

Similarly, both sulfur fertilizer and stocking rate treatments had no effect on lwg $hd^{-1}$ $yr^{-1}$ although a significant increase in lwg $ha^{-1}$ $yr^{-1}$ was apparent when stocking rate was increased from 0.5 to 1.0 A.U. $ha^{-1}$ (Table 3.27).

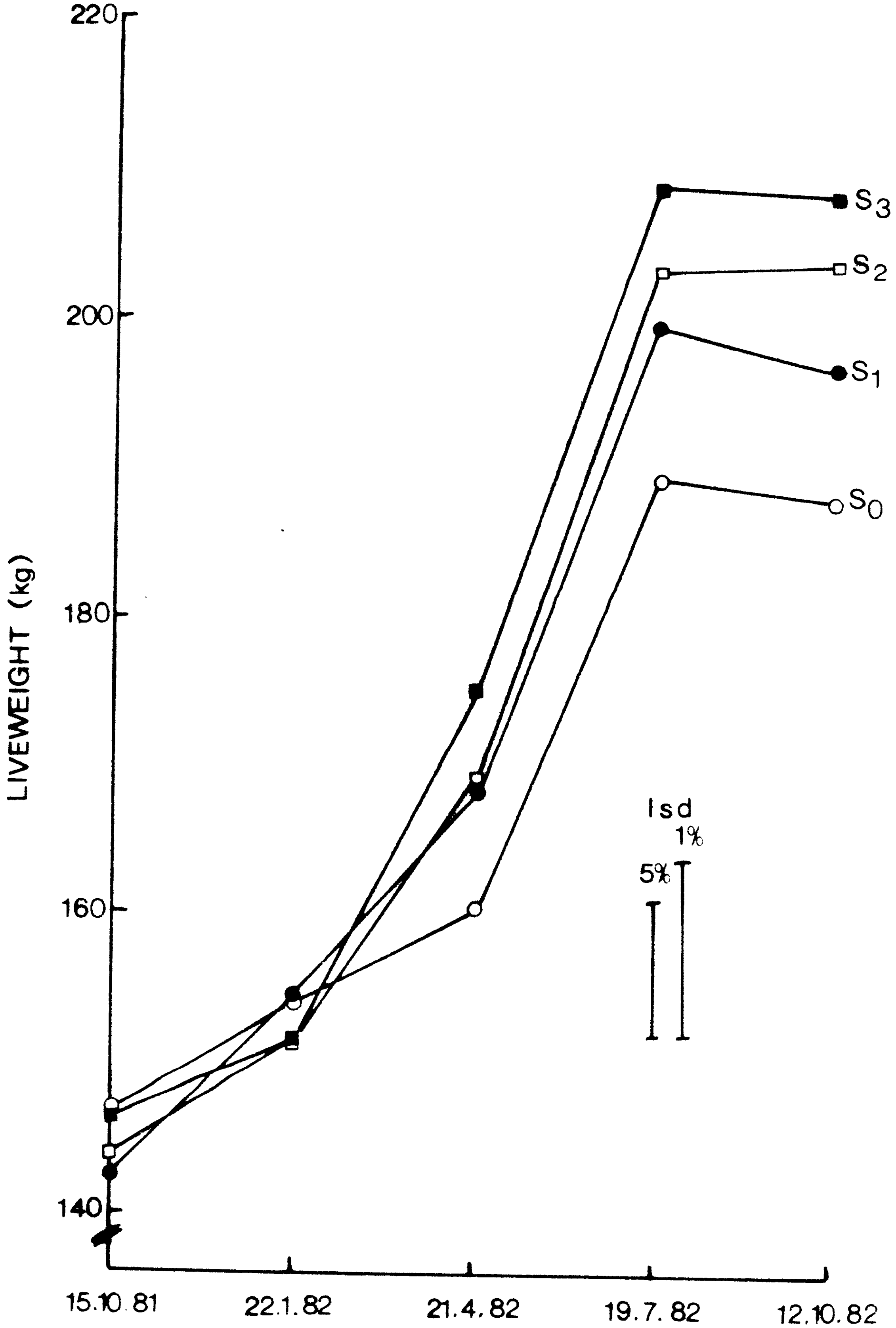
Table 3.27 Liveweight gain parameters of cattle grazing native pasture during the 1981/82 grazing year. (Comparisons are between stocking rate and fertilizer treatments within each parameter DMRT $P < 0.05$).

| Treatment | | Liveweight gain (g) | | |
|---|---|---|---|---|
| Stocking Rate A.U. $ha^{-1}$ | Sulfur Fertilizer | lwg $hd^{-1}day^{-1}$ (kg) | lwg $hd^{-1}yr^{-1}$ (kg) | lwg $ha^{-1}yr^{-1}$ (kg) |
| 0.5 | $S_o$ | 0.125 | 4 .6 | 23.2a |
| | $S_1$ | 0.147 | 53.7 | 26.8a |
| 1.0 | $S_o$ | 0.140 | 51.5 | 51.5b |
| | $S_1$ | 0.168 | 61.3 | 61.3b |

<u>Oversown Pasture 1981/82</u>. There was no response of liveweight to stocking rate during the 1981/82 grazing year (Appendix 2.6). The interaction between liveweight of various fertilizer treatments with time is presented to show the effect of sulfur fertilizer treatments on liveweight (Figure 3.9). The liveweight of the $S_3$ treatment was different ($P < 0.01$) to the $S_o$ treatment from April 1982 until the end of the third grazing year (October 1982). The $S_2$ treatment resulted in a higher ($P < 0.05$) liveweight than the $S_o$ treatment in April 1982, and was still higher ($P < 0.01$) in the following periods. The liveweight of the $S_1$ treatment was higher ($P < 0.05$) than that of the $S_o$ treatment during the last period of weighing.

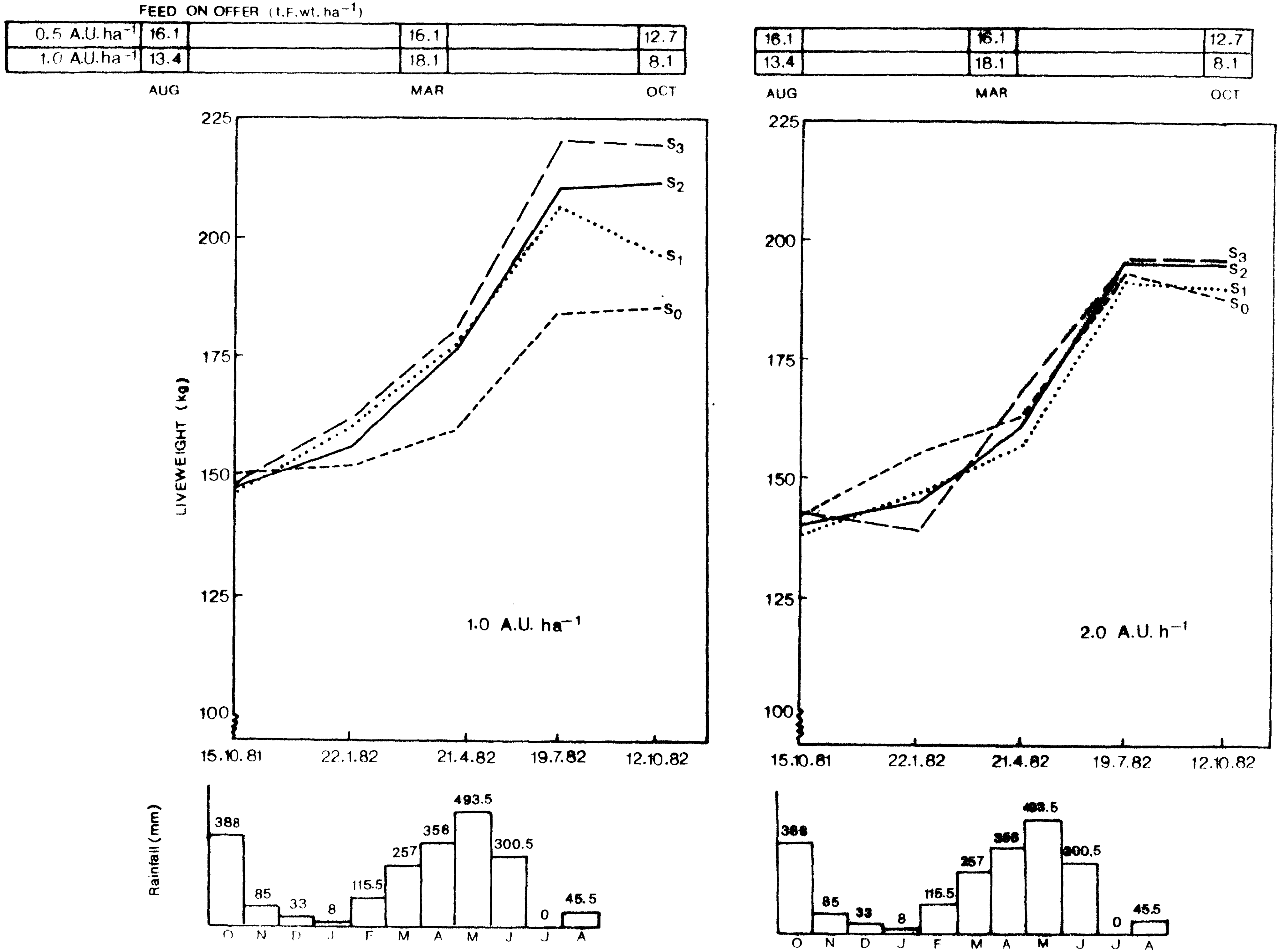
The patterns of liveweight change between treatments, however, appeared similar (Figure 3.10 (a) (b)). A trend of increasing

Figure 3.9. Changes in actual liveweight in relation to applied sulfur fertiliser.



220
200
180
160
140
LIVEWEIGHT (kg)
S3
S2
S1
S0
lsd
1%
5%
15.10.81
22.1.82
21.4.82
19.7.82
12.10.82

Figure 3.10 (a) (b). Actual liveweight changes of cattle grazing oversown pasture at (a) 1.0 AU ha-1 and (b) 2.0 AU $ha^{-1}$ during the 1981/82 grazing year.


FEED ON OFFER (t.F.wt.ha$^{-1}$)
0.5 A.U.ha$^{-1}$ 16.1 16.1 12.7
1.0 A.U.ha$^{-1}$ 13.4 18.1 8.1
AUG MAR OCT
LIVEWEIGHT (kg)
225
200
175
150
125
100
15.10.81 22.1.82 21.4.82 19.7.82 12.10.82
$S_3$
$S_2$
$S_1$
$S_0$
1.0 A.U. ha$^{-1}$
2.0 A.U. h$^{-1}$
Rainfall (mm)
388 85 33 8 115.5 257 356 493.5 300.5 0 45.5
O N D J F M A M J J A

liveweight was observed from the beginning of the third grazing year until the fourth weighing time (19.7.82) with a slight weight loss being recorded in the last weighing period, probably due to the low rainfall received which resulted in a lower green percentage of feed available from the pasture.

There was no liveweight gain head$^{-1}$ day$^{-1}$ response to fertilizer recorded at the oversown pasture during the 1981/82 grazing year (Table 3.28).

Generally, most of the experimental cattle gained weight in the first, second and third weighing periods and lost weight during the last period of weighing. The highest liveweight gain head$^{-1}$ day$^{-1}$ usually occurred in the third period of weighing, and the highest gain (0.453 kg) was obtained by the 1.0 A.U. ha$^{-1}$ with $S_3$ treatment.

Table 3.28 Liveweight gain head$^{-1}$ day$^{-1}$ of cattle grazing oversown pasture within each of the weighing periods during 1981/82 grazing year.

| Treatment | | Lwg head$^{-1}$ day$^{-1}$ (kg) Weighing Period | | | |
|---|---|---|---|---|---|
| Stocking Rate A.U. ha$^{-1}$ | Sulfur Fertilizer | 15.10.81- 22.1.82 (100 days) | 22.1.82- 21.4.82 (89 days) | 21.4.82- 19.7.82 (89 days) | 19.7.82- 12.10.82 (85 days) |
| 1.0 | $S_0$ | 0.020 | 0.077 | 0.281 | 0.022 |
| | $S_1$ | 0.138 | 0.201 | 0.326 | -0.059 |
| | $S_2$ | 0.088 | 0.227 | 0.382 | 0.018 |
| | $S_3$ | 0.142 | 0.202 | 0.453 | 0.018 |
| 2.0 | $S_0$ | 0.122 | 0.090 | 0.341 | -0.063 |
| | $S_1$ | 0.090 | 0.110 | 0.382 | -0.016 |
| | $S_2$ | 0.057 | 0.170 | 0.388 | -0.006 |
| | $S_3$ | -0.042 | 0.331 | 0.303 | 0.000 |

An effect of the sulfur fertilizer treatment upon lwg $hd^{-1}$ $day^{-1}$ and lwg $hd^{-1}$ $year^{-1}$ was found at the 1.0 A.U. $ha^{-1}$ stocking rate (Table 3.29) with lwg increasing as fertilizer increased. Based on the annual liveweight gain per hectare, the higher stocking rate produced significantly higher ($P < 0.05$) gains compared to the lower stocking rate. However, there was no effect of fertilizer on the annual liveweight gain $ha^{-1}$ recorded.

Table 3.29 The mean liveweight gain of cattle grazing oversown pasture during the 1981/82 grazing year. (Comparisons are between stocking rate and fertilizer treatments within each parameter DMRT $P < 0.05$).

| Treatment | | Liveweight gain (g) | | |
|---|---|---|---|---|
| Stocking Rate A.U. $ha^{-1}$ | Sulfur Fertilizer | lwg $hd^{-1}day^{-1}$ (kg) | lwg $hd^{-1}yr^{-1}$ (kg) | lwg $ha^{-1}yr^{-1}$ (kg) |
| 1.0 | $S_o$ | $0.098^{a}$ | $35.8^{a}$ | $35.8^{a}$ |
| | $S_1$ | $0.153^{abc}$ | $55.8^{abc}$ | $55.8^{abc}$ |
| | $S_2$ | $0.178^{bc}$ | $65.0^{bc}$ | $65.0^{abc}$ |
| | $S_3$ | $0.196^{c}$ | $71.5^{c}$ | $71.5^{ab}$ |
| 2.0 | $S_o$ | $0.125^{ab}$ | $45.6^{a}$ | $91.2^{bcd}$ |
| | $S_1$ | $0.142^{abc}$ | $51.8^{abc}$ | $103.6^{cde}$ |
| | $S_2$ | $0.151^{abc}$ | $55.1^{abc}$ | $110.2^{e}$ |
| | $S_3$ | $0.144^{abc}$ | $52.6^{abc}$ | $105.1^{de}$ |

* Calculation based on 365 days

Reproductive Performance. The results indicate that no heifers cycled on the native pasture during the first experimental year while 29% cycled on the oversown pasture (Table 3.30). In the second and third years, figures for both sites were similar (native 66% and 75%, and oversown 52% and 71% respectively). Generally, there appeared to be no relationship between whether a heifer cycled and weight.

Table 3.30 Percentage of heifers cycling in relation to weight class during the three year experimental period.

| | Weight Class | | | | |
|---|---|---|---|---|---|
| | 100-149 | 150-199 | 200-249 | 250-299 | 300-349 |
| Cycling Yr 1 Native | - | 0 | 0 | - | - |
| Non Cycling Yr 1 Native | - | 54.2 | 45.8 | - | - |
| Cycling Yr 2 Native | 4.8 | 19.2 | 33.3 | 9.5 | - |
| Non Cycling Yr 2 Native | 9.5 | 9.5 | 9.5 | 4.8 | - |
| Cycling Yr 3 Native | - | 45.8 | 29.2 | - | - |
| Non Cycling Yr 3 Native | - | 20.8 | 4.2 | - | - |
| Cycling Yr 1 Oversown | - | 2.1 | 14.6 | 12.5 | - |
| Non Cycling Yr 1 Oversown | 2.1 | 8.3 | 35.4 | 22.9 | 2.1 |
| Cycling Yr 2 Oversown | 6.5 | 26.1 | 17.4 | 2.2 | - |
| Non Cycling Yr 2 Oversown | 6.5 | 26.1 | 13.0 | 2.2 | - |
| Cycling Yr 3 Oversown | - | 29.2 | 39.6 | 2.1 | - |
| Non Cycling Yr 3 Oversown | 2.1 | 16.7 | 10.4 | - | - |

## 3.4 DISCUSSION

3.4.1 Soil. At the native site, soil P levels increased during the first and second year of the experiment. Since no fertilizer P had been added (Table 3.5), these increases were most likely due to the experimental cattle via their excreta as documented by Till (1981), Snaydon (1981) and Rouquette *et al*. (1973). The soil P levels at the oversown site had increased above adequacy levels by the end of the first grazing year (September 1980), but decreased by the end of the second grazing year. The latter probably reflects the smaller amounts of rainfall which occurred prior to the sampling made in September 1981. A large increase in soil P levels was recorded during the third grazing year at both native and oversown sites as a result of the application of P as TSP made in October 1981.

The mean soil nitrogen (N) results presented in Table 3.4 showed that higher values were obtained at the oversown site, which may reflect the greater legume content of this pasture although stocking rate, via animal excreta, may also influence soil N status. However, soil N was below the adequacy level at the commencement of the experiment at both sites but was adequate by the end of the first year and remained so for the rest of the experimental period. The increase in N levels, even in the third year, was most likely due to the effect of the dung and urine of experimental animals (Rouquette et al., 1973) and not from the result of sulfur or phosphorus fertilization (Bruce, 1972).

Soil sulfur levels (Table 3.7) were above the adequacy level (Table 3.5) indicated by soil analysis at the beginning of the experiment (Table 3.5), but by the end of the first grazing year all treatments had decreased below the adequacy levels. The decrease in the soil sulfur level during this period was probably due to leaching by rain following the oxidation of elemental sulfur to sulfate (Blair, 1971; Martin and Walker, 1965) and sulfur uptake by plants as shown by the increase in the mean plant sulfur content (Table 3.4). Sulfate levels were restored at the native site by the end of the second grazing year and at the oversown site by the end of the third grazing year.

The soil pH values at both experimental sites appeared similar and quite stable throughout the experiment (Table 3.8), ranging from 4.8 to 5.7. Such values, however, encourage the oxidation rate of elemental S to sulfate (Blair, 1971). S fertilizer had no effect on the soil pH values at either native or oversown sites.

### 3.4.2 Pasture Performance

1979 - 1980. Although the total feed on offer of native pasture (14.88 tonnes fresh weight $ha^{-1}$, Table 3.9) was higher than that at the oversown pasture (12.86 tonnes fresh weight $ha^{-1}$, Table 3.10) at the commencement of the experiment, the latter was generally of a higher quality. This was shown by a greater amount of legume present and a lower amount of Imperata available and also by a higher N on offer (38.5 kg $ha^{-1}$ at oversown and 23.1 kg $ha^{-1}$ at native pasture). However, it was not reflected in a better animal performance during the first grazing year which probably was due to a higher initial weight at the native site. The N levels of all pasture components of native site were below the critical level of 1.0 - 1.4% as recommended (Blaxter and Wilson, 1963; Minson and Milford, 1967) at the beginning of the experiment, but the values increased to above the critical level by the end of the first year (September 1980). By this stage the mean N levels of oversown pasture were above the critical levels.

The phosphorus levels of all pasture components from native and oversown pastures were below the 0.18% level regarded as the minimum P requirement for beef cattle (McDowell, 1974) during the 1979/80 grazing year, while the mean potassium levels of both pastures were above the minimum requirement. In contrast to the results of the grazing experiment conducted by Winter et al. (1977) at Cape York Peninsula, stocking rate had no effect on the N and P content of the pasture components at either site.

Plant analysis revealed low sulfur levels in both the native and oversown pasture at the commencement of the experiment (Table 3.14). The levels were below 0.1%, the minimum requirement suggested by Church (1971) and McDowell (1974), and this is probably due to the soil sulfur being mainly in an unavailable form for the plants.

By the end of the first grazing year, similar changes in botanical composition had occurred in both pastures. The grass

component had been reduced to almost half the original amount which led to an increase in the proportion of Imperata and weed in the pasture and decrease in the total feed on offer. The reduction in the quantity of feed on offer at both pastures was mainly due to reduced rainfall during the period prior to estimation (September 1980) and removal by the grazing animals. The latter affected the botanical composition of the pastures, as is shown by the large decrease of the grass and legume components in the pastures when the experimental animals were evidently selecting the best quality feed available from the pasture. The decrease in legume and grass content of pastures as a result of stocking has also been found by Jones (1972). However, increasing stocking rate resulted in an increase in the native legume component such as Desmodium heterophyllum and D. trifolium, particularly at the oversown pasture, as previously demonstrated by Partridge (1979). The N on offer of oversown pasture as measured at the end of the first grazing year (19.9 kg $ha^{-1}$) was slightly lower than that of native pasture (23.2 kg $ha^{-1}$) at 1.0 A.U. $ha^{-1}$ stocking rate.
Increasing stocking rate slightly decreased the N on offer at both pastures. By this stage, the P content of all pasture components from native and oversown pasture were below the minimum requirement of beef cattle (0.18%, McDowell, 1974), while other nutrients except sodium were above the critical level. The plant sulfur of native and oversown pasture had increased by the end of the first grazing year probably as a result of both the S application and the animal excreta although there was no significant difference between treatments in plant sulfur during the first year. The N/S ratio of the grass component of native pasture (15:1) was slightly higher than that at the oversown pasture

(13:1) and exceeded the satisfactory N/S ratio of 10:1 (Siebert and Vijchulata, 1983). It may therefore be suggested that the quality of both pastures was similar by the end of the first grazing year.

1980 - 1981. The total feed on offer was higher at the native pasture than at the oversown pasture (Tables 3.9, 3.10) at the commencement of the second grazing year, but was lower by the end of the 1980/81 grazing year. However, feed on offer had accumulated at both pastures by the end of the second grazing year as a result of increased rainfall prior to sampling (August 1981). Since these increases did not result in higher animal production compared to the first year, it suggests that the pastures were understocked.

Although the legume component was still greater at the oversown pasture, the total N on offer of both pastures appeared to be similar during the 1980/81 experimental year. However, compared to the first year, the mean N on offer was slightly higher but this did not result in better animal performance. The N/S ratio of pasture components at the native site was below 10:1 while they ranged from 10 to 17:1 at the oversown pasture. These ratios indicate that there was a higher sulfur content of native pasture during the second grazing year, since the plant N and S were above the critical levels recommended by McDowell (1974) and Church (1971). The sodium and phosphorus levels of both pastures were still below the minimum requirements, and thus P fertilizer as TSP was applied as a basal application while supplementation of sodium as common salt (NaCl) to the animals at 30 g $hd^{-1}$ $day^{-1}$ was considered essential to prevent sodium deficiency. The positive effect of sodium supplementation to beef cattle to correct deficient plant and soil sodium levels has been well documented by Hunter et al (1979).

1981 - 1982. The total N of offer of both pasture was lower by the end of the third grazing year compared to the beginning. This decrease was most likely due to a reduction in rainfall prior to the estimation (October 1982). By this stage, the total feed on offer of the oversown site (10.4 tonnes $ha^{-1}$ at 1.0 A.U. $ha^{-1}$) was a little higher than that of the native site (8.1 tonnes $ha^{-1}$ at 1.0 A.U. $ha^{-1}$), but the animal performance on both pastures was similar. The higher total N on offer of oversown pasture (47.5 kg - 20.2 kg $ha^{-1}$ at the commencement and the end of the 1981/82 grazing year) than that of the native pasture (25.8 kg - 15.2 kg $ha^{-1}$) at 1.0 A.U. $ha^{-1}$ stocking rate suggested that higher quality feed was also available at the oversown pasture.

The N/S ratio of pasture components of native pasture increased with time while at the oversown site decreases were recorded. However, these values were close to the satisfactory ratio of 10:1 suggested by Siebert and Vijchulata (1983).

Sulfur had no effect on the N or P content of either pasture throughout the experiment but had an effect on the S content of the grass component at the oversown pasture. The grass S content increased with increasing sulfur fertilizer and differences in animal performance between sulfur treatment and control were recorded (Figure 3.3).

However, the lack of effect of sulfur fertilizer on plant sulfur or animal performance during the first and the second grazing years suggests that the residual effect from previous S applications had accumulated. The S levels of all pasture components of both native and oversown pastures were above the critical levels recommended by Church (1971) and McDowell (1974) and Siebert and Vijchulata (1983). The P content of all pasture components from native and oversown pasture appeared adequate in the third year following a basal P (as TSP) application made at the beginning of the 1981/82 grazing year. The N level and other nutrients except sodium were above the critical levels, therefore the supplementation of common salt (NaCl) to the experimental animals was considered to be necessary.

### 3.4.3 Animal Performance.

Native Site. The daily liveweight gain in the second weighing period of the first grazing year (1979/80) was about 56% higher than the first period of weighing (Table 3.18). This pattern was due mainly to the better quality of feed available at the second period of the first grazing year. This is shown by the increase in plant nitrogen (Table 3.11) and plant sulfur (Table 3.14) levels recorded when the total feed on offer was reduced by 32% compared to the amount at the beginning of the experiment.

There was no significant effect of any treatments on liveweight gain head$^{-1}$ day$^{-1}$ at this site in the 1979/80 grazing year. The liveweight gain presented in Table 3.19 showed that stocking rate had no effect on individual animal performance. However, based on the efficiency of pasture utilization, the higher stocking rate gave a more economical output than the lower stocking rate, as also found by Winter et al. (1977). In general, the response to the stocking rate followed the usual pattern of increase in production per hectare as the stocking rate increased.

A liveweight gain $ha^{-1}$ $year^{-1}$ of 75 kg was recorded from a stocking rate of 1.0 beast $ha^{-1}$ without fertilizer and this value was similar to the estimation of beef production from natural grassland in tropical environments by Stobbs (1976).

The patterns of the liveweight changes at all treatments generally appeared similar in the 1979/80 grazing year. There was no liveweight response to fertilizer recorded in this year, possibly due to the lack of difference in plant S during the first grazing year (Table 3.14). Although the initial weight of the experimental animals differed between treatments (Appendix 2.1), the analysis of variance with the initial weight as a covariate showed that there was no effect of the initial weight on the liveweight gain (Appendix 3.1).

All of the experimental cattle lost weight in the first weighing period of the second year (Table 3.22). However, the differences in liveweight lost between treatments was not significant. The weight loss of the experimental cattle in this period was probably due to animal stress in the adaptation period of these cattle to the new environment and to the lower feed available during this period (as shown in Table 3.9). The significantly higher gains which occurred in the following periods were due to the increase of feed on offer which resulted from the higher rainfall. Production was higher at the lower stocking rate, reflecting the greater available feed.

There were no fertilizer or stocking rate effects on liveweight gain $head^{-1}$ $year^{-1}$ during the second grazing year (Table 3.23). However, the significantly higher production per hectare at the higher stocking rate suggests that the 1.0 beast $ha^{-1}$ stocking rate was more beneficial than the lower stocking rate. Compared to the animal performance of the first year, liveweight gain in the second year was lower, and this was probably due to a reduction in legumes present, particularly at the oversown pasture, and a lower digestibility and palatability of feed on offer.

The patterns of the liveweight changes during the second grazing year (1980/81) were different to those of the first year. There was a significant difference in liveweight between weighing periods (Appendix 2.3), and the fluctuation of liveweight changes followed the patterns of rainfall (Figure 3.6). The fertilizer treatment had little effect on liveweight changes during the second grazing year, but the non-significant differences between treatments based on liveweight gain $head^{-1}$ suggest that the treatment of 1.0 beast $ha^{-1}$, without fertilizer, was more efficient in terms of pasture utilization.

The analysis of variance of the data presented in Table 3.26 showed that no liveweight gain $head^{-1}$ $day^{-1}$ responses to fertilizer or stocking rate were recorded in the third grazing year (1981/82). Although the mean daily and annual liveweight gain $head^{-1}$ of the experimental cattle appeared similar between treatments, the mean annual liveweight gain $ha^{-1}$ from the higher stocking rate was significantly higher than that at the lower stocking rate.

The patterns of liveweight change during this year were different from the previous two years. In the third grazing year, all experimental cattle gained weight until the third weighing period and lost weight during the last period of weighing. These differences were due to the differences in rainfall pattern (Table 3.1) which resulted in seasonal fluctuations in the quantity of the feed on offer as shown in Table 3.9.

The mean daily liveweight gain head$^{-1}$ in the first grazing year (0.225 kg) (Table 3.19) was significantly higher ($P < 0.001$) than in the last two years, while the second grazing year (0.149 kg) (Table 3.24) appeared similar to the third grazing year (0.145 kg) (Table 3.30). Such differences were most likely due to the higher amount of legumes present in the first year and a similar amount of legumes available in the last two years of experiment.

Similar patterns of continuous decreases in the liveweight gains over years were also found by Chadhokar (1977) in Papua New Guinea. The mean daily liveweight gain head$^{-1}$ of Brahman cross heifers used in this experiment in the first grazing year (0.225 kg) was higher than that obtained by Chadhokar (1977) in his experiment, using Imperata pasture (0.190 kg). Soewardi et al. (1975) found a daily liveweight gain head$^{-1}$ of only 0.140 kg of Ongole grade heifers fed Imperata ad lib. This difference is probably due to the higher percentage of the grass component available from this experimental pasture and the native legumes available at the commencement of the experiment.

Unlike the animal production patterns of the native site in the two previous years, the animal production (kg head$^{-1}$ day$^{-1}$) of the higher stocking rate appeared greater than that at the lower stocking rate during the third grazing year, although this difference was not significant. This trend may suggest that increased grazing pressure, within limits, may be used on native pastures dominated by old herbage to open up the pasture, allowing more palatable feed to grow, and resulting in an increase of animal production.

Oversown Site. There was no liveweight gain head$^{-1}$ day$^{-1}$ response to fertilizer or stocking rate treatments recorded during the first year of the experiment. The mean daily liveweight gain head$^{-1}$ in the first period was a little higher than the second period (Table 3.20). This trend, however, was different to that at the native site and was probably due to both the higher legume component and the total feed available in the oversown pasture at the commencement of the experiment (Table 3.10). The annual liveweight gain head$^{-1}$ was not different between treatments, while the annual liveweight gain ha$^{-1}$ at the higher stocking rate was higher ($P < 0.01$) than that at the lower stocking rate. There was no liveweight response to fertilizer or stocking rate recorded in the 1979/80 grazing year. The pattern of liveweight changes was different to that of the native site. At the oversown site, the gains in liveweight were faster in the first period of weighing than in the second weighing period (Table 3.20 and Figure 3.5). This was probably due to the greater amount of legumes present at the beginning of the experiment.

Although a significant interaction occurred between fertilizer and stocking rate treatments on animal production, Table 3.25 shows that only the treatment of 1.0 A.U. ha$^{-1}$ with 30 kg S ha$^{-1}$ ($S_3$) gave a significantly higher ($P < 0.05$) liveweight gain hd$^{-1}$ day$^{-1}$ of 0.217 kg than that of 1.0 A.U. ha$^{-1}$ with 15 kg S ha$^{-1}$ (0.145 kg) and that of 2.0 A.U. ha$^{-1}$ with 30 kg S ha$^{-1}$ (0.118 kg hd$^{-1}$ day$^{-1}$). Increasing the stocking rate depressed liveweight and results are similar to those of Shaw (1978(b). The mean annual liveweight gain hd$^{-1}$ at 1.0 A.U. ha$^{-1}$, 30 kg S ha$^{-1}$

(79.2 kg) was also higher ($P < 0.05$) than that of 2.0 A.U. $ha^{-1}$ 30 kg S $ha^{-1}$ (43.1 kg). Based on production $ha^{-1}$, increasing stocking rate generally produced significantly higher gains and agrees with the work of Shaw (1978 (b).

The patterns of liveweight changes during the 1980/81 grazing year (Figure 3.7) appeared similar to the native site in that the cattle lost weight in the first weighing period due to low rainfall which resulted in lower feed on offer available from the pasture, and gained in the following periods.

The daily liveweight gain $head^{-1}$ in the third grazing year was significantly different ($P < 0.05$) between fertilizer and control treatments within the lowstocking rate (1.0 beast $ha^{-1}$). There were no differences in liveweight gain $head^{-1}$ $day^{-1}$ between fertilizer treatment at both stocking rates (Table 3.29 and Figure 3.9) suggesting that 15 kg S $ha^{-1}$ of sulfur fertilizer appeared adequate for the maintenance of pastures in these circumstances.

The analysis of variance of the animal liveweight gain $head^{-1}$ showed a significant fertilizer effect ($P < 0.05$) at the low stocking rate and also showed no difference between fertilizer treatments at both stocking rates. As with the two previous years, the higher stocking rate gave significantly higher liveweight gains $head^{-1}$ $year^{-1}$ ($P < 0.01$) than the lower stocking rate, but no response of animal production $ha^{-1}$ to fertilizer was recorded in the third grazing year.

The pattern of liveweight changes during the 1981/82 grazing year was different to those in the two previous grazing years. In this year, the experimental cattle gained weight during three periods of weighing and lost weight during the last period. This was mainly due to the different rainfall patterns beteen years which resulted in different amounts of feed available for each season.

There was a significant difference in the mean daily liveweight gain head$^{-1}$ between years in this experiment. The higher liveweight gain head$^{-1}$ day$^{-1}$ was obtained from the 1979/80 grazing year (0.218 kg) (Table 3.21) compared to that in the 1980/81 season (0.162 kg) (Table 3.25) or in the 1981/82 season (0.148 kg) (Appendix 3.3). These differences in animal production reflected the differences in feed available (Table 3.10) within each year, particularly the amount of legume present. The higher feed availability at the beginning of the third grazing year compared to the second year, was not reflected in a higher animal production suggesting that the quality of the pastures in this experiment was the limiting factor for animal production rather than the quantity of the pastures.

Based on the utilization of the pasture, the higher stocking rate consistently gave higher animal production during the three years of experiment.

Reproductive Performance. In the first year of the experiment (1979/80), there were no heifers cycling at the native site while 29% of heifers at the oversown site were cycling (Table 3.30). The higher quality of the oversown pasture, mainly shown by the greater amount of legume component compared to that at the native pasture (Tables 3.9 and 3.10) at the beginning of the experiment, appeared to be the main factor in better reproductive performance found at the oversown pasture. There was no fertilizer or stocking rate effect on reproductive performance of the heifers grazing oversown pasture.

Heifers failed to have an oestrous at the native site during the first year since they were younger.

In the 1980/81 grazing year, 60% of heifers cycled at the native site while 53% cycled at the oversown site and the percentage of heifers cycling at both pastures was again similar at the end of the third grazing year (Table 3.30). The increase in the percentage of heifers cycling by year 2 and 3 was possibly due to their better maintenance, particularly in the control of parasites and diseases, because the final liveweight of the heifers and the quality and quantity of the pastures had no effect on their reproductive performance. The reproductive ability recorded in this experiment however, was similar to that usually obtained in tropical areas (Warrick, 1976).

## 3.5 CONCLUSION

Three major hypotheses were proposed at the conclusion of the literature review (Section 2.3). Two of these three hypotheses were then tested in the field, viz. that; (i) the addition of appropriate fertilizer to the existing pastures, dominated by alang-alang (Imperata cylindrica), will increase the quantity and quality of the pastures, decrease the population of Imperata in the pasture and improve animal production, and (ii) stocking rate and its interaction with the pastures will have a major influence on animal productivity.

The results presented in Chapter 3 of this thesis tended to agree with these hypotheses. However, the addition of sulfur fertilizer did not appear to decrease the population of Imperata cylindrica (alang alang) of either the native or oversown pastures (Tables 3.9 and 3.10). The effect of sulfur fertilizer on animal production was apparent at the oversown pasture in the 1981/82 grazing year, the third year of the experiment. However, the small amount of exotic legumes available at this pasture did not appear to be a major reason for the small effect of fertilizer treatment on animal production recorded in the third grazing year.

Unsatisfactory growth and fertility of beef cattle were recorded at both native and oversown pastures during the experiment. This low production was largely due to the low quality of feed available at both sites rather than the quantity. This is shown by the lower liveweight gain produced in the second year compared to the first year when the total feed on offer was lower. Lack of legumes available at the oversown pasture, as a result of incorrect maintenance before the commencement of the experiment reduced the response of fertilizer in animal production. Sulfur fertilizer failed to suppress the Imperata population because only a small amount of the legume existed on the pasture and was not competitive enough with Imperata. Further, the experimental animals selectively grazed the pastures and reduced the availability of the legumes on the pastures.

Results presented in this thesis however, have demonstrated that the quality of the feed on offer is the major factor restricting animal productivity in the wet tropics. It has been suggested that the most likely successful means of increasing the nutrition of grazing cattle and hence their production, may be to feed nutrient supplements as long as it is economic and beneficial. It has also been suggested that beef production from native pasture may be increased by the introduction of more suitable legumes and grasses. In the long term the latter is a much cheaper alternative. Thus, suitable species need to be identified and tested in grazing situations similar to the present experiment.

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## Appendix 1. Plot layout

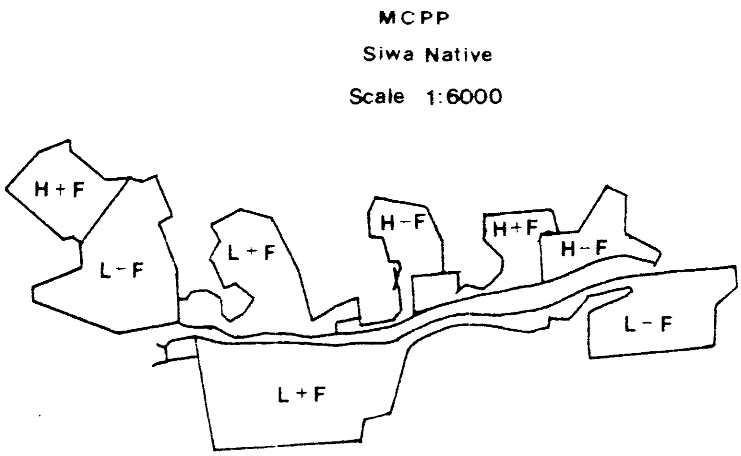
NATIVE

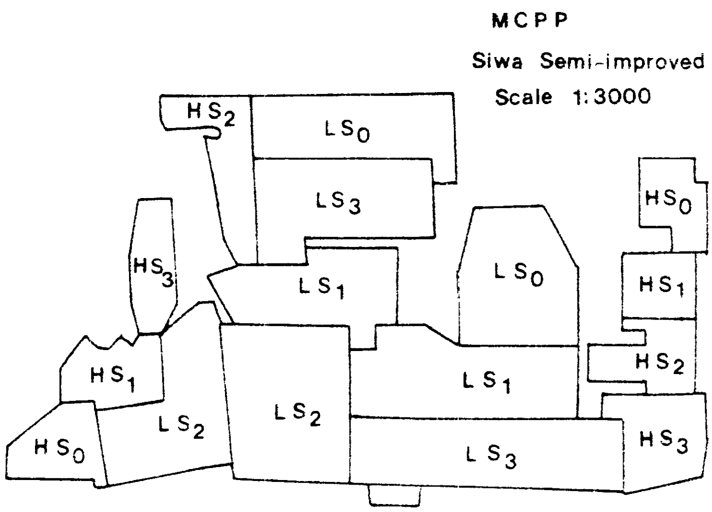
L = low stocking rate

H = high stocking rate

-F = 0 kg S $ha^{-1}$

+F = 30 kg S $ha^{-1}$




SEMI-IMPROVED

L = low stocking rate

H = high stocking rate

$S_o$ = 0 kg S $ha^{-1}$ each year

$S_1$ = 15 kg S $ha^{-1}$ each year

$S_2$ = 30, 15, 15 kg S $ha^{-1}$ (years 1, 2, 3)

$S_3$ = 30 kg S $ha^{-1}$ each year

Appendix 2.1 The actual liveweight of cattle grazing native pasture during the 1979/80 grazing year

| Stocking Rate (A.U. $ha^{-1}$) | Sulfur Fertilizer | Liveweight (kg) Weighing Dates | | |
|---|---|---|---|---|
| | | 17.9.79 | 12.5.80 | 17.9.80 |
| 0.5 | $S_0$ | 109.2 | 158.3 | 194.5 |
| | $S_1$ | 128.3 | 180.0 | 217.8 |
| 1.0 | $S_0$ | 115.0 | 154.0 | 186.5 |
| | $S_1$ | 107.0 | 153.3 | 185.8 |

Appendix 2.2 The actual liveweight of cattle grazing oversown pasture during the 1979/80 grazing year

| Stocking Rate (A.U. $ha^{-1}$) | Sulfur Fertilizer | Liveweight (kg) Weighing Dates | | |
|---|---|---|---|---|
| | | 17.9.79 | 12.5.80 | 17.9.80 |
| 1.0 | $S_0$ | 152.2 | 214.2 | 229.8 |
| | $S_1$ | 149.7 | 202.5 | 238.3 |
| | $S_2$ | 154.2 | 229.2 | 225.0 |
| | $S_3$ | 150.8 | 226.7 | 257.5 |
| 2.0 | $S_0$ | 146.7 | 194.2 | 229.2 |
| | $S_1$ | 147.5 | 190.8 | 215.0 |
| | $S_2$ | 153.0 | 221.7 | 236.7 |
| | $S_3$ | 155.0 | 189.2 | 215.8 |

Appendix 2.3 The actual liveweight of cattle grazing native pasture during the 1980/81 grazing year

| Stocking Rate (A.U. $ha^{-1}$) | Sulfur Fertilizer | Liveweight (kg) Weighing Dates 19.9.80 | 19.13.80 | 27.3.81 | 25.6.81 | 14.10.81 |
|---|---|---|---|---|---|---|
| 0.5 | $S_o$ | 159.8 | 147.8 | 164.8 | 192.0 | 210.0 |
| | $S_1$ | 150.7 | 150.5 | 176.0 | 207.0 | 222.0 |
| 1.0 | $S_o$ | 146.3 | 136.3 | 155.2 | 167.0 | 194.8 |
| | $S_1$ | 156.5 | 145.5 | 168.2 | 190.3 | 219.3 |

Appendix 2.4 The actual liveweight of cattle grazing oversown pasture during the 1980/81 grazing year

| Stocking Rate (A.U. $ha^{-1}$) | Sulfur Fertilizer | Liveweight (kg) Weighing Dates 19.9.80 | 19.12.80 | 27.3.81 | 25.6.81 | 14.10.81 |
|---|---|---|---|---|---|---|
| 1.0 | $S_o$ | 123.0 | 124.8 | 135.8 | 142.3 | 179.3 |
| | $S_1$ | 130.8 | 135.7 | 158.8 | 172.7 | 199.8 |
| | $S_2$ | 137.8 | 126.3 | 137.7 | 142.2 | 194.5 |
| | $S_3$ | 123.2 | 125.0 | 156.2 | 169.0 | 208.0 |
| 2.0 | $S_o$ | 130.5 | 121.5 | 136.7 | 149.7 | 187.3 |
| | $S_1$ | 114.5 | 107.0 | 121.8 | 139.5 | 180.7 |
| | $S_2$ | 124.8 | 116.0 | 142.8 | 153.5 | 195.5 |
| | $S_3$ | 118.8 | 106.3 | 121.2 | 138.5 | 165.0 |

Appendix 2.5 The actual liveweight of cattle grazing native pasture during the 1981/82 grazing year

| Stocking Rate (A.U. $ha^{-1}$) | Sulfur Fertilizer | Liveweight (kg) Weighing Dates 15.10.81 | 22.1.82 | 21.4.82 | 19.7.82 | 12.10.82 |
|---|---|---|---|---|---|---|
| 0.5 | $S_0$ | 146.7 | 156.7 | 178.0 | 205.7 | 192.2 |
| | $S_1$ | 145.7 | 152.8 | 173.7 | 204.3 | 199.0 |
| 1.0 | $S_0$ | 138.8 | 145.5 | 168.7 | 195.0 | 189.8 |
| | $S_1$ | 136.0 | 144.2 | 163.8 | 197.8 | 197.0 |

Appendix 2.6 The actual liveweight of cattle grazing oversown pasture during the 1981/82 grazing year

| Stocking Rate (A.U. $ha^{-1}$) | Sulfur Fertilizer | Liveweight (kg) Weighing Dates 15.10.81 | 22.1.82 | 21.4.82 | 19.7.82 | 12.10.82 |
|---|---|---|---|---|---|---|
| 1.0 | $S_0$ | 150.7 | 152.7 | 159.5 | 184.5 | 186.3 |
| | $S_1$ | 146.7 | 160.5 | 178.3 | 207.3 | 202.3 |
| | $S_2$ | 147.7 | 156.5 | 176.7 | 210.7 | 212.2 |
| | $S_3$ | 148.8 | 163.0 | 181.0 | 221.3 | 219.8 |
| 2.0 | $S_0$ | 143.3 | 155.5 | 163.5 | 193.8 | 188.5 |
| | $S_1$ | 139.2 | 148.2 | 158.0 | 192.0 | 190.7 |
| | $S_2$ | 140.7 | 146.3 | 161.5 | 196.0 | 195.5 |
| | $S_3$ | 144.3 | 140.2 | 169.7 | 196.7 | 196.7 |

Appendix 3.1 Analysis of covariance - initial liveweight versus subsequent liveweight gain - native site 1979/80.

| Source | Sum of Squares | Degrees of freedom | Mean Square | F | Tail Prob. |
|---|---|---|---|---|---|
| Rep | 0.00302 | 1 | 0.00302 | 0.76 | 0.3976 |
| Fert | 0.00285 | 1 | 0.00285 | 0.72 | 0.4108 |
| Stock | 0.00610 | 1 | 0.00610 | 1.53 | 0.2346 |
| RF | 0.00050 | 1 | 0.00050 | 0.13 | 0.7268 |
| RS | 0.00152 | 1 | 0.00152 | 0.38 | 0.5458 |
| FS | 0.00028 | 1 | 0.00028 | 0.07 | 0.7961 |
| RFS | 0.00000 | 1 | 0.00000 | 0.00 | 0.9791 |
| 1-ST Covar | 0.00017 | 1 | 0.00017 | 0.04 | 0.8370 |
| Error | 0.05965 | 15 | 0.00398 | | |

Appendix 3.2 Analysis of covariance - initial liveweight versus subsequent liveweight gain - native site 1980/81.

| Source | Sum of Squares | Degrees of freedom | Mean Square | F | Tail Prob. |
|---|---|---|---|---|---|
| Rep | 0.03686 | 1 | 0.03686 | 1.33 | 0.2661 |
| Fert | 0.02074 | 1 | 0.02074 | 0.75 | 0.3999 |
| Stock | 0.01226 | 1 | 0.01226 | 0.44 | 0.5155 |
| RF | 0.00138 | 1 | 0.00138 | 0.05 | 0.8262 |
| RS | 0.00617 | 1 | 0.00617 | 0.22 | 0.6433 |
| FS | 0.03430 | 1 | 0.03430 | 1.24 | 0.2827 |
| RFS | 0.06504 | 1 | 0.06504 | 2.35 | 0.1458 |
| 1-ST Covar | 0.01060 | 1 | 0.01060 | 0.38 | 0.5450 |
| Error | 0.41440 | 15 | 0.02763 | | |

Appendix 3.3 Analysis of covariance - initial liveweight versus subsequent liveweight gain - oversown site 1981/82.

| Source | Sum of Squares | Degrees of freedom | Mean Square | F | Tail Prob. |
|---|---|---|---|---|---|
| Rep | 0.03513 | 1 | 0.03513 | 2.71 | 0.1101 |
| Fert | 0.06602 | 3 | 0.02201 | 1.69 | 0.1885 |
| Stock | 0.09216 | 1 | 0.09216 | 7.10 | 0.0121 |
| RF | 0.01144 | 3 | 0.00381 | 0.29 | 0.8296 |
| RS | 0.01048 | 1 | 0.01048 | 0.81 | 0.3759 |
| FS | 0.06531 | 3 | 0.02177 | 1.68 | 0.1923 |
| RFS | 0.01774 | 3 | 0.00591 | 0.46 | 0.7153 |
| 1-ST Covar | 0.01351 | 1 | 0.01351 | 1.04 | 0.3157 |
| Error | 0.40254 | 31 | 0.01299 | | |