EFFECT OF STOCKING
Chlorjs gayana - Stylosanthes guianensis
PASTURE WITH SHEEP ON PLANT AND ANIMAL PERFORMANCE

BY

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DECLARATION

I hereby declare that this thesis has been written by me and it is a record of my reseach work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of references.

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CERTIFICATION

This thesis entitled "Effect of stocking Chloris gayana- Stylosanthes guianensis pasture with sheep on plant and animal performance" by O. S. Onifade, meets the regulations governing the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

To

My wife, Comfort Adenike Onifade

my father, Chief Emmanuel Omolosho Onifade
and
my mother, Deaconess Felicia Ebun Onifade.

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ABSTRACT

The effects of stocking rate (12, 18, 24, 30 and 36 sheep/ha) on the productivity of Rhodes grass (C. qayana cv. Callide) pastures (i) alone *or* with Cook stylo (S. guianensi cv. Cook) and (ii) with nitrogen (N) fertilizer (200 kg N/ha) were examined during five grazing periods from late-August to mid-April (154-210 days) during 1985-1990 at Shika in the Northern Guinea Savanna Zone of Nigeria. Phosphorus (30 kg/ha) was applied to the pastures in July before grazing commenced while N was incorporated before the 1985-1986 and 1989-1990 grazing periods.

Dry matter (DM) yields of C. gayana components, green (living portions of sown and other plant species) materials and total herbage declined as stocking rate and days of grazing increased. The amounts of stylo, other plant species and dead material also decreased with increase in days of grazing. The yield of dead material was highest at 12 sheep/ha.

Mean C. gayana sward height exceeded 100 cm at the beginning of each grazing period while its bulk density and tiller density fell as grazing days increased.

The crude protein (CP), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) contents in components of C. gayana and stylo shoots were independent of stocking rates. Calcium and CP contents declined with advanced grazing days in all periods. Magnesium and K contents in C.gayana remained constant and fell, respectively as grazing

days increased with N apolication. Herbage P content remained constant when N was omitted.

There were no significant changes in the structural components - acid and neutral detergent fiores (ADF, NDF), acid detergent lignin (ADL) and cellulose as grazing days increased. The effects of stocking rate was significant only for NDF and cellulose contents of C. gayana in the 1986-1987 period.

Daily liveweight gain of sheep was negatively and linearly related to stocking rate. Losses in daily and cumulative liveweight gain commenced between mid-January and mid-February. Calculated stocking rates giving maximum liveweight gains per hectare were 17.8, 20.4, 24.9, 21.2 and 26.0 sheep/ha in the first, second, third, fourth and fifth grazing periods, respectively. The highest liveweight gain per hectare (202.4 kg) was recorded at 30 sheep/ha during the 1989-1990 grazing period.

TABLE OF CONTENTS

Chapter		Page
	Title	i
	Declaration	ii
	Certification	iii
	Dedication	iv
	Acknowledgements	v
	Abstract	vii
	Table of contents	ix
	List of Tables	xiii
	List of Figures	xx
	List of Appendices	xxi
1.	INTRODUCTION	1
2.	LITERATURE REVIEW	4
2.1	Effect of fertilizer and stocking rate on pasture production	4
2.1.1	Soil fertility	4
2.1.2	Sward height	5
2.1.3	Botanical composition	6
2.1.4	Dry matter yield	10
2.1.5	Chemical composition	13
2.1.6	Highlights of experiments with Rhodes grass and stylo in Nigeria	19
2.2	Effect of fertilizer and stocking rate on animal production	21
2.2.1	Effect of fertilizer	21
2.2.2	Effect of stocking rate	25
2.3	Effect of pasture characteristics on animal production	29

		Page
2.3.1	Sward height	29
2.3.2	Botanical composition	30
2.3.3	Herbage on offer	31
2.3.4	*Herbage chemical composition and* digestibility	34
2.4	Effect of animal characteristics on animal production	37
2.4.1	Animal size and breed	37
2.4.2	Effect of helminthiasis on grazing animal	38
3	MATERIALS AND METHODS	
3.1	Experimental site	40
3.2	Experimental design	42
3.3	Pasture establishment	42
3.4	Pasture measurement and management	45
3.5	Chemical analysis of herbage samples	47
3.6	Animal management	48
3.7	Liveweight measurements	49
3.8	Statistical analysis	49
4	RESULTS	
4.1	Meteorological observation during the experimental period	51
4.2	Soil properties	51
4.3	Pasture production	53
4.3.1	1985- 1986 grazing period	53
4.3.2	1986- 1987 ,, ,,	58

page

4.3.3 1987- 1988 grazing period 64

4.3.4 1988- 1989 ,, ,, ... 72

4.3.5 1989- 1990 ,, ,, ... 77

4.4 Tiller density of C. gayana 83

4.5 Chemical composition of C. gayana 86

4.5.1 1985- 1986 grazing period 86

4.5.2 1986- 1987 ,, ,, ... 92

4.5.3 1987- 1988 ,, ,, ... 101

4.5.4 1988- 1989 ,, ,, ... 109

4.5.5 1989- 1990 ,, ,, ... 112

4.6 Sheep performance 114

4.6.1 1985- 1986 grazing period 114

4.6.2 1986- 1987 ,, ,, ... 118

4.6.3 1987- 1988 ,, ,, ... 125

4.6.4 1988- 1989 ,, ,, ... 129

4.6.5 1989- 1990 ,, ,, ... 132

4.7 Relationship between the liveweight gains and grazing pressure 140

5 DISCUSSION 144

5.1 Soil chemical composition 144

5.2 Plant parameters 145

5.2.1 Botanical composition 145

5.2.2 Dry matter yield 146

5.2.3 Height and bulk density 149

page

5.2.4 Tiller density 150

5.2.5 Chemical composition 150

5.3 Sheep performance 159

5.3.1 Daily liveweight gain 160

5.3.2 Cumulative liveweight gain per head 162

5.3.3 Liveweight gain per hectare 164

SUMMARY AND CONCLUSIONS 166

REFERENCES 171

APPENDIX 187

LIST OF TABLES

		Page
1	Meteorological observation at Samaru (rainfall at Shika)	41
2	Properties of the top (0-15 cm)soil of the paddocks in C. gayana -S.guianensis pasture..	52
3.1	Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and (b) green shoot of C.gayana during the 1985-1986 grazing period	54
3.2	Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1985-1986 grazing period.....	55
3.3	Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a)live stem (b) green leaf of C.gayana and (c) other plant species in the pasture during the 1985-1986 grazing period.	56
4.1	Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and(b) green shoot (stem + leaf) of C.gayana during the 1986-1987 grazing period.....	59
4.2	Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1986-1987 grazing period.	60
4.3	Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) live stem and (b) green leaf of C. gayana during the 1986-1987 grazing period.	62
4.4	Effect of stocking rate grazing duration on dry matter yield (t/ha) of (a) stylo and (b) other plant species in the pasture during the 1986-1987 grazing period.	63
4.5	Effect of stocking rate and grazing duration on (a) height (cm) and (b) mean sward bulk density (kg/ha/cm) of C. gayana during the 1986-1987 grazing period.	65

page

5.1 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and (b) green shoot (stem+leaf) of C. gayana during the 1987-1988 grazing period. 66

5.2 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1987 -1988 grazing period. 68

5.3 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) live stem (b) green leaf of C. gayana and (c) other plant species in the pasture during the 1987- 1988 grazing period 69

5.4 Effect of stocking rate and grazing duration on (a) height (cm) and (b) mean bulk density (kg/ha/cm) of C. gayana during 1987 - 1988 grazing period..... 71

6.1 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and (b) green shoot (stem+leaf) of C. gayana during the 1988-1989 grazing period. 73

6.2 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1988 -1989 grazing period. 74

6.3 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) live stem (b) green leaf of C. gayana and (c) other plant species in the pasture during the 1988- 1989 grazing period 76

6.4 Effect of stocking rate and grazing duration on (a) height (cm) and (b) mean bulk density (kg/ha/cm) of C. gayana during 1988 - 1989 grazing period..... 78

7.1 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and (b) green shoot (stem+leaf) of C. gayana during the 1989-1990 grazing period. 79

7.2 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1989 -1990 grazing period. 80

page

7.3 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) live stem (b) green leaf of C. gayana and (c) other plant species in the pasture during the 1989- 1990 grazing period 82

7.4 Effect of stocking rate and grazing duration on (a) height (cm) and (b) mean bulk density (kg/ha/cm) of C. gayana during 1989 - 1990 grazing period..... 84

8 Effect of stocking rate and grazing duration on tiller density (count/m2) of C. gayana during (a) 1986-1987 (b) 1987-1988 (c) 1988-1989 and (d) 1989-1990 grazing periods..... 85

9.1 Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf crude protein contents (%) during the 1985-1986 grazing period. 87

9.2 Effect of stocking rate and grazing duration on phosphorus content (%) in (a) stem and (b) leaf of C. gayana during the 1985-1986 grazing period. 89

9.3 Effect of stocking rate and grazing duration on potassium content (%) in (a) stem and (b) leaf of C. gayana during the 1985-1986 grazing period. 90

9.4 Effect of stocking rate and grazing duration on calcium content (%) in (a) stem and (b) leaf of C. gayana during the 1985-1986 grazing period. 91

9.5 Effect of stocking rate and grazing duration on magnesium content (%) in (a) stem and (b) leaf of C. gayana during the 1985-1986 grazing period. 93

10.1 Effect of stocking rate and grazing duration on (a) stem and (b) leaf of C. gayana and (c) stylo crude protein contents (%) during the 1986-1987 grazing period..... 94

page

10.2 Effect of stocking rate and grazing duration on (a) stem and (b) leaf of C. gayana and (c) stylo phosphorus contents (%) during the 1986-1987 grazing period..... 95

10.3 Effect of stocking rate and grazing duration on (a) stem and (b) leaf of C. gayana and (c) stylo potassium contents (%) during the 1986-1987 grazing period..... 96

10.4 Effect of stocking rate and grazing duration on (a) stem and (b) leaf of C. gayana and (c) stylo calcium contents (%) during the 1986-1987 grazing period..... 98

10.5 Effect of stocking rate and grazing duration on (a) stem and (b) leaf of C. gayana and (c) stylo magnesium contents (%) during the 1986-1987 grazing period..... 99

10.6 Effect of stocking rate and grazing duration on the content (%) of structural comoonents[1] of the stem and leaf of C. gayana during the 1986-1987 grazing period..... 100

11.1 Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf crude protein contents (%) during the 1987-1988 grazing period. 102

11.2 Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf phosphorus contents (%) during the 1987-1988 grazing period. 103

11.3 Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf potassium contents (%) during the 1987-1988 grazing period. 105

11.4 Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf calcium contents (%) during the 1987-1988 grazing period. 106

11.5 Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf magnesium contents (%) during the 1987-1988 grazing period. 107

page

11.6 Effect of stocking rate and grazing duration on the content (%) of structural components of the stem and leaf crude of C. gayana during the 1987-1988 grazing period..... 108

12.1 Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf crude protein content (%) during the 1988-1989 grazing period. 110

12.2 Effect of stocking rate and grazing duration on C. gayana stem and leaf (a) phosphorus (b) potassium (c)calcium and (d) magnesium content (%) during the 1988-1989 grazing period. 111

13 Effect of stocking rate and grazing duration on C. gayana green shoot (a) crude protein (b) phosphorus (c) potassium (d) calcium and (e) magnesium content (%) during the 1989-1990 grazing period. 113

14.1 Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana pasture during the 1985-1986 grazing period..... 115

14.2 Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (kg/hd) on C.gayana pasture during the 1985-1986 grazing period..... 116

14.3 Effect of stocking rate and grazing duration on sheep liveweight gain (kg/ha) on C.gayana pasture during the 1985-1986 grazing period.,..... 117

15.1 Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana -S. guianensis pasture during the 1986-1987 grazing period..... 120

15.2 Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (kg/hd) on C.gayana -S. guianensis pasture during the 1986-1987 grazing period..... 122

15.3 Effect of stocking rate and grazing duration on sheep liveweight gain (kg/ha) on C.gayana -S. guianensis pasture during the 1986-1987 grazing period..... 123

page

16.1 Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana pasture during the 1987-1988 grazing period..... 126

16.2 Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (kg/nd) on C.gayana pasture during the 1987-1988 grazing period..... 127

16.3 Effect of stocking rate and grazing duration on sheep liveweight gain (kg/ha) on C.gayana pasture during the 1987-1988 grazing period.,..... 128

17.1 Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana pasture during the 1988-1989 grazing period..... 131

17.2 Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (kg/hd) on C.gayana pasture during the 1988-1989 grazing period..... 133

17.3 Effect of stocking rate and grazing duration on sheep liveweight gain (kg/ha) on C.gayana pasture during the 1988-1989 grazing period.,..... 134

18.1 Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana pasture during the 1989-1990 grazing period..... 137

18.2 Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (kg/hd) on C.gayana pasture during the 1989-1990 grazing period..... 138

18.3 Effect of stocking rate and grazing duration on sheep liveweight gain (kg/ha) on C.gayana pasture during the 1989-1990 grazing period.,..... 139

19 Regression of mean daily liveweight gain per head (Y) on grazing pressures* during the grazing periods 142

page

20 Regression equations to data on mean liveweight gain per hectare (Y) and grazing pressures of plant variables* during the grazing periods..... 143

LIST OF APPENDICES

page

1 Analysis for crude protein content..... 187

2 Analysis for structural components..... 188

CHAPTER 1

INTRODUCTION

Ruminant animals offer the cheapest source of domestically produced protein in Nigeria (Ademosun, 1988) if the animals and grazing land resources are carefully managed. Both the small and large ruminants live mainly on roughages, agro-industrial by-products and native pasture grazing but the small ruminants (sheep and goat) which are also kept in the households have access to wastes of varying quality.

The indigenous breeds of sheep and goats in Nigeria have been described (Ferguson, 1964; Adu and Ngere, 1979: Ngere, Adu and Okubanjo, 1984). These are more evenly distributed over the ecological zones of Nigeria than cattle,account for about 35 % of the meat produced locally (Olayiwole and Adu, 1988), contribute to the production of hides and skins and are used in traditional and religious festivals in the country. They also serve as a source of income and a security against crop failure. Small ruminants are handy experimental animals (Ademosun, 1988) that fit into all existing agricultural production systems (Aken'ova, 1985; Adegbola, 1988). However, sheep are the easier to confine within an enclosure, more able to utilize herbaceous forages and have higher growth rate on sown pastures than goats. Sheep require less dry matter intake per body weight to be in positive nutrient balance (Adu, 1990) and less energy level for maintenance and growth than goats.

Nigeria's sheep population was estimated at about 12.85 millions (F.A.O, 1985). The contribution of sheep to total meat production can be increased by improving the nutrition

of local breeds and reducing disease incidence. Ruminant production in Nigeria is constrained by inadequate supply of feed (in quality and quantity) which often reaches critical levels in the dry season. Improved pastures of grass-legume mixtures among other feed resources, can support year-round grazing as they produce nutritious herbage for most of the year (Adegbola and Onayinka, 1966) while sole legume grazing as fodder banks are invaluable in supplementing dry season grazing (Haggar, de-Leeuw and Agishi, 1971). However, utilization of fodder banks is more labour demanding (herding the animals from the natural grassland to the bank and back) than continuously grazing a grass-legume mixture. Forage grazing under good management should reduce the need for costly supplementary concentrate feeds and ensure that the weight gained during the rainy season is at least maintained during the dry season. Thus a decrease in time to reach slaughter weight and higher annual offtake would increase the supply of animal products for human consumption and exportation.

Indoor feeding trials with indigenous sheep and their crosses on grass or legume or grass-legume hays are well documented. The procedure involved is less economical than putting the stock to graze. Grazing trials to determine the productivity of pasture especially with sheep are few in Nigeria. At Ibadan, in the humid zone of Nigeria, 16 and 8 West African Dwarf sheep were supported per hectare during the main wet (June -November) and dry season (November - April) respectively on fallow in an integrated alley farming system sown to Leucaena leucocephala and Gliricidia sepium (Sumberg, 1984). The author recorded a liveweight gain of

218 kg/ha from the concentrate supplemented ewes during the dry season. Stocking rate is a major determinant of animal performance under pasture grazing conditions. A study in this vital area aimed at increasing mutton production from the Nigerian grazing land will provide some basic information to small and large scale (e.g. ranching) livestock farmers regarding the response to grazing of pasture and sheep components.

This study was undertaken to evaluate the effects of stocking Rhodes grass (Chloris gayana cv. Callide) - Cook stylo (Stylosanthes guianensis cv. Cook) pasture with sheep on the plant and animal performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Effect of fertilizer and stocking rate on pasture production.

In grazing situations changes occur in soil fertility and in the height,botanical composition, dry matter and chemical composition of pastures regardless of fertilizer application and stocking rate.

2.1.1 Soil fertility

At Wollongbar in New South Wales, Australia, Mears and Humphreys (1974a) reported that Kikuyu grass (Pennisetum clandestinum) responded to 350 kg N/ha above the basal rates of 0-336 kg N/ha indicating a low soil residual N. The authors also reported that increasing stocking rate from 4.9 to 11.1 weaner cattle/ha over two years did not improve the N economy of the pasture due to the uneven distribution of dung and urine. This observation is similar to those of Peterson, Lucas and Woodhouse (1956) and Shaw, Brockman and Wolton (1966). Davidson (1964) however, suggested that in theory N availability in the soil may be improved by high stocking rates.

At Rodd's Bay, Queensland, Australia, drought depressed N fixation by S. humilis in grazed grass-legume pastures but during favourable weather, soil N was increased by the legume (Vallis, 1972). Similar increases in soil N were reported by Bryan (1962), Henzell (1968) and Williams (1979). In addition to dry conditions, Vallis (1972) indicated that soil N could be decreased by other factors such as the loss of N through volatilization of ammonia in faeces and urine, reduction in plant cover and transfer of N in urine and

faeces to particular spots rather than uniform excretion in the paddock. In another trial with a Siratro based pasture at Samford, Vallis (1972) observed that continuous grazing was better in increasing the soil N than grazing thrice a year.

Phosphorus levels up to 22.5 kg/ha did not affect soil P content in temperate mixed pastures with a long history of superphosphate application because of P and sulphur(S) content of the fertilizer (Curll, 1977a,b).

Till and May (1973) suggested that the rate of S addition to soil should be lowered under grazing conditions than under a cut and carry system because recycling of the mineral made it more available. Watson and Whiteman (1981) supported this suggestion as crude protein (CP), P, potassium (K) and S contents of the pasture increased with increasing stocking rate. It is suggested that periodic tests be carried out on soil chemical properties under sheep grazing to know the nutrient status of the soil.

2.1.2 Sward height

It would appear that the height of grazed pastures generally declines as stocking rates increase. Chacon, Stobbs and Dale (1978) at Beerwah, Queensland, confirmed this in respect of grazed pure Nandi Setaria (Setaria anceps cv. Nandi) and pangola (Digitaria decumbens) pastures. Similarly, on the Guadalcanal Plains in the Solomon Islands, Watson and Whiteman (1981) reported lower plant heights as stocking rates increased from 1.8 to 4.5 cattle/ha. The pastures used were centro (Centrosema pubescens), Siratro (Macroptilium atropurpureum cv. Siratro) and stylo (S. guianensis cv. Endeavour) in a mixture with each of

para (Brachiaria mutica), signal (B. decumbens) and hamil (Panicum maximum cv. Hamil) grasses. With respect to sheep, the height of grazed pasture should not limit herbage intake and animal production.

2.1.3. Botanical composition

In Malawi, Addy and Thomas (1978) stocked a six-week old C. gayana pasture which received 45 kg N and 20 kg P/ha annually at 2.5 to 7.5 livestock units (LU)/ha (1 LU = 342 Kg liveweight). At the end of three wet seasons, these authors recorded no change in the pasture botanical composition. Similarly Mears and Humpbreys (1974a) found that over a two - year period, the proportion of the dominant grass specie; Kikuyu (Pennisetum clandestinum) was independent of stocking rate (4.9 to 11.1 weaner cattle/ha). Stobbs (1969) reported a contrasting finding when heavily grazed Jaragua grass (Hyparrhenia rufa) was partly associated with an increase in weeds content (especially Sporobolus pyramidis) because of its poor competitive ability compared with the more aggresive C. gayana.

Domination of the other grasses by Kikuyu grass in the grazed sward occurred at the higher N rates (336 and 672 kg/ha) (Mears and Humphreys, 1974a) and continued up to the 8th year (Roberts, 1980). Mears and Humphreys (1974a) attributed this rapid development of the grass to the spread of seed in the dung and the basal application of P, S, K and molybdenum (Mo) to the pasture. Similar stability of N fertilized pure pangola grass for a long period and over a wide range of stocking rates was reported under irrigation in northern Australia (Evans, Pulsford and Ebersohn, 1978 cited in Roberts, 1980; Blunt, 1978). On the other hand,

Deans et al. (1976) reported changes in the botanical composition of Pangola grass fertilized at 336 kg N/ha/yr under irrigation due to replacement by couch grass (Cynodon dactylon) after seven years. Jones (1974) also observed that blue couch (Digitaria didactyla) replaced Nandi Setaria (Setaria sphacelata spp sericae cv. Nandi) in the tenth year at the highest stocking rates. At Hurley, U. K., Curll, Wilkins, Snaydon and Shanmugalingam (1985a) showed that the application of 200 kg N/ha reduced the white clover (Trifolium repens cv. Bianca) content of a mixture with perennial ryegrass (Lolium perenne) in a set stocked sheep grazing trial. This was attributed to increased grass growth and selective clover grazing.

Application of superphosphate at the rate of 10-40 kg P/ha in northern Cape York Peninsula, Australia, produced stable pastures of signal and guinea (Panicum maximum) grasses mixed with Endeavour stylo and Siratro at the end of a three-year grazing study with cattle at 0.7 to 2.2 beasts/ha (Winter, Edye, Megarrity and William, 1977a). The grass averaged 58 % while stylo and Siratro averaged 34 and 8 %, respectively. At Rodd's Bay, Queensland, Shaw (1978) also showed that in oversown pasture, stability in the botanical composition of a Townsville stylo (S. humilis) - spear grass (Heteropogon contortus) pasture occurred after the third year at stocking rates higher than 1.1 cows/ha.

In the Mediterranean environment of New South Wales, Australia, Curll (1977a) reported the dominance of subterranean clover (T. subterraneum cv. Mt Baker) in mixture with perennial ryegrass at 0 and 5.6 kg P/ha and at a stocking rate of 13.3 ewes/ha. He attributed this to a

reduction in the amount of ryegrass on offer rather than of an increase in clover content. The reduction in grass was due to its lower ability to withstand repeated close grazing at this stocking rate. On the other hand, application of 11.2 and 22.5 kg P/ha, favoured ryegrass at the lower stocking rate (10 ewes/ha) because there was an increase in the supply of nitrogen from clover which was selectively grazed by sheep. In a similar study with cattle Curll (1977b) showed that with the same levels of phosphorus the grass, phalaris (Phalaris aquatica cv. Australian) dominated subterranean clover in the mixture as a result of P application and increased competition. In the unfertilized plot, phalaris and clover occurred in similar proportions, contrary to the study with sheep in which clover was dominant. This was attributed to the inability of cattle to graze as closely as sheep so that the clover's potential to withstand grazing could be shown.

At Serere, Uganda, Stobbs (1970) reported the suppresion of Siratro by guinea grass and of stylo by Jaragua grass at 1.65 steers/ha while at 2.47 and 4.94 steers per/ha the legumes became dominant. Shaw (1978) observed a similar suppression of Townsville stylo by spear grass at 0.55 and 1.10 cows/ha. Both studies indicated that under lenient grazing where the grass species are abundant and of lower feeding value, the content of the companion legume was reduced presumably because of preferential consumption. In contrast, a decline in legume content was accompanied by a rise in grass and/or weed content as age and of the pasture and stocking rate increased in mixtures of Lotononis bainesii and T. repens with C. gayana cv. Pioneer, Paspalum spp

and D. decumbens (Bryan and Evans, 1973); and of S. guianensis, C. pubescens and Pueraria phaseoloides with P. maximum (Eng, Kerridge and 't Mannetje, 1978a). Curll and Davidson (1983) observed that wild barley (Hordeum leporinum), an annual grass, dominated a phalaris-subterranean clover pasture at 22 sheep/ha due to the high tillering rate of the annual grass and its ability to recover more quickly than the perennial species under frequent grazing. At the lower stocking rate (11 sheep/ha), however, clover dominated. Curll et al. (1985a) also attributed the adverse effect of 45 sheep/ha on white clover content to the selective grazing of the legume by sheep and continuous defolation at a high stocking rate or grazing pressure. Gutteridge (1985), in Thailand ascribed the poor performance of S. humilis cv. Lawson, S. hamata cv. Verano and S. guianensis cv. Endeavour to the poor utilization of bamboo grass (Arundinaria ciliata) where only the leafy material and the very fine stem were consumed while the coarse, inedible portion shaded and reduced the development of the oversown legumes. In the Solomon Islands, Watson and Whiteman (1981) in a study that lasted over four years, reported the contrary. They explained the increase, with time, of the content of centro, Siratro and Endeavour stylo in para and signal grass pastures to the uniform rainfall on the Islands compared with the Australian tropics with periods of moisture deficit and unfavourable winter temperature where legume content declined with time and high stocking rates (Robert, 1980).

Observations at Umudike in south eastern Nigeria showed that stylo was sensitive to mowing and cattle trampling but

tended to recover under sheep grazing because of their preference for the leaf (Anon, 1964). However, Blair Rains (1963) at Shika, Nigeria, recorded higher stylo content in Rhodes grass when grazed (by cattle) rather than mown. This increase was attributed to regular grazing which reduced the N status of the soil, thereby favouring legume growth. The study also showed that grazing the stylo on a 24 hourly basis eliminated the legume compared with grazing at daytime only. This result was ascribed to higher N available from dung in the former than the latter method of grazing thus favouring grass growth.

It appears that both fertilizer regimes and stocking rates with other factors such as the type of grazing animal, method of grazing, age and yield of the pasture, specie reaction to grazing, the competitive abilities of plant species and climate are important in evaluating the botanical changes in grazed pastures. Thus,to ensure year round availability of feed, especially of the leaf components, consideration should be given to the management of pastures.

2.1.4 Dry matter yield

Herbage dry matter yield is influenced by the pasture species involved, season of the year, age and the management imposed on the pasture (Winter et al., 1977a, Chacon et al., 1978; Watson and Whiteman, 1981). Mears and Humphreys (1974a) applied 0-672 kg N/ha to a Kikuyu dominated pasture grazed by cattle and observed that beyond 0 - 336 kg N/ha, increase in N rate resulted in lower availability of leaf, stem and total green matter. This was due to outgoing process of animal consumption and sensescence which exceeded growth ~~response~~ to N at higher rates. Okeagu (1981) worked

on B. decumbens and recorded growth response of the grass up to 400 kg N/ha on the grazed pasture. Increasing N rate from 288 to 480 kg/ha on D. decumbens had variable effect on dry matter yield on offer during a 19-month grazing period in the Wallum region of Queensland, Australia (Tierney and Goward, 1983a). Here, higher yields accompanied the high N rate for 10 months during the whole period while yield on offer favoured the low rate at other times.

Herbage on offer decreased as stocking rate was increased from 25 to 55 sheep/ha and was greater where 200 kg N/ha was applied than where N was not applied (Curll et al., 1985a). At the lowest stocking rate (25 sheep/ha) herbage on offer increased linearly up to 200 kg N/ha before declining. However, at the highest stocking rate herbage on offer declined throughout the growing season.

Annual maintenance application of 10 to 40 kg P/ha to pastures of signal or guinea grass mixed with Endeavour stylo and Siratro (Winter et al., 1977a) did not affect the dry matter on offer significantly until the third season when at the highest P rate legume yield was smaller but total yield was higher than at the lowest rate. Dry matter yield of Townsville stylo oversown in spear grass at Rodd's Bay, Australia (Shaw, 1978) increased with P levels from nil to 22.5 kg/ha/yr. In the presence of P the yield also increased at the higher stocking rates of 0.69 to 1.65 steers/ha.

Curll (1977a) noted that the amount of ryegrass-clover pasture available from unfertilized plots declined over the three-year experimental period. The decline was most pronounced at the high stocking rate (13.3 ewes/ha). In the trial, application of 5.6 to 22.5 kg P/ha increased the

pasture yield at both 10 and 13.3 ewes/ha, but the relationship between pasture yield and P level was non-linear. Similar relationships occurred when a mixed phalaris-clover pasture given the same range of P was cattle-grazed at 1.85 animals/ha (Curll, 1977b). The two pastures had a long history of continuous superphosphate application and it was thought that pasture response was caused by both P and S in the fertilizer applied.

With increasing stocking rate at the same N and P levels, total dry matter, green herbage and leaf yields decreased but green leaf percentage increased (Mears and Humphreys, 1974a; Chacon et al., 1978; Addy and Thomas, 1978; Watson and Whiteman, 1981; Tierney and Goward, 1983a). For a mixed guinea grass-centro, stylo and puero pasture, Eng et al., (1978a) recorded a significant reduction in total and grass component dry matter yields as stocking rate increased. Legume dry matter yield, on the other hand, was not affected at 2 and 4 bulls/ha but declined greatly at 6 bulls/ha, with an increase in the proportion of bare ground and volunteer species. The indication was that the pasture could not withstand the grazing pressure at the high stocking rate.

In north eastern Thailand where cattle preferred the leaves and very fine stems of bamboo grass (A. ciliata), leaf yield and leaf to stem ratio declined with increase in stocking rate from 2.5 to 6.5 AU/ha over a period of 6 months (Gutteridge, 1985). This finding is contrary to the general expectation that the two components increase with higher stocking rates at which more stems are consumed thus stimulating more branch formation and subsequently increased leaf appearance.

In comparing the sward structure of three different grass-legume mixtures, Watson and Whiteman (1981) noted that green bulk density increased as stocking rate increased. Conversely, Chacon et al. (1978) observed that the bulk densities of the sward, green, leaf and dead components tended to decline with increase in stocking rate in pure grass swards. The former may not be conclusive because the measurements were taken only once throughout the four years of study while the latter covered two periods each of summer and spring and one winter period in a sixteen month study.

2.1.5 Chemical composition

Effect of stocking rate on pasture crude protein content

Pate (1968) explained that nitrogeneous compounds were translocated from underground organs of plants to the leaves and meristematic tissues of the shoot apex. This was supported by Henzell and Oxenham (1964) and Mears and Humpheys (1974a) who indicated that CP content of grass pastures decreased in the descending order: leaf, stem, rhizome and roots. As stocking rate increased from 4.3 to 8.0 steers/ha, the leaf and stem CP content of pangola and Setaria increased (Chacon et al., 1978). Mears and Humphreys (1974a) obtained comparable results from grazed kikuyu grass pasture especially at higher N rates and in this case, the leaf and stem CP content was positively and significantly related to nitrogen rates irrespective of sampling date. Okeagu (1989) in a more recent study at Shika, Nigeria, reported significant effects of stocking rate (3 to 9 bulls/ha; 1 bull = 200 kg liveweight) on the CP contents of B. decumbens and D. smutsii pastures in the first grazing period (1985 -1986) of 160 days. However, the effect was

inconsistent in the second grazing period (1986 - 1987) of 252 days except in the B. decumbens during the early dry season when CP values declined with decrease in stocking rate. During both grazing periods, CP values of both pastures decreased as grazing progressed from late wet to late dry season. But in pangola grass pasture, Tierney and Goward (1983b) found that stocking at 4.94 to 9.90 steers/ha had no effect on CP values of D. decumbens. In addition, the CP contents of the pastures declined during the dry and cold winter especially at the low and medium stocking rates. In Malaysia, Chen and Othman (1986) observed no clear effect of stocking rate (4.0 to 8.0 bulls/ha) on the CP content of D. setivalva over a four - year period. In the experiment, CP contents fluctuated significantly among sampling dates.

Effect of season, stocking rates and age and type of pasture on forage mineral content

Bryan and Evans (1973) found no differences in the CP, P, K, Ca and Mg contents of Lotonis bainesii, T. repens, C. gayana cv. Pioneer, Paspalum spp and D. decumbens as stocking rate increased from 1.23 to 2.47 steers/ha. They explained this in terms of similar physiological ages of pasture species at sampling in all paddocks. This is not in agreement with the conclusions from various grass-legume mixtures which indicated that CP, P and S contents of pastures rose as stocking rate increased (Winter et al., 1977a; Eng et al., 1978a; Watson and Whiteman, 1981). Such increases were shown to be higher in the grass than in the legume component. Eng et al. (1978a) reported a decline in

Whiteman (1981) over a four- year period found no difference in the CP and S contents of the pastures. They recorded consistently higher leaf CP and S percentages in para grass than hamil guinea grass and signal grass pastures when analysed over three years at the same stocking rates and with the same legume companions. Among the legumes, centro had higher CP and S contents than Siratro and Endeavour stylo.

Tierney and Goward (1983b) and Chen and Othman (1986) recorded no clear effect of stocking rate on the P, K, Ca and Mg contents of the pure grass pasture offered to cattle. However, the effect of season and stage of growth on mineral contents of grazed pastures differed from one nutrient to the other. While contents of P, K and Mg were higher during summer and low during autumn-winter, calcium content tended to decrease with time from autumn to early summer and began to rise over summer (Tierney and Goward, 1983b). In New Zealand, Ca and Mg contents of pasture periodically grazed down by sheep were highest in summer and lowest in mid winter with variations in Mg levels (Metson and Saunders, 1978). The value for K showed large monthly fluctuations, being lowest in early summer and highest in early spring.

The data of Reid, Post and Olsen (1979) in Uganda indicated a general decline in the Ca, P and K concentrations with the exception of Mg, with maturity of tropical pasture species. This trial examined the mineral contents in selected species of Brachiaria, Chloris, Setaria and Panicum up to the twentieth week of growth . In addition to the effect of stage of maturity on forage mineral content, McDowell, Conrad, Ellis and Loosli (1983) mentioned the interaction of other factors such as the soil

characteristics, plant species, yield, pasture management and climate. Gomide, Noller, Mott, Conrad and Hill (1969) and Blue and Tergas (1969) reported that, with increased growth and maturity of tropical grasses K content decreased. From the wet to the dry season in the Australian Northern Territory, the P and K contents of plucked C. gayana cv. Callide leaf declined from 0.21 to 0.11 % and 2.9 to 2.0 %, respectively (McCosker, 1987). Earlier, Jones (1963) in Zimbabwe found that with the exception of Ca the contents of other minerals in H. dissoluta and C. dactylon declined with advanced maturity and season.

Oyenuga (1960a,b) studied the effect of cutting frequencies on guinea grass and Guatemala grass (Tripsacum laxum). The levels of P and Mg in the two grasses decreased as the frequency of cutting increased from every 3 to 12 weeks. On the other hand, Ca contents tended to increase.

Effect of P application on pasture mineral content

With increase in P from 20 to 250 kg /ha the P and Ca percentages of grasses and P contents of legumes appeared to increase (Bryan and Evans, 1973; Eng et al., 1978a). However, Winter et al. (1977a) found that the P contents of signal and guinea grasses were not affected by lower rates of P (10 - 40 kg/ha). With sheep (Curll, 1977a) and cattle (Curll, 1977b) the non-significant effect of superphosphate rates on the P content of green and dead herbage of the temperate pastures examined was ascribed to the combined effect of P and S in the superphosphate received by the pasture over a long time.

Superphosphate application had no effect on legume CP content until the third year and this occurred in stylo only

(Eng et al., 1978a). This is at variance with the reports by Shaw et al., (1966), Andrew and Robins (1969) and Bryan and Evans (1973) that CP content of legumes increased with applied P levels.

From the foregoing, it can be deduced that for any given grazed forage species, the interactions among climatic, soil and management may confound the levels of CP and minerals in the whole pasture plant or its component parts .

2.1.5.2 Structural components

Acid detergent fibre (ADF)

Okeagu (1989) investigated the effect of stocking at 3, 6 and 9 bulls/ha on ADF content of B. decumbens and D. smutsii in Shika, Nigeria. The higher ADF values reported as stocking rate decreased in the two-year trial was attributed to reduced production of less lignified new tillers in the low stocking rate compared with the high stocking rate. In the same study, ADF contents of both grasses increased as the age of the grazed sward increased. This is in agreement with the reports of Colburn and Evans (1967), Gomide et al. (1969) and Coward-Lord, Arroyo-Aguilu and Garcia-Molinari (1974) that with age, plant lignocellulose content rose.

Neutral detergent fibre (NDF)

This constitutes the total fibre fraction of a plant. The difference between 100 and NDF (cell wall) gives the neutral detergent soluble (NDS) fraction of the plant (cell content) which consists of proteins, lipids, soluble carbohydrates and ash. In Shika, Okeagu(1989) found that NDF contents of B. decumbens increased as stocking rate decreased during the first year of grazing. This was

attributed to large proportion of young tillers at the higher stocking rate compared with the lower stocking rates. Another factor that accounted for reductions in NDF and other cell components was increased mineralization of soil nitrogen as recorded for mechanically harvested perennial ryegrass (Wilman, Daly, Koocheki and Lwoga, 1977).

Generally, NDF contents of pasture plants increased with maturity and decline in leaf to stem ratio (Coward-Lord et al., 1974; Griffin and Jung, 1981; Okeagu, 1989). Also, between pasture species differences in NDF contents occurred (Okeagu, 1989).

Acid detergent lignin (ADL)

The ADL contents of B. decumbens and D. smutsii increased as the stocking rate decreased (Okeagu, 1989). This finding was ascribed to faster lignification as a result of reduced moisture, high temperature, reduced leaf to stem ratio, higher plant density and higher content of old plants during the dry season. In the same study, ADL contents in both grasses were increased as grazing continued into the dry season. The emergence of inflorescence, high temperature, species differences, (McLeod and Minson, 1974) and changes in the leaf to stem ratio (Cook and Harris, 1950) have been found to increase the lignin content of the grass forage.

Cellulose

In Brazil, Gomide et al.(1969) recorded that cellulose content rose from 28 to 40 % at 4 and 36 weeks of growth respectively in P. purpureum and P. maximum while in other grasses (D. decumbens, P. clandestinum and C. dactylon) the changes (36 to 40, 26 to 30 and 31 to 32 % respectively) were

negligible. Frequent cutting or grazing to maintain a leafy, vegetative pasture appeared to reduce the variations in cellulose content (Bailey, 1964; Borget, 1966; Waite, 1970) of both temperate and tropical grasses.

The data of Okeagu (1989) indicated lower cellulose contents at the high, than the medium or low stocking rate. In addition, he found that cellulose content increased as the grasses advanced in age during each of the two grazing periods. In ten tropical grasses, Coward-Lord et al. (1974) recorded a range of 30.8 to 35.2 % cellulose in a cutting experiment. Other studies on tropical grasses showed that the stem tissue had higher levels of cellulose and hemicellulose than the leaf (Bailey and Connor, 1972; Bailey and Hunt, 1973). From the foregoing, it would seem that cell structural constituents of grazed pastures increase as duration of grazing increased.

2.1.6 Highlights of experiments on Rhodes grass and stylo in Nigeria.

Rhodes grass and stylo have been sown in Nigeria by broadcasting or drilling (Blair Rains, 1963; Haggar, 1971; Akinola, 1977; Onifade and Akinola, 1986). Schofield stylo was oversown in savanna grassland (Haggar et al., 1971) while Rhodes grass (Blair Rains, 1963) and Cook stylo (Saleem, 1985) were undersown in millet (P. typhoides) and in sorghum (Sorghum bicolor) respectively.

Application of 20 kg P/ha to Schofield stylo increased the initial growth (Agishi and de Leeuw, 1986). A basal N application is beneficial in N deficient soils but 50 and 200 kg N/ha, respectively will suppress Alysicarpus glumaceus (Blair Rains, 1963) and Cook stylo (Onifade and Akinola,

1990) in Rhodes grass.

Dry matter yield of Cook stylo increased with increasing seeding proportions of the legume in stylo-Rhodes grass mixtures (Onifade and Akinola, 1986). This effect persisted into the second year when the mixture produced a total dry matter yield of 8.2 to 8.6 t/ha. Haggar (1971) observed higher yield of Schofield stylo under four cuttings than under two cuttings in a year when 84-252 kg N/ha was applied to a Rhodes grass-stylo pasture. Cutting at the lower frequency favoured stylo yield when nitrogen was not applied. Comparable results were given for Cook stylo in mixture with Rhodes grass (Onifade and Akinola, 1990) and for Schofield stylo in signal grass (Akinola, 1981). Akinola (1977) reported total DM yields of 13.5 and 14.4 t DM/ha of Schofield stylo-signal grass when the legume was broadcast and drilled in rows, respectively.

A pure sward of Rhodes grass receives up to 200 kg N/ha under rainfed conditions. Under flood irrigation, the dry matter yield increased with added fertilizer N up to 400 kg/ha (Ariba, 1987).

Rhodes grass and Endeavour stylo were among other hays evaluated with supplemented sheep in an indoor feeding trial (Brinckman, 1974). Rams gained 112 g/hd/day on stylo and 62 g/hd/day on the grass hay. When the hays were fed alone, losses in body weight, 81 g and 65 g/hd/day, were recorded for the grass and stylo, respectively - indicative of their poor quality. In a comparative nutritive evaluation, involving the use of 200 g concentrate and 1 kg of Cook or Endeavour stylo hay per ram per day, Cook stylo intake was higher but daily liveweight gains from Endeavour stylo was

higher (142.9 g versus 91.4 g) (Adu, Agishi and Brinckman, 1977).

The various studies cited above were conducted on cut conserved and fed forages of both Rhodes grass and stylo. There is the need to examine the productivity of these species with the grazing animals such as sheep doing the harvesting themselves.

2.2. Effect of fertilizer and stocking rate on animal production

2.2.1 Effect of fertilizer

2.2.1.1 Nitrogen

Grazing trials have demonstrated that N fertilized grass swards give higher cattle liveweight gains than legume based ones (Grof and Harding, 1970; Jones, 1973). In northern Queensland, Australia, Grof and Harding (1970) working with a guinea grass - centro pasture noted a mean cattle liveweight gain of 470 kg which was lower than the 661 kg/ha/yr recorded when the grass received 165 kg N/ha. Studies over a four- year period in south eastern Queensland showed highest annual liveweight gain of 475 kg/ha from Nandi Setaria grass pasture fertilized at 336 kg N/ha/yr compared with liveweight gains of 243 kg and 233 kg/ha from Setaria mixed with greenleaf desmodium (Desmodium intortum cv.Greenleaf) and Siratro, respectively (Jones 1973). The stocking rates were higher for the nitrogen fertilized than the mixed grass-legume pastures.

The responses of animals to nitrogen fertilized grass pastures also depend on the type of grass, location, season, grazing system and rate of application (Evans and Hacker,

1973; Chacon et al., 1978; Okeagu and Akinola, 1982). Evans and Hacker (1973), over three summer periods found no differences in beef production from any of the pasture grasses, Nandi, Kazungula and Narok Setaria, Kikuyu and pangola fertilized at 476 kg N/ha/yr and rotationally grazed by cattle. On the other hand, Chacon et al. (1978) working on the same station, Beerwah, in south eastern Queensland, reported growth rates of 342 and 462 g/hd/day for steers continuously grazed on Nandi Setaria and pangola grass, respectively at 378 kg N/ha/yr. Okeagu and Akinola (1982) found significant increases in daily liveweight gain of cattle grazing signal grass as the level of fertilization rose from 100 to 400 kg N/ha. In the first wet season, steers gained 0.30 and 0.69 kg/hd/day at the least and highest N levels respectively. In the second wet season, the corresponding liveweights gained were 0.44 and 0.86 kg/hd/day. At Serere, Uganda, annual cattle liveweight gain of up to 560 kg/ha was reported with 157 kg N/ha to grass pastures (Stobbs, 1969).

The effects of 288 and 480 kg N/ha on liveweight gains per animal and per hectare on pangola grass differed little over stocking rates from 4.94 to 9.90 steers/ha (Tierney and Goward, 1983a). The liveweight losses and gains per hectare for the two N levels varied from -223 to 778 kg over 19 months of grazing with the losses in weight occurring during an extreme cold winter when grass crowns died. Mears and Humphreys (1974b) recorded significant differences in liveweight gains per hectare between 0 and 672 kg N/ha on Kikuyu grass. Liveweight gains per hectare were lower in the first than in the second year, varying from 300 to 1056 kg

for zero and the highest N level, respectively. The corresponding higher values in the second year of 637 and 1475 kg/ha were related to more favourable climatic conditions for pasture growth, cycling of previous N applications and higher clover content at low N levels. They also reported that maximum efficiency of response to N was in the range of 134 to 336 kg/ha for liveweight gain.

Curll et al. (1985a) in the U.K. noted that without nitrogen fertilization liveweight gains per hectare for sheep set-stocked on perennial ryegrass - white clover declined rapidly at stocking rates above 25 sheep/ha. With 200 kg N/ha, liveweight gains were similar to unfertilized plot at 25 sheep/ha but increased at higher stocking rates. The deduction from the literature points to higher animal production with application of nitrogen fertilizer to grazed pasture. This may also hold true where the existing sown species is dominant.

2.2.1.2. Phosphorus

Increases in animal liveweight gains due to a rise in the level of P applied have been associated with increases in pasture DM production (Robinson and Lazenby, 1976; Curll, 1977a; 1977b), legume content of the Rhodes grass - Desmodium spp pasture, P and CP content of the plant material (Bryan and Evans, 1973) and organic matter digestibility (Thornton and Minson, 1973).

On a natural pasture oversown with white clover, Robinson and Lazenby (1976) initially related sheep liveweight gains to the amount of pasture available. In the

latter part of the five-year study, higher liveweight gains were recorded from pastures to which higher P levels were applied due to an improvement in pasture quality. Curll (1977a, 1977b) working separately with sheep and cattle found that over a three-year experimental period, single superphosphate (22.5 kg P/ha) increased the pasture on offer and consequently animal liveweight gains. Over a six-year period, Evans and Bryan (1973) in south eastern Queensland, reported that pasture which received 12 kg P/ha in form of single super-phosphate produced half the daily liveweight gain (from March to September) of that which received 24 kg P/ha.

In the first year of 24 weeks' grazing and in the third year, at stocking rates of 2 and 4 steers/ha, the application of 20 kg P/ha as triple superphosphate to guinea grass - stylo, centro and puero pasture resulted in higher liveweight gains than the applications of rock phosphate at 20-80 kg P/ha (Eng, 't Mannetje and Chen, 1978b). This result favoured the use of triple superphosphate with readily available P than rock phosphate on grass-legume pastures for higher liveweight gain.

The effect of phosphorus on liveweight gains is not always positive. Winter et al. (1977b) recorded that in the third and final year of their study, the application of 10 kg P/ha/yr as double superphosphate which gave the lowest gain in the first two years markedly increased daily liveweight gain per animal to give a non-significant effect of P over the study period. The mean annual liveweight gain/ha of 237 kg was recorded in the second and third year from the P fertilized (40 kg/ha) B. decumbens and P. maximum pastures

both mixed with Siratro and Endeavour stylo and stocked at 1.7 animals/ha. This low value from the humid equatorial of Northern Cape York Peninsula differed from results from the wet tropics (Grof and Harding, 1970) and in the subtropics (Evans and Bryan, 1973; Jones, 1974). Winter et al. (1977b) attributed the low value first to the 4 to 4.5 months of dry season compared with a maximum period of 3 months of low production in the other environments.
Secondly, the animals were not removed from the pasture when they reached 450 kg but 542 kg/head. Perhaps lighter animals would have increased the production level.

The effect of applying P as single superphosphate to Rhodes grass pasture, with and without a legume,on soil chemical changes and on plant and animal responses are worth investigating.

2.2.2. Effect of stocking rate

The widely quoted model proposed by Mott (1960) showed the relationship between gain/animal (Ya) and stocking rate (x) to be a modified exponential function of the form:
$Ya = k - ab^x$ where k, a and b are constants. The constants were calculated from theoretical considerations and examination of results from eight stocking rate trials (one with sheep) to give the equation:-
$Ya = 1.1214-(0.0014)\ (84.54)^x$.

The reports of Petersen, Lucas and Mott (1965), Owen and Ridgman (1969) and Conniffe, Browne and Walshe (1970) from theoretical studies and grazing trials with sheep or steers supported the model of Mott (1960) for the relationship between stocking rate and gain per animal. The trends for

gain per animal were similar before an optimum stocking rate (OSR) was reached but differred beyond the OSR. However, reviews by Riewe (1961) of cattle stocking rate trials, Cowlishaw (1969) of 14 grazing studies and Hart (1972) of cattle grazing trials based mainly on continuous grazing system showed the relationship to be linear. Other studies with cattle and sheep that conformed with the linear model are those by Bennett, Morley, Clark and Dudzinski (1970) Scarisbrick (1971) and Jones (1974). The relationship was expressed as $Ya = a - bx$ (Jones and Sandland, 1974). They also proposed that gain at optimum stocking rate could be predicted from two stocking rates with replications and at stocking rates greater than twice the OSR, gain per animal was negative.

Connolly (1976) re-examined the work of Jones and Sandland (1974) and concluded that first, a choice of three or more stocking rates and possibly herd replication spanning the true OSR would reduce the biases that might arise from specifying a linear relationship between animal gain and stocking rate and also allow some discrimination between the linear and quadratic models. Secondly, a wide spread in stocking rate would reduce the variances of estimated OSR and gain at this rate. It would also show up departures from linearity much better.

Bird, Cayley and Watson (1978) stocked pure rye-grass and subterranean clover with steers at 1.2, 1.8, 2.4, 3.0 and 3.27 animals/ha and reported optimum stocking rates of 2.68 and 3.04 steers/ha in the first and second year respectively using the linear model. However, the maximum liveweight gains per animal at these stocking rates were not the

economic optimum because the animals were too lean for the market. This error was attributed to the choice of stocking rates not spanning the optimum as suggested by Connolly (1976) despite the number of stocking rates.

Stobbs (1970) observed that liveweight gain per head fell with a reduction in stocking rate during the wet season. This contrasted the model proposed by Jones and Sandland (1974) but was attributed to the excessive growth of Hyparrhenia rufa at low stocking rates, as a consequence of which a large proportion of the herbage was of very low nutritive value. Winter et al. (1977b) also reported another anomally of complete absence of significant effect of stocking rate on daily liveweight gain per head when cattle grazed B. decumbens or P. maximum mixture with Siratro and Endeavour stylo. However, when the data was analysed to test the effect of season (Edye, William and Winter, 1978), it was established that the linear effect (Jones and Sandland, 1974) was operating during the dry season and the "Stobbs" effect in the wet season. The two factors found to contribute to this wet season relationship were (i) the differential compensatory effect and (ii) the differences observed in the cattle such as the grazing pattern at low and high stocking rate and the type of pasture species which affects the behaviour of cattle grazing grass-dominated pastures. On the other hand, Shaw (1978) found that the antagonistic relationship between stocking rate and the wet and dry season did not affect the results obtained in the speargrass - Townsville stylo pasture.

Grazing trials evaluating the effect of stocking rate on liveweight gain in sheep are limited. Curll (1977a) found

that ewe liveweight gain per head was significantly lower at 13.3 ewes/ha than at 10 ewes/ha. Marsh and Laidlaw (1978) reported higher daily live-weight gains at 32 sheep/ha than at 48 sheep/ha on ryegrass -clover mixture grazed over 12 weeks in a two-year experiment. They recorded a decline in daily liveweight gains with time at the two stocking rates.

In Australia, Birrell (1981) observed that seasonal variation in liveweight of Corriedale sheep was greatly influenced by the stocking rate which varied from 10 to 25 wethers/ha. During winter and spring, liveweight changes at a particular stocking rate were similar.

Curll et al. (1985) in the U.K. reported that gain per head decreased throughout the five and a half month of experiment at 45 and 55 wethers /ha in a set stocked grazing study.

In Kenya (Thairu and Tessema, 1987), sheep grazing natural pasture consisting of Themeda trianda, C. ciliaris, D. abyssinica, Solanum incanum, Commelia spp among other species gained 30 g/hd/day at 4.35 sheep/ha. Over the 323 days of grazing, there was no significant difference in daily liveweight gain (32 g/hd) when the stocking rate was 2.73 sheep/ha. The report also revealed that daily gain was up to 90 g/hd during the wet season.

The relationship between gain per hectare and stocking rate is curvilinear (Mott, 1960). This was supported by other workers except Peterson et. al. (1965). Data from sheep grazing trials (Owen and Ridgman, 1968) also fitted the curvilinear model. However, from further studies on the implications of the linear relationship between gain per animal and stocking rate (Jones and Sandland, 1974), the

authors expressed the relationship between gain per hectare (Yh) and stocking rate (x) by a quadratic equation: $Yh = ax-bx^2$. The maximum gain per hectare occurred when x = a/2b and Yh = 0. In addition, it was deduced that at maximum gain per hectare, the corresponding gain per head was half the theoretical gain per head at zero stocking rate i.e. when x = 0.

On ryegrass-clover pastures in Australia, continuous stocking at 13.3 ewes/ha produced lower liveweight gain per hectare over a three-year period than at 10 ewes/ha (Curll, 1977a). Data from the U.K. (Curll et. al., 1985) showed that beyond 25 wethers/ha, liveweight gain/ha decreased on the ryegrass-clover pasture grazed continuously for five and a half months.

Thus a careful selection of stocking rates is very important in new grazing experiments. The results indicating the OSR could be effectively compared with trials from other environment and would be a guide for future studies and livestock farmers with sown pastures.

2.3 Effect of pasture characteristics on animal production

2.3.1. Sward height

Allden and Whittaker (1970) showed that the tiller heights of L. rigidum were much more closely related to the rate of herbage intake by sheep than was yield per hectare. They recorded a seven-fold increase in the rate of intake (1.0 and 7.1 g DM/min) for tillers 3.7 to 7.7 cm, high, respectively while a constant rate was maintained for heights beyond 7.7 cm.

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In a continuous grazing trial, Le Du and Hutchinson

(1982) reported a depression in L. perenne intake of cattle when the plant height fell below 6-8 cm. They also noted that sward height varied, depending on sward density and composition.

Hodgson, Rodrigues Capriles and Fenlon (1977) found that the maximum intake of cattle on D. decumbens in a strip grazing experiment occurred when sward height was 40-45 cm prior to the start of grazing.

The influence of sward height on liveweight gains of weaner steers was greater when grazing on S. anceps than on D. decumbens (Chacon et al., 1978), indicating a pasture species effect. The correlations for S. anceps and D. decumbens were 0.37 and 0.07 ($P< 0.05$), respectively. S. anceps is taller, erect and of tufted growth habit whereas D.decumbens is a short growing creeper. The swards heights did not exceed 30 cm during the grazing seasons. It is advisable therefore to manage grazed pastures at low heights for higher animal production.

2.3.2 Botanical composition

Evans and Bryan (1973) reported a positive correlation ($r = 0.89$) between legume content and liveweight gain per animal in a complex pasture of Lotononis bainesii, T. repens with C. gayana cv. Pioneer, two Paspalum spp and D. decumbens. This relationship was used to explain the observed reduction in annual liveweight gain over the six

years when the legume content decreased. This report is in general agreement with other findings with cattle in Australia (Norman, 1970; Evans, 1970; 't Mannetje, 1974) for Townsville stylo and Siratro and in Uganda (Stobbs, 1970) for stylo and Siratro. Curll et al. (1985a, 1985b) also recorded a close relationship (r = 0.96) between daily sheep liveweight change and clover content of a mixture with L. perenne. Under the tropical humid conditions of the Solomon Islands where pasture growth was not limited by soil moisture, Watson and Whiteman (1981) reported the relationships between legume content and gain per cow and gain per hectare, to be curvilinear and nil respectively in grass-legumes pasture mixtures. The three pastures comprised B. mutica, B. decumbens or P. maximum cv. Hamil each mixed with the legumes C. pubescens, M. atropurpureum and S. guianensis cv. Endeavour.

The correlation between edible weed content of pasture and liveweight gain was negative (Van Rensburg, 1969; Eng et al., 1978b) hence the importance of evaluating the amount of other plant species in grazed pastures. Van Rensburg (1969) observed that the high proportion of Tephrosia radican and other edible legumes and browse plants maintained the weight of cattle and tended to narrow the gain per animal between pure grass and mixed grass -legume pastures. In general, grazing studies should evaluate the proportion of edible (sown or volunteer) herbage species and relate to animal production.

2.3.3 Herbage on offer

The quantity of herbage on offer affects animal production from pasture and determines the carrying capacity.

When herbage was in short supply, grazing sheep found it difficult to prehend the feed (Willoughby, 1958; Arnold, 1962) and the frequency and intensity of grazing were highest (Allden and Whittaker, 1970). Birrell (1981) observed that when the green DM yield of L. perenne and T. subterraenum was above 1.5 t/ha, the amount of herbage consumed by Corriedale sheep increased as the yield increased.

The amounts of green kikuyu grass (P. clandestinum) and total green pasture on offer per animal (grazing pressure) were positively related to liveweight gain per animal over a twelve-week grazing period from autumn to winter in New South Wales, Australia (Mears and Humphreys, 1974b). Associations between available green pasture and liveweight gains have also been reported by Willoughby (1959) for sheep and Yates et al. (1964), Winter et al. (1977b), Chacon et al. (1978) and Watson and Whiteman (1981) for cattle in pure grass or mixed grass-legume pastures.

In Northern Cape York Peninsula, Australia, Winter et al. (1977b) found the relationship between daily liveweight gain of cattle and total green DM yield of B. decumbens and P. maximum with legumes to fluctuate with season. The relationship was positive in the dry season and negative in the wet season.

Watson and Whiteman (1981) reported that maximum liveweight gain per animal occurred when the green DM on offer per animal of B. mutica or B. decumbens and legume in mixed pastures was 1300 - 1400 kg/hd. These values were similar to those recorded by 't Mannetje (1974) for buffel (Cenchrus ciliaris) - Siratro but higher than (450 -670 kg/ha/hd) recorded for sole Sorghum almum pasture

(Yates et al.,1964). Watson and Whiteman (1981) also observed that a higher green DM requirement (2,400 kg/hd) for P. maximum cv. Hamil signified better selection opportunity for the animals to attain maximum liveweight gain from the pasture.

The relationship between green DM on offer per animal and liveweight gain per hectare (Watson and Whiteman, 1981), though complex, showed that maximum liveweight gain per hectare was obtained at levels of DM approximately half those giving maximum liveweight gain per animal.

Chacon et al. (1978) found a higher positive correlation (r = 0.52) between liveweight gain per animal and yield of S. anceps leaf offered than (r =0.33) for D. decumbens leaf. On the other hand, the correlation between liveweight gain and leaf dry matter bulk density was higher for D. decumbens than for setaria (r= 0.67 versus r= 0.26) at similar herbage yield levels. In the same trial, leaf to stem ratio was negatively correlated with liveweight gain of cattle on both pastures. This could be attributed to animal preference for the leaf which was more than 60 % of the diet.

In the coastal lowlands of south eastern Queensland, Tierney and Goward (1983b) demonstrated that during winter, liveweight losses of steers were accelerated when total pasture presentation DM yield of pangola grass declined below 1000 kg/ha. In the same trial, the relationship between total yield and liveweight gain was positive in the first year during autumn - winter - early spring. However, the relationship was negative in the other two years during spring to summer. The inconsistent trend in this relationship over the years agreed with the data of

Eng et al. (1978b) on guinea grass - legumes mixture. The substantial amount of DM in Rhodes grass herbage (2.5 t /ha) on offer at the end of the rainy season resulted in small losses in liveweight gain of Malawi Zebu and its crossbred at 2.5 LU/ha during the dry season in Malawi (Addy and Thomas,1978).

2.3.4 Herbage chemical composition and digestibility

Herbage preference has been shown to be dependent on palatability (Heady, 1964). Sheep have been reported to consistently select herbage high in CP and low in crude fibre (Wilson and Lansbury, 1958; Weir and Torell, 1959). Mohammed (1966) compared in vivo and in vitro digestibility methods for lucerne (Medicago sativa) hay fed to sheep and cattle and observed that sheep digested material high in protein more than cattle while cattle digested forage higher in crude fibre better.

Laredo and Minson (1973) indicated the importance of maintaining a great proportion of leaf in the swards of C. gayana, D. decumbens, P. maximum, P. clandestinum and S. splendida through effective management practices. They reported higher voluntary intake by sheep for leaf than for the stem despite the higher digestibility of stem (55.8 %) than the leaves (52.6 %).

To show that the performance of grazing animals is not limited by the protein content of the herbage on offer, Mears and Humphreys (1974b) suggested 1.2 % N as the requirement for maintaining animals in positive N balance. Reference was also made to the critical digestible crude protein (DCP) value of 3 % DCP (Milford and Minson, 1966). The leaf and

stem CP contents especially of the top of Setaria and pangola swards, were found to be more influential on steer liveweight gains than herbage yields (Chacon et al., 1978). From the numerical analysis conducted (Chacon et al., 1978) higher liveweight gains on pangola than Setaria were due to higher pangola CP content.

Gardener (1980) pointed out that CP content of fed herbage could be a poor indicator of animal liveweight gain or loss when other factors beside CP limited intake. These include reduced intake of limited but high quality green grass and reduced rumen content due to higher rate of digestion. He found that the CP content of the Townsville stylo -based native pasture was above 6.25 %, a value suggested by Siebert and Kennedy (1972) as adequate for the maintenance of liveweight of cattle on low quality tropical pastures.

Romero and Siebert (1980) observed that low herbage digestibility was a major factor limiting liveweight gains in cattle put to graze tropical pastures. This low digestibility was related to low voluntary feed intake (Minson, 1971) and longer retention of fibrous material in the rumen (Thorton and Minson, 1973). The grazing animal was nevertheless able to overcome this difficulty by selecting leafy material (Stobbs, 1973) and eating it in much larger quantities than stem (Laredo and Minson, 1973). Arnold (1962) noted that the DM digestibility (DMD) of a grazed pasture during spring to summer remained high for two to three weeks longer than that of cut pasture which had started to decline. He attributed this delay to selective grazing by sheep. The return of some minerals to the pasture through

urine and faeces of grazing animals could also account for this observation. Besides herbage selection by grazing animals, higher liveweight gains of steers on pangola grass compared with Setaria grass pasture were related to higher leaf and stem in vitro dry matter digestibility (IVDMD) of the top of the sward (Chacon et al., 1978).

The positive relationship between intake and crude protein content of pasture in indoor trials is well documented (Egan, 1965; Weston 1971). However, in grazing studies with sheep (Asiedu, Oppong and Opoku, 1978) and cattle (Hodgson et al., 1977) there were no correlations between the two, possibly because the mean CP contents of the grazed herbages were above the critical value of 7 % below which intake is reduced (Minson, 1967). The studies of Hodgson et al. (1977) and Asiedu et al. (1978) revealed that the digestible dry matter intake of the animals was greatly influenced by the (IVDMD) than other variables.

Osbourn, Terry, Outen and Cammell (1974) found that the intake and eating behaviour of sheep were clearly more correlated with the cell content than the (DMD). They also attributed the high correlations between the digestibility of diets and intake mainly to the high correlation that can exist between cell wall content and digestibility within one forage specie.

In a pen feeding trial, Ozanne, Purser, Howes and Southey (1976) showed that increasing P concentration in grass-legume hay by higher P fertilizer rates resulted in increased feed intake and consequently liveweight gains. A similar relationship (r = 0.95) was observed in the third year of a grazing trial on a *P. maximum* - stylo, centro and

puero pasture (Eng et al., 1978a). The response was not due solely to higher P content but possibly to both hemicellulose and cellulose digestion within the rumen which increased with increasing P content in the feed and secondly, induced changes in organic rather than inorganic components of the plant material. Response in terms of liveweight gains (Eng et al., 1978a) and voluntary feed intake (Rees and Minson, 1976) to increasing Ca concentration in the feeds were also attributed to the same reasons given above for P.

Since the leaf is higher in quality than the stem at maturity,its proportion after the seeding stage will determine the length of time grazing animals could be sustained in the pasture.

2.4 Effect of animal characteristics on animal production

2.4.1. Animal size and breed

As the body sizes of grazing sheep increase, daily herbage intake tended to increase correspondingly (Raymond, 1948, Cited by Asiedu et al., 1978). Spedding (1970) observed that bigger animals eat more than smaller ones (of the same breed) owing to their greater need and/or greater capacity for consumption of feed. The amount of abdominal fat or the degree of fatness has been reported to be inversely related to voluntary feed intake (Ferguson, 1956; Mather, 1959; Tayler,1959).

Blaxter, Wainman and Wilson (1961) concluded that voluntary intake in sheep varies with the metabolic body size ($W^{0.734}$). However, Playne (1970) indicated that very large

differences occurred in the intake of regrowths of buffel grass when expressed as a function of the metabolic weight ($g/kgW^{0.75}$) compared with Kikuyu, Rhodes and Pangola grasses of the same digestibility but of higher voluntary intake.

Gartner and O'Rouke (1976) and Curll (1977b) recorded greater response in animal liveweight gains of crossbreds over purebreds in their studies with Hereford and its cross with Simmental cattle.

2.4.2. Effect of helminthiasis on grazing animal

Diseases, often complicated by problems of poor management and inadequate nutrition, generally hamper economic production of small ruminants. Helminthiasis is a major disease problem of small ruminants in Nigeria (Ogunsusi, 1985) and the two most important ones are parasitic gastroenteritis complex and fascioliasis.

Some of the causative agents of parasitic gastro-enteritis complex are Haemonchus contortus, Trichostrongylus spp., Cooperia spp, Nematodirus spp and Ostertagia spp. Their distribution is wide in Nigeria (Okon, Ogunsusi and Fabiyi, 1980) and in the Guinea Savanna, infection is highest during June and July and lowest from December to April (Ogunsusi, 1985). The acute clinical forms of the disease noticed in young animals mainly during the wet season are sudden signs of gastro-enteritis, anaemia and death while the chronic forms in adult animals are shown in `Wasting' towards the end of the dry season (Ogunsusi 1985).

Fasciola gigantica and F. hepatica are the causative agents of fascioliasis. Studies with the former are common in the tropics. In Nigeria and other West African countries, the snail, Lymnaea natalensis, serves as intermediate host in

the transmission of the liver fluke disease (Schillhorn, 1981). Ogunsusi (1985) observed that the infection of animals in the Guinea Savanna occurred at the end of the rains and middle of the dry season with the snail hosting the fluke at the beginning of the dry season. In addition, clinical forms were usually observed between April and June.

High stocking rates are associated with high levels of parasitism (Downey, 1978) and the effect of rotational grazing is controversial because of the different rotational practices. The integration of grazing management, use of anthelminthics and dependence on acquisition of immunity have been suggested (Ogunsusi, 1985) as means of reducing the worm load to levels suitable for economic livestock production. At Shika, Schillhorn and Brinckman (1975) recommended drenching of lambs every four weeks during the wet season to reduce helminth load.

Perhaps effective quarantine or routine drenching of sheep before stocking in the late wet season and during the grazing period will reduce the level of these parasites for increased animal production.

CHAPTER 3

MATERIALS AND METHODS

3.1 Site of experiment

The experiment was conducted at the National Animal Production Research Institute (NAPRI), Shika (11°15'N, 7°32'E, altitude 610 m) in the Northern Guinea Savanna Zone of Nigeria. The land was under bush fallow until it was cleared in preparation for forage production in 1983.

3.1.1 Climate

Shika climate is characterized by well-defined wet and dry seasons. The wet season lasts from May to September and the dry season, from October to April. Meteorological observations at Shika and at Samaru, 10 km north east of Shika, are given in Table 1. Shika receives an annual rainfall of 1054 mm (60 -year mean). April is the hottest month while the temperature is lowest in December/January. The two prevailing winds are the south-east rain bearing wind and the dry north-east wind called the harmattan.

3.1.2 Vegetation and soil

The Northern Guinea Savanna Zone is defined as an Isoberlinia-Hyparrhenia dominant open woodland (Keay, 1959). The commonest trees in this zone include Isoberlinia doka, I. dalzielli, Monotes kerstingii, Swartzia madagascariensis and Uapaca togoensis (Blair Rains, 1963) while among those contributing to browsing are Acacia spp, Parkia clappertoniana, Prosopis africana and Piliostigma thonningii. The perennial grasses include Hyparrhenia rufa,

Table 1: Meteorological observations at Samaru* (rainfall at Shika)

	Year	Month J	F	M	A	M	J	J	A	S	O	N	D	TOTAL/MEAN
Rainfall (mm)	1985	0	0	35.0	0	103.0	279.4	262.9	191.3	253.8	1.9	0	0	1228.0
	1986	0	0	0	0	47.2	87.5	333.3	328.4	275.3	0	0	0	1071.7
	1987	0	0	0	0	81.6	253.2	306.5	324.2	110.5	75.2	0	0	1151.2
	1988	0	0	0	35.2	91.1	220.5	178.9	354.7	155.1	30.2	0	0	1065.7
	1989	0	0	0	14.2	85.0	101.0	220.2	191.5	90.4	66.0	0	0	768.3
	1990	0	0	0	15.3	148.5	125.7	212.7	231.7	187.3	6.4	0	0	927.6
Mean 1930 -	1990	0	0.9	4.3	35.0	110.8	160.0	221.0	291.8	194.6	35.4	0	0	1054.0
Number of rainy days	1985	0	0	3	0	9	10	16	16	17	1	0	0	72
	1986	0	0	0	0	6	8	14	18	14	0	0	0	60
	1987	0	0	0	0	4	13	16	24	8	5	0	0	78
	1988	0	0	0	5	8	13	7	18	16	1	0	0	68
	1989	0	0	0	1	7	8	10	13	9	3	0	0	51
	1990	0	0	0	1	10	13	13	18	15	2	0	0	72
Mean screen temp (°C)	1985	23.1	21.9	28.1	28.1	27.8	24.3	22.5	22.1	23.5	23.3	22.6	20.8	
	1986	21.1	25.2	27.2	29.4	28.0	25.2	23.8	23.9	24.0	24.3	22.8	19.8	
	1987	21.5	24.7	27.3	29.0	29.5	25.9	25.2	24.5	25.4	24.3	22.1	21.4	
	1988	21.2	23.8	28.4	29.2	28.7	25.4	23.8	23.4	24.3	23.4	21.9	20.0	
	1989	17.1	20.7	26.1	28.4	26.8	25.4	24.5	23.7	24.9	23.6	21.9	19.9	
	1990	21.9	22.7	25.8	30.1	27.2	25.5	24.1	24.1	25.1	25.6	24.6	23.9	
Sunshine (hrs/day)	1985	8.0	6.4	5.6	4.8	7.7	7.5	5.9	7.2	7.2	7.6	9.6	6.2	
	1986	8.5	9.6	7.1	8.4	8.0	7.8	6.2	6.9	7.8	8.5	8.6	7.0	
	1987	9.2	8.9	6.5	7.0	9.0	7.6	7.6	6.0	8.0	8.6	9.0	8.8	
	1988	6.5	8.3	7.0	7.9	8.0	7.3	5.4	5.6	6.5	9.4	10.1	7.3	
	1989	7.0	6.2	8.7	9.2	7.7	7.3	6.7	5.8	6.5	8.5	9.3	8.0	
	1990	7.8	7.7	7.8	8.4	7.5	7.2	6.4	6.8	7.4	8.4	9.3	9.0	

*Samaru(Lat. 11° 11' N., Long. 7° 38' E. Alt. 686 M)

H. dissoluta, Andropogon schirensis, A. gayanus var bisquamulatus, Cymbopogon giganteus, Brachiaria brizantha, B. mutica, B. jubata, Paspalum commersonni, Pennisetum polystachyon and Setaria sphacelata. Among the commoner annual grasses are A.pseudapricus, Chloris pilosa, Digitaria gayana, Dactyloctenium aegyptium, Eragrostis tremula and Pennisetum pedicellatum.

Shika soils belong to the ferruginous (alfisols and ultisols in soil taxonomy,U.S.D.A. 1975) tropical soils group derived from sandy parent material and crystalline acid rock (Klinkenberg and Higgins, 1968). The physical properties of the sandy loam soil of the trial site have been described (Kowal, 1968). The soil is known to be deficient in nitrogen and phosphorus.

3.2 Experimental design

The grazing trial was set out as a randomized block design with two replicates and set stocked with rams at 12, 18, 24, 30 or 36 per hectare. This involved grazing Rhodes grass (Chloris gayana cv. Callide) - stylo (Stylosanthes guianensis cv. Cook), unfertilized or N fertilized Rhodes grass pasture. Three rams grazed each paddock which varied from 0.25 to 0.09 ha to provide for the different stocking rates. Rams were balanced for liveweight and allotted to the different paddocks at the beginning of each grazing period.

3.3 Pasture establishment

3.3.1 Soil sampling and soil analysis

Soil analysis helps to provide a guide on the suitability of soils for growing various crops and for the

application of irrigation.

During late May, 1985 random samples were taken by means of an auger from the soil surface (0-15 cm), bulked and analysed for physical and chemical properties. Soil samples taken in May, 1989 (after three grazing periods on phosphorus fertilized sole Rhodes grass pasture) at the same depth from paddocks stocked at different rates were also analysed for the properties (Table 2).

The physical composition of the soil samples were based on the United State Department of Agriculture classification (Brady, 1974). Soil samples were analysed for pH (in water), mineral nutrient and cation exchange capacity (C.E.C.). Total nitrogen content was determined by the standard Kjeldahl method (AOAC, 1975). Available phosphorus (ppm) was extracted by shaking 2 g of soil with 40 ml of 0.002N H_2SO_4 followed by filtering (IITA,1979). Exchangeable cations were estimated by shaking 2 g of soil with 3 % acetic acid at 1:40 soil: solution ratio for 2 hours and filtering (IITA, 1979). Calcium, Mg and K were determined on an atomic absorption spectrophotometer using a Perkin Elmer, model 306 instrument.

3.3.2 Land preparation

Two areas (50 m apart) were prepared for the pastures used in the grazing trials. These were disc ploughed and harrowed. A second harrowing one week after helped to work in the fertilizer applied and control emerging weed seedlings.

3.3.3 Seeding and fertilizer application

The seeds of C. gayana and S. guianensis used in the study were produced at NAPRI, Shika. The stylo seed was immersed in hot water (70°C) for 10 minutes to remove hardseededness,sun dried and dressed with Fernasan D (25 % w/w Thiram and 20 % w/w BHC (Lindane) to prevent fungus attack and theft by ants. Details of pasture seeding and fertilizer application are given below:

Grazing period (Year)	1 1985/86	2 1986/87	3 1987/88	4 1988/89	5 1989/90
Pasture type	C. gayana*	C. gayana + stylo**	C. gayana + stylo**	C. gayana + stylo**	C. gayana + stylo**
Fertilizer application(ha^{-1})	30 kg P + 200 kg N	30 kg P	30 kg P	30 kg P	30 kg P + 200 kg N

* Sown June 1984, grazed only in 1985/86
** Sown 25 August, 1985, grazed 1986-1990

Both pastures were sown by hand broadcast at a grass:legume seeding ratio of 3:7 at 5 kg pure germinable seed (PGS) per hectare. During early July in each grazing period, pastures received P as single superphosphate and/or N in the form of calcium ammonium nitrate. In 1989, nitrogen was applied to the pasture to improve the productivity of the grass since the stylo component had been eliminated by 1987.

3.4 Pasture measurement and management

Pasture yield components, except tiller density, were sampled one to three day(s) before the start of each grazing period, at six-week intervals thereafter and at the end of each grazing period. Tillers of C. gayana were counted from the second to the fifth grazing period and at the beginning

and at 126 and 168 days of grazing. Height of C. gayana was not measured in the first grazing period. Herbage in each paddock was cutback in May prior to the commencement of grazing periods 1 to 4 and in June 1989 to remove uneven growth. The paddocks got burnt accidentally in July, 1989 after the application of fertilizers.

3.4.1. Sward height and bulk density

The mean sward height (excluding inflorescences of C. gayana) was determined from twenty random measurements per paddock. The bulk density of green C. gayana was calculated in terms of kilogrammes per hectare per centimeter of the grass height. This is expressed as kg/ha/cm.

3.4.2. Tiller counts

The total number of distinct (living and above 5 cm height) C. gayana tillers were counted from ten random 0.5 m square quadrats in each of the ten paddocks. Similar counts from two quadrats were carried out in each of the cages used as control.

3.4.3 Estimation of herbage on offer

Herbage yield was estimated from six random 0.5 m square quadrats per paddock, cut at a height of 5 cm above the ground level with a hand sickle. A permanent 2 m square cage was located in a representative position in each paddock as an ungrazed control plot. Yield was also estimated from these cages. The cut samples were weighed and mixed. Two subsamples of approximately 500 g fresh weight were taken, one was hand sorted into:-

(i) green shoots of the sown species (C. gayana was further

sorted into green leaf blade and live stem with inflorescence),

(ii) dead material consisting of dried whole or parts of all plants species and

(iii) others plants (weed) which were separated into different species.

The second subsample and the hand sorted components were oven dried at 80°C for 48 hrs and weighed for dry matter content. Green material consisted of living portions of sown and other plant species. The sum of green and dead materials made up the total herbage yield.

3.5 Chemical analysis of herbage samples

The dried herbage samples of the sown species were milled through a Christy-Norris laboratory hammermill to pass a 1 mm mesh, and stored in airtight containers pending analysis.

3.5.1. Crude protein contents

The milled samples were estimated for dry matter and CP contents using the standard Kjeldahl method (AOAC, 1975)- Appendix 1.

3.5.2. Structural components

The procedure for determining acid detergent fibre (ADF), acid detergent lignin (ADL), neutral detergent fibre (NDF) and cellulose as developed by Van Soest (1967) was used (Appendix 2). Cellulose percentage was the difference between % ADF and % ADL values.

3.5.3. Phosphorus, potassium, calcium and magnesium

The P, K, Ca and Mg contents in the herbage sample were estimated using the wet digestion method (IITA, 1979).

Phosphorus was determined colorimetrically with spectronic 20 while the standard flame photometric method (EEL, flame photometer Model A) was used to estimate the concentration of K. Calcium and Mg were obtained with an atomic absorption spectro photometer.

3.6 Animal management

Pasture in each of the ten paddocks was set stocked with three Yankasa rams which averaged 20 ± 0.5 kg by weight. The grazing schedule applied was as follows:

Year	Grazing period		Number of grazing days
	Commenced	Ended	
1985/86	23 October, 1985	8 April 1986	168
1986/87	21 August, 1986	20 March 1987	210
1987/88	25 August, 1987	8 March, 1988	196
1988/89	12 September `88	14 Feb. 1989	154
1989/90	5 September 1989	6 March, 1990	182

The rams were not provided with shelter or supplementary feed during the course of the experiment. However, they had ample supplies of drinking water and mineral lick in each paddock at all times. They were removed from the paddock for weighing and dipping only.

Anthelmintic treatments and dipping, using an organophosphate acaricide (Supergam) to control ectoparasites, were carried out before the start of each grazing period and at four -week intervals thereafter. Dipping became weekly when the presence of the fly Chrysomia regalis and cases of cutaneous myasis (an acute dermatitis of sheep caused by the larva) were noticed in September, 1986 and 1987.

The number of rams that died during the grazing periods and the causes are shown below:

Grazing period	Number of dead rams	Causes of death				
		Predator	Diarrhoaea	Starva-tion*	Myasis	Others
1	2	-	-	-	-	2
2	15	2	4	2	7	-
3	12	4	3	3	2	-
4	10	-	4	3	-	3
5	6	-	3	2	-	1

*At the stocking rates of 30 and 36 sheep/ha

Dead rams were replaced with similar ones (in liveweight) being grazed outside the paddocks. Grazing was terminated at the end of each period just before rams in paddocks stocked at 36 sheep/ha became recumbent.

3.7 Liveweight measurements

Rams were weighed fortnightly in the morning after a 14 hour fasting period without feed or water. Liveweight gain per hectare was estimated from the product of stocking rate per hectare and daily liveweight gain per head. The additions of the mean 14-day weight gains per head gave the cumulative liveweight gains per head. Similarly, the additions of the mean 14-day weight gains/ha for each grazing period gave the total liveweight gain/ha.

3.8 Statistical analysis

Plant and animal data were analysed as a split plot (in time) design with grazing days and stocking rate as the main plot and subplot, respectively. The analysis for each grazing period was done separately.

The Duncan`s New Multiple Range test (Steel and Torrie,

1980) was used to compare means of stocking rates and grazing days. The relationships between each of the daily liveweight gain/hd and liveweight gain/ha and stocking rate were known through regression analysis of the mean data. Similarly the relationships between liveweight gain /ha and per head and grazing pressures (kg of DM on offer /hd) of plant variables (green C. gayana, green material and total herbage) were also determined for each grazing period. The data were fitted to regression equations in the form recorded by Mears and Humphreys (1974b):

$$Y = a + bx - cx^2,$$

where Y = liveweight gain/head/day or per hectare;

x = grazing pressure;

a, b and c are constants.

CHAPTER FOUR

RESULTS

4.1 Meteorological observations during the experimental period.

Meteorological observation recorded during 1985 to 1990 are summarised in Table 1. Rainfall in 1989 (768.3 mm) was below the 60- year average (1054 mm) while that in 1985 (1228 mm), the wettest year, was higher. The number of rainy days was least (51) in 1989 and highest (78) in 1987. Rainfall during the first, second, third, fourth and fifth grazing periods (GP), were 0, 420, 254, 88 and 145 mm, respectively.The corresponding number of rainy days and extent of rains were 0,0; 19,38; 20,47; 9,19 and 11,41 days. The coldest and hottest months were January, 1989 (17.1°C) and May, 1987 (29.5°C) respectively. Other months showed little temperature variations. Sunshine between August and April when the grazing experiment were carried out ranged from 6.2 to 9.6 hrs/day.

4.2 Soil properties

The changes observed in the physical properties of the soil at the experimental site (Table 2) in 1989 were not consistent with stocking rate.

Pregrazing soil analysis showed low levels of N and P (Table 2). Soil pH fell after the three grazing periods (GP 2,3 and 4). The N, P, Na and Ca contents of the soil investigated increased as the pasture aged except for K and particularly Mg which declined. Total N increased as stocking rate increased.

Table 2: Physical and chemical properties of the top (0-15 cm) soil of the pasture paddocks in C. gayana - S. guianensis pasture.

Properties	May, 1985	May, 1989 Stocking rate (sheep/ha) 12	18	24	30	36	Mean
Physical (%)							
Clay	10	10.8	12.8	13.8	9.8	9.8	11.4
Silt	34	24.6	26.6	28.6	22.6	30.6	26.6
Sand	56	64.6	60.6	57.6	67.6	59.6	62.0
Chemical							
pH (H_2O)	5.40	6.63	6.78	6.48	6.51	6.40	6.56
Exchange cations (Meq/100 g soil)							
Na	0.07	0.11	0.11	0.17	0.15	0.15	0.14
K	0.45	0.43	0.23	0.50	0.57	0.35	0.42
Ca	1.78	1.81	1.93	1.81	1.81	2.43	1.96
Mg	0.96	0.49	0.49	0.58	0.68	0.49	0.53
Total N (%)	0.03	0.06	0.06	0.06	0.07	0.10	0.07
Available P (ppm/gm)	8.48	14.04	10.57	12.05	11.81	17.20	13.13
Organic carbon (%)	0.07	0.96	0.95	0.99	1.08	1.60	1.12
C.E.C. (Meq/100g soil)	ND	6.80	6.40	6.80	6.20	7.80	6.80

ND - Not determined.

4.3 Pasture production

4.3.1. 1985-1986 grazing period (GP 1)

4.3.1.1 Yields of total herbage and green shoot (stem + leaf) of C. gayana

With increasing stocking rate, yields of total herbage and stem + leaf components of C. gayana declined (Table 3.1). The yields of total herbage and green shoot of C. gayana at the 36 sheep/ha were significantly lower ($P< 0.01$) than at 12 sheep/ha, while the differences between the other stocking rates were not significant. The yields of total herbage and green shoot of C. gayana declined from 14.13 to 8.83 and 12.27 to 5.84 t /ha respectively. Within the grazing period, the highest and lowest yields of C. gayana, 12.60 and 5.28 t/ha, occurred at the 36 sheep/ha group.

4.3.1.2 Yields of green and dead materials

Paddocks stocked at 12 sheep/ha produced significantly ($P< 0.01$) more green material than at the highest stocking rates (Table 3.2). Green material on offer at the 18, 24, 30 and 36 sheep/ha respectively were similar (8.76, 8.56, 8.54 and 8.26 t/ha. On the other hand, stocking rate had no effect on the yields of dead material. While the yields of green material declined as the grazing period advanced those of dead materials increased. The differences in yield of green material between 126 and 168 days of grazing and of dead material between 42 to 126 days of grazing were not significant.

4.3.1.3. Yields of live stem and green leaf components of C. gayana

The yields of the stem and leaf components at the different stocking rates are shown in Tables 3.3a and b, respectively. Averaged over the five sampling dates, stem

Table 3.1: Effect of stocking rate (SR) and grazing duration (GD) on dry matter yield (t/ha) of (a) total herbage and (b) green shoot of C. gayana during the 1985-1986 grazing period.

	(GD)[2]					
SR[1]	0	42	84	126	168	Mean
			(a)			
12	13.56	12.41	11.16	10.74	10.28	11.63[a]
18	13.91	11.80	10.22	9.42	9.21	10.91[ab]
24	14.36	12.21	10.38	9.23	8.75	10.98[ab]
30	14.45	12.10	10.03	8.69	8.16	10.48[ab]
36	14.38	11.06	9.73	8.37	7.79	10.26[b]
Mean	14.13[a*]	11.91[b]	10.30[c]	9.29[cd]	8.83[d]	
			(b)			
12	12.20	10.70	8.83	7.63	6.74	9.22[a]
18	11.87	9.52	8.09	6.90	5.95	8.46[ab]
24	12.16	9.72	7.78	6.48	5.80	8.36[ab]
30	12.55	10.03	7.83	6.32	5.42	8.43[ab]
36	12.60	9.12	7.34	6.22	5.28	8.11[b]
Mean	12.27[a*]	9.82[b]	7.97[c]	6.71[d]	5.84[d]	

*Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05).
[1] SR = Stocking rate, [2] GD = Grazing days

SED		a	b
SR	=	0.45	0.33
GD	=	0.41	0.30
SR x GD	=	1.01	0.75

Table 3.2: Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1985-1986 grazing period.

	GD					
SR	0	42	84	126	168	Mean
			(a)			
12	12.51	10.94	8.93	7.70	6.74	9.36[a]
18	12.80	9.97	8.19	6.90	5.95	8.76[ab]
24	12.66	10.01	7.85	6.48	5.80	8.56[ab]
30	12.85	10.23	7.88	6.32	5.42	8.54[ab]
36	13.03	9.37	7.39	6.22	5.28	8.26[b]
Mean	12.77[a]*	10.10[b]	8.05[c]	6.72[d]	5.84[d]	
			(b)			
12	1.05	1.44	2.23	3.04	3.54	2.26[a]
18	1.46	1.84	2.03	2.53	3.26	2.22[a]
24	1.70	2.20	2.54	2.75	2.95	2.43[a]
30	1.60	1.88	2.15	2.37	2.74	2.15[a]
36	1.35	1.69	1.89	2.15	2.51	1.92[a]
Mean	1.43[c]*	1.81[bc]	2.17[bc]	2.57[ab]	3.00[a]	

*Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05).

SED	a	b
SR	= 0.33	0.18
SD	= 0.30	0.16
SR x GD	= 0.74	0.39

Table 3.3: Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a)live stem (b) green leaf of C.gayana and (c) other plant species in the pasture during the 1985-1986 grazing period.

SR	GD 0	42	84	126	168	Mean
			(a)			
12	9.73	8.88	7.98	7.06	6.50	8.02[b]
18	8.96	8.07	7.36	6.70	5.95	7.41[ab]
24	9.48	8.54	7.24	6.22	5.80	7.45[ab]
30	9.88	9.07	7.33	6.13	5.42	7.55[ab]
36	9.74	8.36	7.02	6.05	5.28	7.29[b]
Mean	9.54[a]	8.58[b]	7.3[c]	6.43[d]	5.79[d]	
			(b)			
12	2.47	1.83	0.87	0.57	0.25	1.20[a]
18	2.92	1.45	0.73	0.20	0.00	1.06[ab]
24	2.68	1.18	0.54	0.26	0.00	0.93[ab]
30	2.67	0.96	0.50	0.19	0.00	0.86[ab]
36	2.86	0.76	0.33	0.17	0.00	0.82[b]
Mean	2.72[a]	1.23[b]	0.59[c]	0.28[c]	0.05[c]	
			(c)			
12	0.31	0.24	0.10	0.05	0.00	0.14[a]
18	0.58	0.45	0.10	0.00	0.00	0.23[a]
24	0.50	0.29	0.07	0.00	0.00	0.17[a]
30	0.31	0.20	0.05	0.00	0.00	0.11[a]
36	0.43	0.25	0.05	0.00	0.00	0.15[a]
Mean	0.42[a]	0.28[b]	0.07[c]	0.01[c]	0.00[c]	

*Means in the same row or column followed by similar superscripts do not differ significantly ($P<0.05$).

SED	a	b	c
SR =	0.31	0.09	0.06
GD =	0.29	0.08	0.06
SR xGD =	0.70	0.20	0.14

yields at the stocking rates of 12, 18, 24, 30 and 36 sheep/ha were 8.02, 7.41, 7.45, 7.55 and 7.29 t/ha respectively. The corresponding leaf yields were 1.20, 1.06, 0.93, 0.86 and 0.82 t/ha. Yields of both components declined ($P< 0.01$) with advancing days of grazing. Stem and leaf yields at the beginning of grazing (23-10-85) were 9.54 and 2.72 t/ha respectively and declined to 5.79 and 0.05 t/ha at the end of the grazing period (8-4-86). This gave a range of leaf:stem ratio from 1:3.5 to 1:116.6. Thus the stem component constituted virtually the live material left at the end of the grazing period on day 168. For both the leaf and stem components, the differences between the lowest and the highest stocking rates were significant while there were no marked differences in the yields at other stocking rates.

4.3.1.4. Yield of other plant species in the sward

The dry matter yield of other plant species in the pasture was not significantly affected by stocking rate (Table 3.3c) but declined significantly ($P< 0.01$) from 0.42 t/ha at the beginning to zero at the end of the grazing period. The contribution of these other species to yield of green material and total herbage was zero from 126 days of grazing onwards. The dominant species and their contribution to yield were: S. guianensis cv. Cook, 25 %; gamba (A. gayanus), 25 %; Isoberlinia doka, 15 %; Indigofera spp 10 % and annuals 25 %. The annuals such as Dactyloctenum aegyptium, Eleusine indica and Pennisetum pedicellatum remained green in the paddocks only up to 42 days of grazing.

4.3.2. 1986-1987 grazing period (GP 2)

4.3.2.1 Yields of total herbage and green shoot (stem + leaf) of C. gayana.

Yields of total herbage and green shoot of C. gayana before grazing commenced were not significantly different (P> 0.05) from yields at 42 days of grazing (Table 4.1). Thereafter, yields declined to the minimum amounts of 5.36 and 3.57 t/ha for total herbage and green shoot of C. gayana at the end of the grazing period respectively.

In this trial, total herbage and green shoot yields were higher in the control plot than in the grazed paddocks. Irrespective of sampling date, dry matter yields for paddocks stocked at 12, 18, 24, 30 and 36 sheep/ha averaged 8.23, 8.00, 7.70, 7.35 and 6.93 t/ha respectively. The proportion of green shoot of C. gayana to total green material (C. gayana + other plant spp) in the paddocks ranged from 80.6 % at the beginning to 97.8 % at the end of the grazing period respectively.

4.3.2.2 Yields of green and dead materials

Green material on offer at the 36 sheep/ha rate was significantly lower (P< 0.01) than at the other stocking rates except at the 30 sheep/ha (Table 4.2a). The control plot had the highest amount of 8.67 t /ha. The amount of dead material was highest (1.27 t) in the least stocking rate and lowest (0.55 t/ha) in the control plot (Table 4.2b). While the amount of dead material in the paddocks increased as the grazing days advanced, the amount of green material declined. The amount of green material declined markedly (P< 0.01) from 10.30 t/ha at the beginning of grazing to 3.65 t/ha at the end of the grazing period. The proportion of

Table 4.1: Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and(b) green shoot (stem + leaf) of C.gayana during the 1986-1987 grazing period.

SR	Grazing days 0	42	84	126	168	210	Mean
			(a)				
12	10.04	10.48	9.02	7.43	6.30	6.10	8.23^{b}
18	10.71	10.45	8.66	6.37	5.96	5.85	8.00^{bc}
24	10.23	10.01	8.85	6.88	5.92	4.84	7.70^{bc}
30	10.16	9.90	8.52	6.19	5.02	4.17	7.35^{cd}
36	10.44	8.92	7.85	5.88	4.51	3.98	6.93^{d}
Control	10.21	10.96	10.22	8.85	7.93	7.12	9.22^{a}
Mean	10.30^{a}	10.02^{a}	8.77^{b}	6.93^{c}	5.95^{d}	5.36^{d}	
			(b)				
12	8.23	8.30	6.88	4.94	4.31	4.00	6.11^{b}
18	8.31	8.05	6.72	4.66	4.30	4.00	6.01^{b}
24	8.06	7.49	6.36	4.75	4.12	3.00	5.63^{bc}
30	8.49	7.17	6.09	4.48	3.42	2.50	5.36^{cd}
36	8.24	6.41	5.68	4.22	3.01	2.34	4.98^{d}
Control	8.47	9.01	8.30	6.84	6.26	5.58	7.41^{a}
Mean	8.30^{a}	7.74^{a}	6.67^{b}	4.98^{c}	4.24^{d}	3.57^{e}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05).

SED		a	b
SR	=	0.11	0.10
GD	=	0.11	0.10
SRxGD	=	0.28	0.24

Table 4.2: Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1986-1987 grazing period.

SR	GD 0	42	84	126	168	210	Mean
			(a)				
12	10.00	9.86	8.12	5.37	4.38	4.00	6.96^{b}
18	10.71	10.00	7.87	4.80	4.35	4.00	6.96^{b}
24	10.23	9.31	7.35	5.08	4.12	3.00	6.51^{bc}
30	10.16	9.20	7.59	4.69	3.42	2.50	6.27^{cd}
36	10.44	8.25	6.90	4.32	3.01	2.34	5.88^{d}
Control	10.21	10.85	10.09	7.86	6.92	6.06	8.67^{a}
Mean	10.30^{a}	9.58^{b}	7.99^{c}	5.35^{d}	4.37^{e}	3.65^{f}	
			(b)				
12	0.00	0.62	0.90	2.06	1.93	2.10	1.27^{a}
18	0.00	0.45	0.79	1.56	1.62	1.85	1.04^{b}
24	0.00	0.70	1.00	1.79	1.80	1.84	1.19^{ab}
30	0.00	0.70	0.93	1.50	1.77	1.77	1.08^{b}
36	0.00	0.70	0.95	1.56	1.50	1.63	1.05^{b}
Control	0.00	0.10	0.12	1.00	1.00	1.06	0.55^{c}
Mean	0.00	0.54^{d}	0.78^{c}	1.58^{b}	1.58^{b}	1.71^{a}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED		a	b
SR	=	0.12	0.03
GD	=	0.12	0.03
SRxGD	=	0.28	0.07

dead to green material increased from 5.6 % to 46.8 % at 42 and 210 days of grazing respectively.

4.3.2.3. Yields of live stem and green leaf components of C. gayana.

Mean yields of the stem and leaf components declined significantly ($P< 0.01$) as the stocking rate and grazing days increased (Table 4.3). Prior to stocking, yields were similar for all paddocks with means of 5.94 and 2.36 t/ha for the stem and leaf components respectively. Leaf yield at the 36 sheep/ha rate was significantly lower than that at any other stocking rates. Furthermore, it was observed that towards the end of the grazing period leafless stems dominated the herbage yield of all paddocks. There were no significant differences in leaf yields. The ratio of leaf to stem ranged from 1:6.6 to 1:3.1 for the highest stocking rate and the control groups respectively.

4.3.2.4 Yields of stylo and other plant species

The yield of stylo in the one year old C. gayana - stylo pasture was not affected by the stocking rates (Table 4.4a). Similarly, stocking rate did not significantly affect the yield of other species (Table 4.4b). Stylo and other species declined as grazing days increased and were virtually negligible in the paddocks from 168 days onwards. Yield of stylo was highest (1.31 t/ha) at 42 days of grazing but this was not significantly different from the yields at the start of grazing (1.15 t/ha, day 0) when stylo constituted 11.2% of the total herbage production. Generally the proportion of other species in the total herbage declined as grazing days increased. These comprised P. pedicellatum (35 %), Vernonia pausiflora (20 %), A. gayanus (15 %) and Sesbania

Table 4.3: Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) live stem and (b) green leaf of C. gayana during the 1986-1987 grazing period.

SR	GD 0	42	84	126	168	210	Mean
				(a)			
12	6.11	6.25	5.44	4.83	4.25	4.00	5.15^{b}
18	5.88	5.95	5.35	4.57	4.25	4.00	5.00^{b}
24	5.64	5.60	5.19	4.67	4.12	3.00	4.70^{c}
30	5.90	5.56	5.10	4.40	3.42	2.50	4.48^{c}
36	6.11	5.41	4.97	4.11	3.01	2.34	4.33^{c}
Control	6.02	6.31	5.88	5.36	5.20	4.80	5.60^{a}
Mean	5.94^{ax}	5.85^{a}	5.32^{ab}	4.65^{bc}	4.04^{cd}	3.44^{d}	
				(b)			
12	2.13	2.05	1.44	0.11	0.06	0.00	0.96^{b}
18	2.43	2.10	1.37	0.09	0.05	0.00	1.01^{b}
24	2.42	1.88	1.17	0.09	0.00	0.00	0.93^{b}
30	2.59	1.61	0.99	0.08	0.00	0.00	0.88^{b}
36	2.12	1.00	0.71	0.11	0.00	0.00	0.66^{c}
Control	2.46	2.70	2.42	1.48	1.05	0.78	1.81^{a}
Mean	2.36^{a}	1.89^{b}	1.35^{c}	0.33^{d}	0.19^{d}	0.13^{d}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR =	0.08	0.06
GD =	0.08	0.06
SRxGD =	0.19	0.14

Table 4.4: Effect of stocking rate grazing duration on dry matter yield (t/ha) of (a) stylo and (b) other plant species in the pasture during the 1986-1987 grazing period.

SR	GD 0	42	84	126	168	210	Mean
				(a)			
12	1.11	1.21	0.85	0.12	0.06	0.00	0.56^{b}
18	0.87	1.35	1.00	0.14	0.05	0.00	0.57^{b}
24	1.54	1.41	0.67	0.29	0.00	0.00	0.65^{b}
30	0.72	1.11	0.94	0.21	0.00	0.00	0.50^{b}
36	1.44	1.30	0.99	0.10	0.00	0.00	0.64^{b}
Control	1.24	1.50	1.23	0.92	0.61	0.48	1.00^{a}
Mean	1.15^{abx}	1.31^{a}	0.95^{b}	0.30^{c}	0.12^{cd}	0.08^{d}	
				(b)			
12	0.69	0.35	0.39	0.30	0.00	0.00	0.29^{a}
18	1.36	0.61	0.14	0.00	0.00	0.00	0.35^{a}
24	0.62	0.41	0.32	0.04	0.00	0.00	0.23^{a}
30	0.95	0.92	0.56	0.00	0.00	0.00	0.41^{a}
36	0.77	0.54	0.24	0.00	0.00	0.00	0.26^{a}
Control	0.50	0.35	0.57	0.10	0.06	0.00	0.26^{a}
Mean	0.82^{a}	0.53^{ab}	0.37^{b}	0.07^{c}	0.01^{c}	0.00^{c}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED		a	b
SR	=	0.06	0.04
GD	=	0.06	0.04
SRxGD	=	0.14	0.09

spp (10 %) the remaining 20 % being made up of Tridax procumbens and Aspilia heterophyla.

4.3.2.5. Height and sward bulk density of C. gayana

While the decline in height and bulk density of C. gayana was consistent with increasing grazing days, the differences in bulk density due to stocking rate were not stastistically significant (Table 4.5). The mean height of C. gayana in the control (133.5 cm) was significantly ($P< 0.01$) higher than in the grazed plots. The height of the grass maximised in all paddocks at 42 days of grazing when it ranged from 125 cm at the highest stocking rate to 149 cm in the control. Regardless of stocking rate the highest mean bulk density (76.0 kg/cm/ha) was recorded at the commencement of grazing and the least (39.7 kg/ha/cm) was observed at the end of the grazing period.

4.3.3. 1987-1988 grazing period (GP 3)

4.3.3.1 Yields of total herbage and green shoot (stem + leaf) of C. gayana.

The amounts of total herbage and green shoot of C. gayana varied significantly ($P< 0.01$) with stocking rates and followed the order: control > 12 $\geqslant$ 18 $\geqslant$ 24 $\geqslant$ 30 = 36 (Table 5.1). Yields prior to the start of grazing (day 0) and up to the 42 nd day of grazing were not significantly different among plots. Beyond the latter date, mean yields decreased with increase in grazing days. The amount of green shoot of C. gayana declined from 8.89 t/ha at the beginning to 4.70 t/ha at the end of the grazing period. At the end of grazing, live stem of C. gayana only constituted total green material on offer at 24, 30 and 36 sheep/ha. The highest

Table 4.5: Effect of stocking rate and grazing duration on (a) height (cm) and (b) mean sward bulk density (kg/ha/cm) of C. gayana during the 1986 1987 grazing period.

SR	GD 0	42	84	126	168	210	Mean
				(a)			
12	117.5	141.0	133.0	121.0	106.0	96.5	119.2^{b}
18	108.5	131.5	121.5	115.0	106.0	95.0	112.9^{bc}
24	109.0	131.5	114.0	106.5	90.5	97.0	105.1^{cd}
30	106.0	125.5	110.0	97.5	89.5	77.5	100.0^{d}
36	108.0	125.0	90.5	89.0	81.0	72.0	94.3^{d}
Control	107.0	149.0	146.0	143.5	135.5	120.0	133.5^{a}
Mean	109.3^{c*}	133.9^{a}	119.2^{b}	112.1^{bc}	101.4^{d}	90.0^{e}	
				(b)			
12	70.0	59.0	51.8	40.8	40.8	41.4	51.3^{a}
18	76.6	61.5	55.4	40.5	40.6	42.1	52.8^{a}
24	74.0	57.0	55.8	44.7	45.7	38.0	53.6^{a}
30	80.2	57.1	55.4	45.9	38.2	32.3	53.1^{a}
36	76.4	51.3	62.8	47.4	37.2	32.5	52.8^{a}
Control	79.2	60.5	65.4	47.7	46.2	46.5	55.5^{a}
Mean	76.0^{a}	57.8^{b}	56.1^{b}	44.5^{c}	41.8^{cd}	39.7^{d}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR & GD =	2.3	1.6
SR X GD =	5.7	4.0

Table 5.1: Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and (b) green shoot (stem+leaf) of C. gayana during the 1987-1988 grazing period.

SR	GD 0	42	84	126	168	Mean
			(a)			
12	10.51	10.78	8.79	7.68	7.02	8.96^{b}
18	10.14	10.30	8.28	7.19	6.59	8.50^{c}
24	10.38	10.06	8.46	7.01	6.41	8.46^{c}
30	9.78	9.77	8.20	6.93	5.41	8.02^{d}
36	10.20	9.98	7.98	5.85	5.12	7.82^{d}
Control	10.13	10.70	9.86	8.99	8.66	9.67^{a}
Mean	10.19^{a*}	10.26^{a}	8.59^{b}	7.27^{c}	6.54^{c}	
			(b)			
12	9.37	9.11	6.97	5.39	4.62	7.09^{b}
18	8.77	8.69	6.48	5.35	4.61	6.78^{bc}
24	9.05	8.51	6.71	5.51	4.60	6.87^{bc}
30	8.59	8.25	6.69	5.31	3.60	6.50^{c}
36	8.98	8.43	6.29	4.94	3.53	6.43^{c}
Control	8.60	9.02	8.19	7.49	7.22	8.10^{a}
Mean	8.89^{a*}	8.67^{a}	6.89^{b}	5.68^{c}	4.70^{d}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR =	0.16	0.13
GD =	0.15	0.12
SR x GD =	0.36	0.28

yields of green shoot of C. gayana and of total herbage were 9.37 and 10.78 t/ha, respectively from the lowest stocking rate.

4.3.3.2 Yields of green and dead materials

The yield of green material declined as the grazing days increased (Table 5.2a) while that of dead material increased (Table 5.2b). The ratio of green material to total herbage yield declined from 93 % to 72 % with increase in grazing days. The control plot gave higher green dry matter on offer but lower dead material than any of the the grazed paddocks. The differences in yields of green and dead material at 18,24,30 and 36 sheep/ha were not significant. The ratio of dead material to total herbage was highest (15.5 %) at the lowest stocking rate and smallest (9.0 %) in the ungrazed plot.

4.3.3.3 Yields of live stem and green leaf components of C. gayana

While the yield of stem reached a maximum on the 42 nd day of grazing, the yield of leaf decreased from the beginning to the end of the grazing period (Table 5.3a,b). The mean leaf yields at 126 and 168 days of grazing though not significantly different, were 0.35 and 0.19 t/ha respectively. The yield of the and leaf component at 12 sheep/ha was significantly higher than yields at other stocking rates. The mean leaf yields during the period at 18, 24, 30 and 36 sheep/ha were not significantly different. Leaf yield was less than 1.0 t/ha after 84 days of grazing and was negligible (at 12 and 18 sheep/ha) or nil at the end of the grazing period.

Table 5.2 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1987 -1988 grazing period.

	GD					
SR	0	42	84	126	168	Mean
			(a)			
12	9.91	9.86	7.47	5.68	4.82	7.55[a]
18	9.29	9.49	7.10	5.58	4.61	7.21[bc]
24	9.60	9.21	7.29	5.61	4.63	7.27[bc]
30	9.13	8.83	7.16	5.45	3.61	6.86[c]
36	9.45	9.15	6.91	5.00	3.53	6.82[c]
Control	9.53	10.00	9.11	7.98	7.42	8.81[a]
Mean	9.50[a*]	9.44[a]	7.51[b]	5.89[c]	4.76[d]	
			(b)			
12	0.60	0.92	1.31	2.00	2.20	1.41[a]
18	0.86	0.81	1.17	1.61	1.98	1.29[ab]
24	0.79	0.85	1.17	1.40	1.78	1.20[abc]
30	0.65	0.84	1.04	1.48	1.81	1.16[abc]
36	0.66	0.83	1.07	1.36	1.10	1.00[bc]
Control	0.60	0.70	0.76	1.01	1.25	0.86[c]
Mean	0.60[c*]	0.82[b]	1.09[b]	1.48[b]	1.69[a]	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR =	0.14	0.08
GD =	0.12	0.07
SR x GD =	0.30	0.18

Table 5.3 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) live stem (b) green leaf of C. gayana and (c) other plant species in the pasture during the 1987 - 1988 grazing period.

SR	GD 0	42	84	126	168	Mean
			(a)			
12	7.06	7.05	5.96	5.09	4.51	5.92^{b}
18	6.57	6.88	5.58	5.05	4.51	5.72^{bc}
24	6.81	7.01	5.80	5.31	4.60	5.91^{b}
30	6.53	6.85	5.87	5.21	3.61	5.61^{c}
36	6.76	6.97	5.64	4.84	3.53	5.55^{c}
Control	6.38	6.61	6.57	6.46	6.27	6.46^{a}
Mean	6.69^{a*}	6.90^{a}	5.90^{b}	5.33^{c}	4.51^{d}	
			(b)			
12	2.31	2.06	1.01	0.30	0.11	1.16^{a}
18	2.20	1.80	0.90	0.30	0.11	1.06^{bc}
24	2.24	1.50	0.91	0.20	0.00	0.97^{bc}
30	2.06	1.40	0.82	0.15	0.00	0.89^{c}
36	2.22	1.46	0.65	0.10	0.00	0.89^{c}
Control	2.21	2.41	1.62	1.03	0.95	1.64^{a}
Mean	2.21^{a*}	1.77^{b}	0.99^{c}	0.35^{d}	0.19^{d}	
			(c)			
12	0.54	0.75	0.50	0.29	0.21	0.46^{a}
18	0.51	0.80	0.62	0.23	0.00	0.43^{a}
24	0.55	0.71	0.58	0.10	0.03	0.39^{a}
30	0.54	0.68	0.47	0.10	0.00	0.36^{a}
36	0.56	0.73	0.62	0.05	0.00	0.39^{a}
Control	0.40	0.50	0.51	0.24	0.00	0.31^{a}
Mean	0.52^{a*}	0.69^{a}	0.55^{a}	0.17^{b}	0.04^{b}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED		a	b	c
SR	=	0.10	0.05	0.04
GD	=	0.09	0.05	0.04
SR x GD	=	0.22	0.11	0.09

4.3.3.4 Yields of stylo and other plant species

The stylo established in the pasture was eliminated from the paddocks except the control plot at the end of its first grazing period. The yield of stylo at the 0, 42, 84, 126 and 168 days of grazing in the control plot were 0.52, 0.61, 0.40, 0.25 and 0.20 t/ha, respectively.

There was no significant effect of stocking rate on yields of other species but they declined significantly in quantity during the grazing period (Table 5.3c). The dry matter contributed by other species at 0, 42, 84, 126 and 168 days of grazing were 0.52, 0.69, 0.55, 0.17 and 0.04 t/ha, respectively. The major "other species" and their proportions were Vernonia pausiflora (35 %), Pennisetum pedicellatum (30 %), Sesbania spp (20 %) and A. gayanus (10 %).

4.3.3.5. Height and bulk density of C. gayana

The ungrazed C. gayana was significantly taller ($P<0.01$) than the grazed grass (Table 5.4a). Within the grazed paddocks heights of C. gayana declined whereas the bulk density increased, as stocking rate increased (Table 5.4b). The bulk density at the highest stocking rate was significantly ($P< 0.05$) higher than at the 12 and 18 sheep/ha. The mean values of height and bulk density were inversely proportional to increase in grazing days. The height of grass at 42 days of grazing was highest compared with other days. The interaction between stocking rate and grazing days was significant not for bulk density but for height. The grass was tallest in the control (149 cm) at 42 days of grazing and shortest (60 cm) under the highest stocking rate at the end of the grazing period.

Table 5.4 Effect of stocking rate and grazing duration on (a) height (cm) and (b) mean bulk density (kg/ha/cm) of C. gayana during 1987 - 1988 grazing period.

SR	GD 0	42	84	126	168	Mean
			(a)			
12	122.5	132.5	124.0	116.0	99.5	118.9^{b}
18	122.5	129.5	121.0	110.0	96.0	115.8^{bc}
24	110.0	117.5	110.0	95.0	90.0	104.7^{cd}
30	107.5	116.0	107.5	90.0	75.0	99.2^{d}
36	110.0	110.0	100.0	75.0	60.0	91.0^{e}
Control	120.0	149.0	145.0	142.5	138.0	138.9^{a}
Mean	115.4^{abx}	125.8^{a}	117.9^{ab}	104.9^{c}	93.1^{c}	
			(b)			
12	76.6	68.8	56.3	46.5	46.4	58.8^{b}
18	71.6	67.2	53.8	48.9	48.8	58.0^{b}
24	82.3	72.6	61.0	57.4	51.1	64.9^{ab}
30	80.0	71.3	62.7	59.5	48.0	64.3^{ab}
36	81.7	76.6	62.8	65.9	58.8	69.2^{a}
Control	71.6	60.5	56.6	52.6	52.3	58.7^{b}
Mean	77.3^{a*}	69.5^{b}	58.8^{c}	55.1^{c}	50.9^{d}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR =	2.5	1.5
GD =	2.3	1.3
SR x GD =	5.7	3.2

4.3.4. 1988-1989 grazing period (GP 4)

Pasture components up to 126 days are presented due to the six-week cutting intervals but the grazing period lasted 154 days.

4.3.4.1. Yields of total herbage and green shoot (stem + leaf) of C. gayana

The mean yields of of total herbage and green C. gayana declined significantly ($P<0.01$) from the ungrazed control plot,through the lowest,to the highest stocking rate (Table 6.1). Yields also declined as the grazing days increased. The proportion of green C. gayana fell from 90 % at the beginning to 76 % of the total herbage yield by the 126th day. As in the previous years, live grass stem constituted green matter on offer at the end of the grazing period.

4.3.4.2. Yields of green and dead materials

Green material on offer declined significantly ($P<0.01$) as stocking rate increased although yield at 18, 24 and 30 sheep/ha were similar (Table 6.2a). Similarly, the yields of dead material fell from 1.29 at the least to 0.93 t/ha at the highest stocking rates (Table 6.2b). The control plot gave the highest yield of green and the least yield of dead materials. The amount of dead material was highest (1.65 t/ha) at the end of the grazing period, while the pre-grazing (day 0) yield of green material was the highest (8.77 t/ha). Based on the observations above, the proportion of dead to green material increased from 4.8 % at the beginning to 31.2 % at the end of the grazing period. The differences between the highest and least amounts of green and dead materials during the grazing period were significant ($P<0.01$).

Table 6.1 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and (b) green shoot (stem+leaf) of C. gayana during the 1988-1989 grazing period.

SR	GD 0	42	84	126	Mean
			(a)		
12	9.41	9.06	8.53	7.36	8.59^{b}
18	9.13	8.76	8.11	7.01	8.25^{b}
24	9.15	8.54	7.73	6.54	7.99^{c}
30	9.05	8.04	7.18	6.17	7.61^{c}
36	8.63	7.77	6.76	5.56	7.18^{d}
Control	9.79	10.09	9.89	9.02	9.70^{a}
Mean	9.19^{a*}	8.25^{b}	7.93^{b}	6.95^{c}	
			(b)		
12	8.56	7.55	6.76	5.29	7.04^{b}
18	8.30	7.31	6.43	4.95	6.75^{bc}
24	8.27	7.13	6.30	4.73	6.61^{c}
30	8.05	6.93	5.96	4.65	6.40^{c}
36	7.57	6.54	5.74	4.23	6.02^{d}
Control	8.73	8.68	8.28	7.69	8.34^{a}
Mean	8.25^{a*}	7.36^{b}	6.58^{c}	5.26^{d}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR =	0.10	0.09
GD =	0.08	0.07
SR x GD =	0.20	0.17

Table 6.2 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of pasture (a) green and (b) dead material during the 1988-1989 grazing period.

SR	GD 0	42	84	126	Mean
			(a)		
12	9.11	7.97	6.81	5.29	7.30^{b}
18	8.81	7.71	6.53	4.95	7.00^{bc}
24	8.75	7.49	6.35	4.73	6.83^{c}
30	8.55	7.23	5.96	4.65	6.60^{c}
36	8.10	6.94	5.74	4.23	6.25^{d}
Control	9.31	9.48	8.84	7.89	8.88^{a}
Mean	8.77^{a*}	7.80^{b}	6.70^{c}	5.29^{d}	
			(b)		
12	0.30	1.08	1.72	2.07	1.29^{a}
18	0.32	1.05	1.58	2.06	1.25^{a}
24	0.40	1.05	1.38	1.81	1.16^{b}
30	0.50	0.81	1.21	1.52	1.01^{c}
36	0.53	0.83	1.03	1.35	0.93^{c}
Control	0.49	0.60	1.05	1.14	0.82^{d}
Mean	0.42^{d*}	0.90^{c}	1.33^{b}	1.65^{a}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR =	0.10	0.02
GD =	0.08	0.02
SR x GD =	0.19	0.04

4.3.4.3. Yields of live stem and green leaf components of C. gayana

The yields of the stem and leaf components of C. gayana were influenced by stocking rate as indicated in Table 6.3 a and b respectively. Pre-grazing yields of both components were not significantly affected by stocking rate. The differences between mean leaf yields at 18, 24, 30 and 36 sheep/ha were not significant. The order of significance for stem yields was, Control > 12 = 18 ≥ 24 ≥ 30 > 36 while the highest and lowest yields were 6.75 and 5.48 t/ha, in the control and 36 sheep/ha plots, respectively. Data in Table 6.3a,b suggested that the yields of both components declined as the grazing days increased. By the end of the grazing period, only the most leniently grazed C. gayana had leaves. The ratio of leaf: stem ranged from 1:4.4 at the beginning to 1:20.9 at the end of the grazing period.

4.3.4.4 Yields of stylo and other plant species

As grazing days increased, the yields of stylo (Table 6.3c) in the control plot significantly ($P < 0.01$) decreased from 0.37 t before the start of grazing to 0.20 t/ha after 126 days of grazing. The yields of other plant species were not influenced by stocking rate but declined significantly with increase in grazing days. Mean yields at 0, 42 and 84 days of grazing were 0.46, 0.38 and 0.08 t/ha respectively while the pasture was almost weed-free at the end of the grazing period. In addition, it was noted that the difference between weed yields at 0 and 42 days of grazing was not significant.

Table 6.3 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) live stem (b) green leaf of C. gayana and (c) other plant species in the pasture during the 1988 - 1989 grazing period.

SR	GD 0	42	84	126	Mean
			(a)		
12	7.01	6.50	6.15	5.05	6.18^{b}
18	6.80	6.34	5.93	4.95	6.00^{b}
24	6.85	6.28	5.83	4.73	5.92^{bc}
30	6.57	6.20	5.75	4.65	5.79^{c}
36	6.15	5.90	5.64	4.23	5.48^{d}
Control	6.92	6.95	6.68	6.46	6.75^{a}
Mean	6.72^{a*}	6.36^{b}	6.00^{c}	5.01^{d}	
			(b)		
12	1.55	1.05	0.61	0.24	0.86^{b}
18	1.50	0.97	0.50	0.00	0.74^{bc}
24	1.43	0.86	0.48	0.00	0.69^{bc}
30	1.48	0.73	0.21	0.00	0.60^{c}
36	1.41	0.65	0.10	0.00	0.54^{c}
Control	1.81	1.73	1.60	1.23	1.59^{a}
Mean	1.53^{a*}	1.00^{b}	0.58^{c}	0.24^{d}	
			(c)		
12	0.55	0.42	0.05	0.00	0.25^{a}
18	0.51	0.41	0.10	0.00	0.25^{a}
24	0.48	0.35	0.05	0.00	0.22^{a}
30	0.50	0.30	0.00	0.00	0.20^{a}
36	0.53	0.40	0.00	0.00	0.23^{a}
Control	0.21(0.37)[1]	0.40(0.40)	0.31(0.25)	0.00(0.20)	0.23^{a}(0.31)
Mean	0.46^{a*}	0.38^{a}	0.08^{b}	0.00^{b}	

ns in the same row or column followed by similar superscripts do not differ ficantly at (P=0.05).

	a	b	c
=	0.06	0.04	0.02
=	0.05	0.03	0.02
GD =	0.13	0.08	0.04

[1], values for stylo in ( )

4.3.4.5 Height and bulk density of C. gayana

Without grazing, C. gayana was tallest and most bulky compared with when grazed (Table 6.4). In addition, height and bulk density values varied ($P< 0.01$) between the stocking rates. The heights of C. gayana at the 18, and 24 sheep/ha were similar. Averaged over all stocking rates, height and bulk density of C. gayana declined as the grazing days increased. The differences between the mean heights at 0 and 42 days of grazing and between the bulk densities at 42 and 84 days of grazing were not significant. The highest green C. gayana bulk density of 63.7 kg/ha/cm was recorded in the control plot at 84 days of grazing.

4.3.5 1989-1990 grazing period (GP 5)

4.3.5.1. Yields of total herbage and green shoot (stem + leaf) of C. gayana.

Yields of both total herbage and green shoot of ungrazed C. gayana were significantly higher ($P< 0.01$) than in the stocked plots (Table 7.1). The green shoot produced 6.80, 6.31 and 5.91 t/ha for stockings at 12, 24 and 36 sheep/ha, respectively. Yields also declined with increase in grazing days although the difference between total herbage yields at 0 and 42 days of grazing was not significant. Green shoots of C. gayana was the only green material for the sheep towards the end of the experiment. The proportions of green shoot of C. gayana to total herbage was 94.6 % at the beginning of the grazing period and 75 % by the 168th day.

4.3.5.2. Yields of green and dead materials

Yields of green and dead material increased ($P< 0.01$) as stocking rate decreased (Table 7.2). For the ungrazed sward, yields of green and dead material were highest and lowest

Table 6.4 Effect of stocking rate and grazing duration on (a) the height (cm) and (b) mean bulk density (kg/ha/cm) of C. gayana during the 1988-1989 grazing period.

SR	GD 0	42	84	126	Mean
			(a)		
12	135.0	124.0	113.5	106.0	119.6^{c}
18	140.0	130.0	117.5	105.0	123.1^{b}
24	141.0	134.5	117.5	102.2	123.9^{b}
30	135.0	120.0	104.5	87.5	111.8^{d}
36	120.0	110.0	99.5	82.0	102.9^{e}
Control	145.0	139.0	130.0	125.0	134.8^{a}
Mean	136.0^{a*}	126.3^{a}	113.8^{b}	101.3^{c}	
			(b)		
12	63.5	61.0	59.6	50.0	58.5^{ab}
18	59.3	56.2	54.8	47.2	54.5^{cd}
24	58.7	53.1	53.7	46.2	52.9^{d}
30	59.6	57.9	57.0	53.1	57.0^{bc}
36	63.1	59.5	57.7	51.6	58.1^{b}
Control	60.2	62.5	63.7	61.5	62.0^{a}
Mean	60.7^{a*}	58.4^{b}	57.8^{b}	51.6^{c}	

*Means in the same row or column followed by similar superscripts do not differ significantly at P<0.05.

SED	a	b
SR =	1.7	0.9
GD =	1.4	0.7
SR x GD =	3.4	1.7

Table 7.1 Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) total herbage and (b) green shoot (stem+leaf) of C. gayana during the 1989 -1990 grazing period.

	GD					
SR	0	42	84	126	168	Mean
			(a)			
12	9.45	9.21	8.87	7.30	6.30	8.23^{b}
18	9.30	8.90	7.92	6.63	5.85	7.72^{c}
24	9.42	8.40	7.88	6.23	5.40	7.46^{cd}
30	9.37	8.65	7.36	5.63	5.00	7.20^{de}
36	9.52	8.30	6.85	5.30	4.60	6.91^{e}
Control	9.35	9.63	9.52	8.61	8.19	9.06^{a}
Mean	9.40^{a*}	8.85^{a}	8.01^{b}	6.61^{c}	5.89^{d}	
			(b)			
12	9.02	8.01	7.18	5.35	4.45	6.80^{b}
18	8.83	7.93	6.52	4.98	4.18	6.48^{c}
24	8.82	7.70	6.55	4.63	3.90	6.31^{cd}
30	8.90	7.70	6.19	4.43	3.60	6.16^{d}
36	8.81	7.41	5.94	4.10	3.30	5.91^{e}
Control	8.95	8.95	8.64	7.60	7.10	8.25^{a}
Mean	8.89^{a*}	7.59^{b}	6.80^{c}	5.18^{d}	4.42^{e}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED		a	b
SR	=	0.07	0.04
GD	=	0.07	0.04
SR x GD	=	0.16	0.09

Table 7.2: Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) green and (b) dead material during the 1989 -1990 grazing period.

	GD					
SR	0	42	84	126	168	Mean
			(a)			
12	9.25	8.61	7.67	5.65	4.45	7.13^{b}
18	9.11	8.40	6.92	5.18	4.18	6.76^{c}
24	9.22	8.00	6.88	4.83	3.90	6.56^{cd}
30	9.12	8.10	6.41	4.43	3.60	6.33^{de}
36	9.31	7.90	6.04	4.10	3.30	6.13^{e}
Control	9.15	9.30	8.90	7.80	7.20	8.47^{a}
Mean	9.19^{a*}	8.39^{b}	7.10^{c}	5.33^{d}	4.44^{e}	
			(b)			
12	0.20	0.60	1.20	1.65	1.85	1.10^{a}
18	0.20	0.50	1.00	1.45	1.68	0.97^{ab}
24	0.20	0.40	1.00	1.40	1.50	0.90^{bc}
30	0.25	0.55	0.95	1.20	1.40	0.87^{bc}
36	0.21	0.40	0.81	1.20	1.30	0.78^{c}
Control	0.20	0.33	0.63	0.81	0.99	0.59^{d}
Mean	0.21^{c*}	0.46^{bc}	0.91^{ab}	1.28^{a}	1.45^{a}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED		a	b
SR	=	0.47	0.03
GD	=	0.43	0.03
SR x GD	=	1.04	0.08

respectively. With increase in days of grazing, yield of green material declined while that of dead material increased. The values for the latter sward component at 126 and 168 days of grazing were similar. The amount of green material increased only in the control plot at 42 days of grazing and thereafter declined significantly ($P< 0.01$) for all the treatments. Green material constituted 97.8 % of the total herbage at the beginning and 75.3 % at the end of the grazing period.

4.3.5.3. Yields of live stem and green leaf components of C. gayana.

As stocking rate and grazing days increased yields of the stem and leaf components of C. gayana fell significantly (Table 7.3a,b). Yields were greatest in the control plot and least in the 36 sheep/ha treatment. There were no significant differences in the yields of stem at the stocking rates of 18, 24 and 30 sheep/ha. The table also revealed a reduction in leaf yield from 1.35 to 0.95 t/ha, at the least and highest stocking rates respectively. Yields of leaf in the grazed paddocks declined below 1.0 t/ha from 126 days till the end of the grazing period. Presentation yields of both stem and leaf components were similar at the start of grazing but leafless stems dominated the yield at the end of the grazing period particularly in the 30 and 36 sheep/ha plots. The data indicated that, regardless of stocking rate, the leaf:stem ratio declined from 1:3.0 on day 0 to 1:12.0 after 168 days of grazing.

4.3.5.4 Yield of other plant species

The effects of increasing stocking rate and days of grazing on the yields of other species are given in

Table 7.3: Effect of stocking rate and grazing duration on dry matter yield (t/ha) of (a) live stem (b) green leaf of C. gayana and (c) other plant species in the pasture during the 1989 - 1990 grazing period.

SR	GD 0	42	84	126	168	Mean
			(a)			
12	6.72	6.01	5.59	4.70	4.30	5.45^{b}
18	6.63	6.10	5.10	4.49	4.08	5.27^{c}
24	6.60	6.00	5.27	4.28	3.80	5.18^{c}
30	6.70	6.20	5.05	4.20	3.60	5.15^{c}
36	6.51	6.00	5.00	4.00	3.30	4.96^{d}
Control	6.65	6.55	6.20	5.50	5.40	6.07^{a}
Mean	6.64^{a*}	6.14^{b}	5.36^{c}	4.53^{d}	4.08^{e}	
			(b)			
12	2.30	2.00	1.64	0.65	0.15	1.35^{b}
18	2.20	1.83	1.42	0.42	0.10	1.21^{c}
24	2.22	1.70	1.28	0.38	0.10	1.13^{cd}
30	2.20	1.50	1.14	0.23	0.00	1.01^{de}
36	2.30	1.41	0.94	0.10	0.00	0.95^{e}
Control	2.30	2.40	2.24	2.05	1.70	2.14^{a}
Mean	2.25^{a*}	1.81^{b}	1.44^{c}	0.65^{d}	0.34^{d}	
			(c)			
12	0.23	0.60	0.49	0.30	0.00	0.32^{a}
18	0.29	0.48	0.41	0.20	0.00	0.27^{ab}
24	0.40	0.30	0.33	0.20	0.00	0.25^{ab}
30	0.22	0.40	0.23	0.00	0.00	0.17^{b}
36	0.50	0.50	0.10	0.00	0.00	0.22^{ab}
Control	0.20	0.35	0.25	0.20	0.10	0.22^{ab}
Mean	0.31^{a*}	0.44^{a}	0.30^{a}	0.15^{b}	0.02^{c}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a&c	b
SR =	0.03	0.03
GD =	0.03	0.03
SR * GD =	0.07	0.06

Table 7.3 c. Difference in yield was significant only between 12 and 30 sheep/ha. By the end of the grazing period other plant species in the paddocks had been eliminated. As observed for the previous grazing periods, the ratio of weed to total herbage, green material and green C. gayana declined as the grazing days increased. The main "other plant species" were P. pedicellatum, V. pausiflora, I. doka, Sesbania spp and A. gayanus with corresponding percentages of 20, 20, 10, 20 and 15, respectively.

4.3.5.5. Height and bulk density of C. gayana

Ungrazed (control) C. gayana was significantly (P< 0.01) taller (136.2 cm) than the grazed plant and the heaviest stocking resulted in the shortest (103.0 cm) plant (Table 7.4). The bulk density was highest in the control plot (60.5 kg/ha/cm) and varied significantly but not consistently among the stocking rates. The mean bulk densities at 12, 18, 24, 30 and 36 sheep/ha were 53.5, 52.4, 54.4, 55.4 and 57.4 kg/ha/cm, respectively. Plant height decreased as grazing days increased. Bulk densities were not significantly different (P< 0.01) from one another for 0,42 and 84 days of grazing but were higher than at later days of grazing.

4.4. Tiller density (number of tillers/unit area) in C. gayana

During GP 2 and GP 3,the ungrazed sward had fewer tillers at day 0 than the grazed swards but produced more tillers over the grazing days in GP 2, GP 3 and GP 4 (Table 8).

4.4.1 1986-1987 grazing period (GP 2)

Tiller density in the stocked paddocks was similar (Table 8a). The mean density was highest (479 tillers) in

Table 7.4 Effect of stocking rate and grazing duration on (a) height (cm) and (b) mean bulk density (kg/ha/cm) of C. gayana during 1989 - 1990 grazing period.

SR	GD 0	42	84	126	168	Mean
			(a)			
12	145.0	140.0	125.0	115.0	110.0	127.0^{b}
18	145.0	139.0	120.0	105.0	1000	121.6^{c}
24	140.0	130.5	115.0	100.0	95.0	116.7^{d}
30	145.0	130.0	110.0	90.0	85.0	111.0^{e}
36	140.0	120.0	105.0	80.0	70.0	103.0^{f}
Control	140.0	143.5	139.0	132.5	126.0	136.2^{a}
Mean	142.5^{a*}	133.6^{b}	119.0^{c}	103.8^{d}	96.8^{e}	
			(b)			
12	62.2	57.2	57.4	46.5	40.5	53.5^{de}
18	60.9	57.5	54.3	47.4	41.8	52.4^{e}
24	63.0	59.2	57.0	46.3	41.0	54.4^{cd}
30	61.4	59.2	56.3	49.2	42.4	55.4^{c}
36	63.0	61.8	56.6	51.3	47.1	57.4^{b}
Control	64.0	62.4	62.2	57.5	56.4	60.5^{a}
Mean	62.4^{a*}	59.5^{a}	57.1^{a}	50.0^{b}	45.7^{b}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR =	0.5	0.4
GD =	0.4	0.3
SR x GD =	1.0	0.8

Table 8: Effect of stocking rate and grazing duration on tiller density (count/m²) ofC. gayana during (a) 1986-1987 (b) 1987-1988 (c) 1988-1989 and (d) 1989-1990 grazing periods.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	511	513	506	511	515	502	510[a]
126	449	445	431	429	435	482	445[b]
168	404	397	381	362	337	452	389[c]
Mean	455[ab*]	452[ab]	439[b]	434[b]	429[b]	479[a]	
				(b)			
0	554	562	539	529	518	527	538[a]
126	491	454	401	372	344	505	421[b]
168	394	387	340	302	270	481	362[c]
Mean	466[b]	467[b]	427[c]	401[ca]	377[d]	504[a]	
				(c)			
0	498	496	473	451	419	527	477[a]
126	401	380	310	270	198	501	343[b]
Mean	450[b]	438[b]	392[c]	361[c]	309[d]	514[a]	
				(d)			
Pre[1]	242	141	147	159	141	nd	166[c]
0	640	610	550	526	484	nd	562[a]
126	324	208	166	156	140	nd	199[b]
Mean	402[a]	319[b]	287[c]	281[c]	255[d]	-	

[1] Counted in July, 1989 before nitrogen application.
* Means in the same row or column followed by similar superscripts do not diffe significantly (P=0.05).
nd = not determined

SED	a	b	c	d
SR	10	9	12	12
GD	8	7	9	10

the control and least (429 tillers/m²) with stocking at 36 sheep/ha. Tiller densities decreased as days of grazing advanced.

4.4.2. 1987-1988 grazing period (GP 3)

The densities at 12 and 18 sheep/ha were equal (Table 8b) and higher than at other stocking rates. Tiller density decreased from 538 on day 0 to 362 tillers/m² on the 168th day of grazing.

4.4.3. 1988-1989 grazing period (GP 4)

At the beginning of grazing, C. gayana had 477 tillers/m² but by the second and last measurement, the value had declined significantly ($P<0.01$) to 343 tillers/m² (Table 8c). The table also showed significant differences in tillering between the grazed swards, which followed the order: 12=18>24=30>36.The least stocking rate produced 150 % more tillers than at the highest stocking rates.

4.4.4 1989-1990 grazing period (GP 5)

The pre grazing tiller counts conducted first after fire had swept through all the paddocks and subsequently during the grazing process indicated that mean tiller numbers were least (166/m²) following burning and highest (562/m²) at the start of grazing (Table 8d). Among the stocking rates, the most sparse sward was 36 sheep/ha (255 tillers/m²) and the densest, that at 12 sheep/ha (402 tillers/m²).

4.5 Chemical composition

4.5.1. 1985-1986 grazing period (GP 1)

4.5.1.1 Crude protein (CP) content

The CP protein contents of the grass stem and leaf did not alter significantly due to stocking rate but fell ($P< 0.01$) as the days of grazing increased (Table 9.1). The

Table 9.1 Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf crude protein contents (%) during the 1985-1986 grazing period.

GD	SR 12	18	24	30	36	Mean
			(a)			
0	5.9	5.4	5.5	5.6	5.5	5.6[a]
42	4.8	4.4	4.6	5.0	4.4	4.6[b]
84	3.6	3.7	3.7	3.6	3.7	3.7[c]
126	3.4	3.1	3.1	3.2	3.5	3.3[c]
Mean	4.4[a]*	4.2[a]	4.2[a]	4.4[a]	4.3[a]	
			(b)			
0	11.3	11.0	10.8	11.1	10.9	11.0[a]
42	8.9	9.1	9.3	8.6	9.2	9.0[b]
84	6.3	6.2	6.5	6.4	6.4	6.4[c]
Mean	8.8[a]	8.8[a]	8.9[a]	8.7[a]	8.8[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR	ns	ns
GD	0.30	0.15

respective values were 5.6, 4.6, 3.7 and 3.3 % at 0, 42, 84 and 126 days of grazing for the stem component and 11.0, 9.0 and 6.4 % at 0, 42 and 84 days of grazing for the leaf components. The leaf CP content ranged from 6.2 to 11.3 % while that of the stem varied from 3.1 to 5.9 % CP.

4.5.1.2. Phosphorus content

On the average, C. gayana leaf had a markedly higher P (0.08 - 0.20 %) content than the stem (0.03 -1.15 %) (Table 9.2). Stocking rate did not exert any significant effect on P content of both components. On the other hand, it declined significantly as days of grazing advanced. Stem P content were similar for 84 and 126 days of grazing but lower than those for 0 and 42 days of grazing. Leaf P content fell from 0.18 % to 0.10 % between 0 and 84 days of grazing, respectively.

4.5.1.3. Potassium content

The K content of leaf and stem of C. gayana though not consistent with stocking rate were highest ($P<0.01$) at 12 and 30 sheep/ha respectively (Table 9.3). As the days of grazing increased leaf and stem K contents decreased. The K content in the stem at 126 days was half that at day 0. The content of K in the leaf was richer than in the stem.

4.5.1.4. Calcium content

The leaf Ca content trebled that of the stem except at the beginning of grazing (Table 9.4). The overall effect of stocking rate on both stem and leaf components was not significant. With increase in the number of grazing days, stem Ca content declined, while leaf Ca content reached a maximum on day 42 and then declined.

Table 9.2 Effect of stocking rate and grazing duration on phosphorus content (%) in (a) stem and (b) leaf of C. gayana during the 1985-1986 grazing period.

GD	SR 12	18	24	30	36	Mean
			(a)			
0	0.15	0.12	0.10	0.12	0.15	0.13[a]
42	0.08	0.10	0.10	0.08	0.10	0.09[b]
84	0.05	0.05	0.05	0.05	0.03	0.05[c]
126	0.03	0.03	0.03	0.05	0.03	0.03[c]
Mean	0.09[a]*	0.08[a]	0.07[a]	0.08[a]	0.08[a]	
			(b)			
0	0.20	0.18	0.19	0.18	0.15	0.18[a]
42	0.13	0.13	0.15	0.16	0.14	0.14[b]
84	0.10	0.10	0.10	0.08	0.13	0.10[c]
Mean	0.14[a]	0.14[a]	0.15[a]	0.14[a]	0.14[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR	ns	ns
GD	0.007	0.009

Table 9.3 Effect of stocking rate and grazing duration on potassium content (%) in (a) stem and (b) leaf of C. gayana during the 1985-1986 grazing period.

GD	SR 12	18	24	30	36	Mean
			(a)			
0	1.07	0.89	0.76	0.93	0.90	0.91[a]
42	0.65	0.46	0.65	0.76	0.59	0.62[b]
84	0.59	0.43	0.53	0.65	0.46	0.53[c]
126	0.46	0.46	0.38	0.51	0.46	0.45[c]
Mean	0.69[a]*	0.56[b]	0.58[b]	0.71[a]	0.60[b]	
			(b)			
0	1.46	1.23	1.13	1.20	1.11	1.23[a]
42	1.03	0.86	1.09	0.81	0.97	0.95[b]
84	0.92	0.59	0.76	0.62	0.57	0.73[c]
Mean	1.14[a]	0.89[b]	0.99[b]	0.88[b]	0.94[b]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR	0.04	0.05
GD	0.03	0.04

Table 9.4 Effect of stocking rate and grazing duration on calcium content (%) in (a) stem and (b) leaf of C. gayana during the 1985-1986 grazing period.

GD	SR 12	18	24	30	36	Mean
			(a)			
0	0.17	0.16	0.15	0.16	0.19	0.17[a]
42	0.12	0.14	0.14	0.15	0.13	0.14[ab]
84	0.13	0.12	0.13	0.15	0.13	0.13[ab]
126	0.10	0.11	0.10	0.15	0.10	0.11[b]
Mean	0.13[a]*	0.13[a]	0.13[a]	0.15[a]	0.14[a]	
			(b)			
0	0.49	0.45	0.46	0.45	0.38	0.45[b]
42	0.53	0.58	0.49	0.58	0.55	0.55[a]
84	0.49	0.43	0.52	0.53	0.39	0.47[b]
Mean	0.50[a]	0.49[a]	0.49[a]	0.52[a]	0.44[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR	ns	ns
GD	0.006	0.02

4.5.1.5. Magnesium content

Although the leaf and stem of C. gayana contained 0.11 -0.14 % and 0.05 - 0.08 % Mg, respectively, these values were not significantly affected by either stocking rate or number of grazing days (Table 9.5). While the stem Mg content was highest at the beginning of grazing and lowest at the 42 and 126 days of grazing, leaf Mg content remained relatively constant at 0.13 % throughout the grazing period.

4.5.2. 1986-1987 grazing period (GP 2)

4.5.2.1. Crude protein content

Crude protein content was highest at the beginning and declined significantly ($P < 0.01$) with increase in duration of grazing (Table 10.1). The content in the leaf of grass and whole stylo plant was higher than in the stem of grass. Whole stylo plant had higher values than grass leaf only at the start of grazing but not after. Stocking rate had no clear effect on the CP content except that the high CP content in the stylo at the least stocking rate (11.21 %) was significantly higher than at other stocking rates and the control plot.

4.5.2.2. Phosphorus content

Phosphorus content of the stem and leaf of C. gayana and whole stylo plant was independent of stocking rate (Table 10.2). Similarly there were no consistent trends between P content as the grazing days increased. The levels in the leaf of the grass and stylo were higher than in the stem of the grass at the same stocking rate.

4.5.2.3. Potassium content

Potassium content was not significantly affected by stocking rates (Table 10.3) As the days of grazing increased

Table 9.5 Effect of stocking rate and grazing duration on magnesium content (%) in (a) stem and (b) leaf of C. gayana during the 1985-1986 grazing period.

GD	SR 12	18	24	30	36	Mean
			(a)			
0	0.08	0.08	0.07	0.08	0.08	0.08[a]
42	0.05	0.07	0.05	0.06	0.06	0.06[a]
84	0.08	0.07	0.07	0.09	0.06	0.07[a]
126	0.06	0.07	0.05	0.06	0.05	0.06[a]
Mean	0.07[a]*	0.07[a]	0.06[a]	0.07[a]	0.06[a]	
			(b)			
0	0.14	0.12	0.14	0.14	0.11	0.13[a]
42	0.13	0.14	0.12	0.13	0.13	0.13[a]
84	0.13	0.13	0.14	0.14	0.12	0.13[a]
Mean	0.13[a]	0.13[a]	0.13[a]	0.14[a]	0.12[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR	ns	ns
GD	ns	ns

Table 10.1: Effect of stocking rate and grazing duration on (a) stem and (b) leaf of C. gayana and (c) stylo crude protein contents (%) during the 1986-1987 grazing period.

GD	SR 12	18	24	30	36	Control	Mean
			(a)				
0	6.5	6.6	6.8	6.7	7.0	6.8	6.75[a]
84	4.6	4.6	5.1	5.1	4.6	4.8	4.81[b]
126	4.4	4.3	4.9	4.3	4.1	3.7	4.29[b]
210	4.4	3.7	3.7	3.1	3.3	3.1	3.52[b]
Mean	4.99[a]*	4.79[a]	5.11[a]	4.78[a]	4.75[a]	4.62[a]	
			(b)				
0	9.1	9.6	9.8	9.3	9.5	9.8	9.50[a]
84	8.0	8.4	9.0	8.6	8.9	8.8	8.60[ab]
126	7.9	7.4	7.7	6.9	7.9	7.4	7.59[b]
Mean	8.34[a]	8.46[a]	8.82[a]	8.24[a]	8.74[a]	8.65[a]	
			(c)				
0	14.5	12.6	12.0	13.1	10.8	10.7	12.27[a]
84	10.4	8.1	7.9	8.8	9.0	8.6	8.80[b]
126	8.8	7.3	7.5	6.9	6.4	7.8	7.45[c]
Mean	11.21[a]*	9.33[b]	9.11[b]	9.62[b]	8.73[b]	9.04[b]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b	c
SR	ns	ns	0.44
GD	0.34	0.13	0.31

Table 10.2: Effect of stocking rate and grazing duration on (a) stem and (b) le. of C. gayana and (c) stylo phosphorus contents (%) during the 1986-1987 grazing period.

GD	SR 12	18	24	30	36	Control	Mean
			(a)				
0	0.12	0.13	0.13	0.12	0.14	0.14	0.13[a]
84	0.03	0.06	0.03	0.06	0.03	0.09	0.05[b]
126	0.10	0.14	0.15	0.15	0.13	0.15	0.14[a]
210	0.05	0.11	0.09	0.10	0.05	0.06	0.08[b]
Mean	0.08[a]*	0.11[a]	0.10[a]	0.11[a]	0.09[a]	0.11[a]	
			(b)				
0	0.16	0.17	0.20	0.22	0.28	0.20	0.21[a]
84	0.28	0.13	0.30	0.13	0.18	0.10	0.19[a]
126	0.16	0.16	0.18	0.15	0.15	0.15	0.16[a]
Mean	0.20[a]	0.15[a]	0.23[a]	0.17[a]	0.20[a]	0.15[a]	
			(c)				
0	0.15	0.12	0.17	0.18	0.16	0.15	0.16[a]
84	0.08	0.08	0.13	0.06	0.08	0.50	0.16[a]
126	0.10	0.20	0.20	0.23	0.18	0.28	0.20[a]
Mean	0.11[a]*	0.13[a]	0.17[a]	0.16[a]	0.14[a]	0.31[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b	c
SR	ns	ns	ns
GD	0.007	ns	ns

Table 10.3: Effect of stocking rate and grazing duration on (a) stem and (b) le of C. gayana and (c) stylo potassium content (%) during the 1986-1987 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	0.98	1.13	1.12	1.13	1.26	1.08	1.12[a]
84	0.51	0.80	0.68	1.40	0.68	0.68	0.79[a]
126	0.65	0.41	1.57	0.84	1.00	1.54	1.00[a]
210	1.15	1.03	1.19	1.00	1.27	1.00	1.09[a]
Mean	0.82[a]*	0.84[a]	1.14[a]	1.09[a]	1.05[a]	1.08[a]	
				(b)			
0	1.46	1.56	1.50	1.62	1.68	1.50	1.56[a]
84	1.46	1.11	1.03	1.67	0.81	0.68	1.13[a]
126	1.23	1.29	1.13	1.35	1.43	1.32	1.29[a]
Mean	1.38[a]	1.32[a]	1.22[a]	1.55[a]	1.31[a]	1.17[a]	
				(c)			
0	1.50	1.54	1.19	1.89	1.58	1.54	1.54[a]
84	1.00	0.78	0.65	0.59	0.70	1.09	0.80[b]
126	0.78	1.08	1.13	1.12	1.13	1.46	1.12[b]
Mean	1.09[a]*	1.13[a]	1.00[a]	1.20[a]	1.14[a]	1.36[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b	c
SR	ns	ns	ns
GD	ns	ns	0.06

K content in the stem and leaf of C. gayana were not significantly different. On the other hand, the K contained in stylo was significantly higher (P< 0.01) at the beginning of the grazing than at the other grazing days. The contents at 84, and 126 days of grazing were 0.80 and 1.12% respectively.

4.5.2.4. Calcium content

The Ca percentage in stylo and the leaf and stem of C. gayana fluctuated during the grazing period and among stocking rates (Table 10.4). The content ranged from 0.15 to 0.30% in the stem and from 0.24 to 0.35 % in the leaf of C. gayana. The table also showed that increasing grazing days significantly (P< 0.01) affected Ca content in the leaf of grass and whole stylo but not the stem of C. gayana.

4.5.2.5. Magnesium content

C. gayana and stylo tissues appeared to contain the same amount of Mg (Table 10.5). Stocking rate did not exert any influence on Mg content but the content in stylo increased significantly with increase in the duration of grazing. C. gayana leaf had a higher mean Mg content on the 84th day of grazing than at any other time.

4.5.2.6. Acid detergent fibre (ADF) and neutral detergent fibre (NDF)

Neither stocking rate nor duration of grazing had a major effect on C. gayana stem ADF (Table 10.6a). The ADF values at 12, 24, 36 sheep/ha and the control were 57.5, 60.5, 57.2 and 59.3 % respectively. Generally leaf ADF was lower than that of the stem. The value for stylo ranged from 47.6 to 59.5 %. NDF content increased significantly (P< 0.01) as the stocking rate increased (Table 10.6b).

Table 10.4: Effect of stocking rate and grazing duration on (a) stem and (b) leaf of C. gayana and (c) stylo calcium content (%) during the 1986-1987 grazing period.

GD	SR 12	18	24	30	36	Control	Mean
			(a)				
0	0.21	0.20	0.12	0.19	0.33	0.21	0.21[a]
84	0.21	0.20	0.35	0.15	0.14	0.12	0.20[a]
126	0.23	0.20	0.33	0.13	0.26	0.42	0.26[a]
210	0.17	0.45	0.30	0.12	0.45	0.30	0.30[a]
Mean	0.21[a]*	0.26[a]	0.28[a]	0.15[a]	0.30[a]	0.26[a]	
			(b)				
0	0.42	0.34	0.38	0.40	0.35	0.40	0.38[a]
84	0.33	0.33	0.25	0.45	0.22	0.21	0.30[b]
126	0.22	0.22	0.38	0.22	0.15	0.31	0.25[c]
Mean	0.32[a]	0.30[a]	0.34[a]	0.35[a]	0.24[a]	0.25[a]	
			(c)				
0	0.17	0.17	0.41	0.14	0.22	0.22	0.22[b]
84	0.13	0.18	0.08	0.18	0.15	0.13	0.14[c]
126	0.25	0.42	0.40	0.37	0.37	0.37	0.37[a]
Mean	0.18[a]*	0.26[a]	0.30[a]	0.23[a]	0.25[a]	0.24[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b	c
SR	ns	ns	ns
GD	ns	0.03	0.03

Table 10.5: Effect of stocking rate and grazing duration on (a) stem and (b) leaf of C. gayana and (c) stylo magnesium content (%) during the 1986-198 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	0.06	0.06	0.04	0.08	0.05	0.06	0.06[a]
84	0.09	0.08	0.05	0.08	0.08	0.09	0.08[a]
126	0.05	0.09	0.12	0.08	0.08	0.07	0.08[a]
210	0.08	0.08	0.11	0.04	0.02	0.08	0.07[a]
Mean	0.07[a*]	0.08[a]	0.08[a]	0.07[a]	0.06[a]	0.08[a]	
				(b)			
0	0.06	0.05	0.06	0.06	0.06	0.06	0.06[c]
84	0.12	0.13	0.10	0.08	0.09	0.10	0.10[a]
126	0.08	0.08	0.09	0.08	0.08	0.07	0.08[b]
Mean	0.09[a]	0.09[a]	0.08[a]	0.07[a]	0.08[a]	0.08[a]	
				(c)			
0	0.05	0.07	0.06	0.07	0.06	0.06	0.06[c]
84	0.08	0.08	0.08	0.11	0.08	0.06	0.08[b]
126	0.08	0.13	0.04	0.10	0.09	0.13	0.10[a]
Mean	0.07[a*]	0.09[a]	0.06[a]	0.09[a]	0.08[a]	0.08[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b	c
SR	ns	ns	ns
GD	ns	0.005	0.009

Table 10.6: Effect of stocking rate and grazing duration on the content (%) of structural components[1] of the stem and leaf of C. gayana during the 1986-1987 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	58.8	59.0	58.4	58.7	58.8	58.8	58.9[a]
0+	48.3	48.5	48.5	49.7	47.0	49.0	
210	56.2	61.4	62.6	60.2	55.7	59.8	59.3[a]
Mean	57.5[a*]	60.2[a]	60.5[a]	60.0[a]	57.2[a]	59.3[a]	
				(b)			
0	75.6	76.2	78.8	79.2	81.2	78.0	78.2[b]
0+	72.2	74.6	76.0	76.7	74.8	76.2	
210	78.0	80.0	82.1	81.3	81.7	80.9	80.6[a]
Mean	76.8[e]	78.1[d]	80.5[b]	80.3[bc]	81.5[a]	79.5[c]	
				(c)			
0	10.2	10.4	9.5	10.4	11.4	10.4	10.4[a]
0+	7.8	6.1	6.4	8.2	4.7	6.8	
210	7.3	12.7	13.9	12.4	8.7	11.5	11.1[a]
Mean	8.8[a*]	11.6[a]	11.7[a]	11.4[a]	10.1[a]	11.0[a]	
				(d)			
0	48.6	48.5	48.9	49.0	47.3	48.7	48.5[a]
0+	40.5	42.4	41.5	42.3	41.8	nd	
210	48.9	48.6	48.7	48.8	47.2	48.9	48.5[a]
Mean	48.7[a*]	48.6[a]	48.8[a]	49.0[a]	47.3[b]	48.8[a]	

[1] a= acid detergent fiber b= neutral detergent fiber
c= acid detergent lignin d= cellulose
+ values in the row are for leaf fraction
nd = not determined
* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b	c	d
SR	ns	0.64	ns	ns
GD	ns	0.40	ns	ns

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Mean grass stem NDF was 78.2 % before stocking and 80.6 % after 210 days of grazing. Leaf of C. gayana and stylo had lower NDF values than the grass stem at the beginning of the grazing period.

4.5.2.7 Acid detergent lignin (ADL) and cellulose

Neither stocking rate nor days of grazing had a marked effect on the ADL content of C. gayana stem (Table 10.6c). ADL was lower in C. gayana leaf (4.7 to 8.2 %) and stylo shoot (5.8 to 12.0 %) lower than in C. gayana stem (9.5 to 11.4 %) before grazing started. C. gayana stem cellulose content was significantly lower ($P < 0.01$) at 36 sheep/ha than at any other stocking rate while its leaf cellulose was not consistent (Table 10.6d).Duration of grazing did not influence stem cellulose content.

4.5.3. 1987-1988 grazing period (GP 3)

4.5.3.1 Crude protein content

Table 11.1a indicated that the CP content of stem of the unstocked grass (4.46 %) did not differ markedly from that of the stocked grass (4.52- 5.55 %). The corresponding leaf values were 8.85 % and 7.92 -8.81 % (Table 11.1b), showing that the leaf was richer in CP than the stem. CP in both the stem and leaf fractions declined significantly ($P < 0.01$) as the days of grazing increased.

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4.5.3.2. Phosphorus content

The P content of stem and leaf was not significantly ($P > 0.05$) affected by stocking rate or days of grazing although there was the tendency for values to decrease as grazing days increased (Table 11.2). Phosphorus content of leaf was higher (0.15 -0.22 %) than that of the stem (0.11 - 0.14 %) at the same stage of grazing.

Table 11.1: Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf crude protein contents (%) during the 1987-1988 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	6.1	6.2	7.5	7.9	7.3	6.0	6.82[a]
84	5.6	4.4	6.3	7.5	5.7	5.0	5.75[ab]
126	4.8	3.9	4.1	4.3	4.4	4.4	4.36[b]
168	2.1	3.6	2.3	2.5	2.1	2.4	2.49[c]
Mean	4.64[a]*	4.52[a]	5.09[a]	5.55[a]	4.88[a]	4.46[a]	
				(b)			
0	10.7	10.10	10.8	10.6	10.7	10.2	10.51[a]
84	8.5	7.5	8.3	7.7	8.6	8.0	8.26[b]
126	6.1	6.1	7.3	6.0	7.1	7.5	6.68[c]
Mean	8.42[a]	7.92[a]	8.81[a]	8.08[a]	8.81[a]	8.85[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR	ns	ns
GD	0.30	0.17

Table 11.2: Effect of stocking rate and grazing duration on phosphorus content (%) in (a) stem and (b) leaf of C. gayana during the 1987-1988 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	0.12	0.13	0.16	0.15	0.14	0.14	0.14[a]
84	0.13	0.14	0.15	0.12	0.13	0.14	0.14[a]
126	0.10	0.12	0.12	0.11	0.11	0.10	0.11[a]
168	0.10	0.09	0.09	0.11	0.11	0.11	0.10[a]
Mean	0.11[a]*	0.12[a]	0.13[a]	0.12[a]	0.12[a]	0.12[a]	ns
				(b)			
0	0.20	0.20	0.25	0.20	0.24	0.24	0.22[a]
84	0.18	0.20	0.16	0.20	0.22	0.16	0.19[a]
126	0.15	0.14	0.16	0.15	0.20	0.12	0.15[a]
Mean	0.18[a]	0.18[a]	0.19[a]	0.18[a]	0.22[a]	0.16[a]	ns

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

4.5.3.3. Potassium content

Stem and leaf concentrations of K did not vary significantly ($P > 0.05$) among the stocking rates but declined markedly as grazing days increased (Table 11.3). The leaf fraction had higher percentages of K than the stem.

4.5.3.4. Calcium content

Averaged over the stocking rates, the Ca content of the stem was unaffected whereas that of the leaf declined significantly ($P < 0.01$) as the grazing days increased (Table 11.4). For the same stage /days of grazing, the leaf contained more Ca than the stem.

4.5.3.5. Magnesium content

The Mg contents of the leaf and stem component neither varied significantly nor followed any pattern with respect to either stocking rate or increase in days of grazing (Table 11.5). Leaf and stem Mg contents were about the same.

4.5.3.6. Acid detergent fibre (ADF) and neutral detergent fiber (NDF)

Increased stocking rate and days of grazing had no significant effect on the stem ADF and NDF contents (Tables 11.6a and b). Pooled over all stocking rates, ADF values varied from 54.1 to 56.8 % and 51.4 to 58.9 % for the 0 and 168th days of grazing, respectively. Mean leaf ADF content determined at the beginning of grazing was lower than that of the stem. The leaf averaged 75.2 % NDF prior to grazing.

4.5.3.7. Acid detergent lignin (ADL) and cellulose

The mean stem ADL content was not significantly influenced ($P > 0.05$) by stocking rate or days of grazing in

Table 11.3: Effect of stocking rate and grazing duration on potassium content (% in (a) stem and (b) leaf of C. gayana during the 1987-1988 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	1.40	1.74	1.90	1.94	1.73	1.80	1.75[a]
84	1.13	1.40	1.05	1.27	1.38	1.40	1.24[b]
126	0.80	1.04	1.05	1.03	1.08	0.92	0.98[c]
168	0.80	0.82	0.80	0.70	0.75	0.83	0.78[c]
Mean	1.03[a]*	1.25[a]	1.20[a]	1.24[a]	1.24[a]	1.25[a]	ns
				(b)			
0	1.99	1.98	2.07	2.43	2.09	2.00	2.09[a]
84	1.26	1.36	1.44	1.68	1.43	1.40	1.36[b]
126	1.09	1.01	1.06	1.08	1.06	1.18	1.08[c]
Mean	1.45[a]	1.43[a]	1.52[a]	1.73[a]	1.53[a]	1.53[a]	ns

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR	ns	ns
GD	0.15	0.10

Table 11.4: Effect of stocking rate and grazing duration on calcium content (%) in (a) stem and (b) leaf of C. gayana during the 1987-1988 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	0.20	0.20	0.17	0.20	0.17	0.24	0.21[a]
84	0.15	0.14	0.22	0.26	0.21	0.24	0.22[a]
126	0.14	0.15	0.18	0.30	0.22	0.26	0.22[a]
168	0.22	0.22	0.27	0.11	0.13	0.24	0.20[a]
Mean	0.18[a*]	0.20[a]	0.21[a]	0.22[a]	0.18[a]	0.27[a]	ns
				(b)			
0	0.40	0.35	0.40	0.36	0.38	0.35	0.38[a]
84	0.30	0.28	0.26	0.32	0.34	0.30	0.30[b]
126	0.25	0.24	0.26	0.29	0.28	0.24	0.26[b]
Mean	0.32[a]	0.30[a]	0.31[a]	0.32[a]	0.33[a]	0.30[a]	

* Means in the same row or column followed by similar superscripts do not diffe significantly (P=0.05).

SED	a	b
SR	ns	ns
GD	ns	0.02

Table 11.5: Effect of stocking rate and grazing duration on magnesium content (%) in (a) stem and (b) leaf of C. gayana during the 1987-1988 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	0.09	0.10	0.10	0.09	0.07	0.09	0.09[a]
84	0.06	0.09	0.13	0.09	0.08	0.14	0.10[a]
126	0.10	0.11	0.07	0.12	0.13	0.12	0.11[a]
168	0.09	0.10	0.09	0.05	0.06	0.07	0.08[a]
Mean	0.09[a]*	0.10[a]	0.10[a]	0.09[a]	0.09[a]	0.11[a]	ns
				(b)			
0	0.09	0.09	0.12	0.08	0.09	0.10	0.10[a]
84	0.05	0.07	0.07	0.11	0.08	0.06	0.07[a]
126	0.09	0.10	0.11	0.09	0.08	0.09	0.09[a]
Mean	0.08[a]	0.09[a]	0.10[a]	0.09[a]	0.08[a]	0.08[a]	ns

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

Table 11.6: Effect of stocking rate and grazing duration on the content (%) of structural components[1] of the stem and leaf of C. gayana during the 1987-1988 grazing period.

GD	SR 12	18	24	30	36	Control	Mean
			(a)				
0	55.9	56.8	55.1	55.8	56.6	55.2	55.2[a]
0+	43.7	44.2	42.9	47.6	44.2	45.2	44.6
168	55.5	58.4	58.9	57.3	51.4	56.8	56.4[a]
Mean	55.7[a]*	57.8[a]	56.5[a]	56.6[a]	54.0[a]	56.0[a]	ns
			(b)				
0	79.2	80.6	82.8	78.5	83.3	80.1	80.8[a]
0+	74.4	75.9	76.8	76.0	72.9	75.2	75.2
168	84.0	84.0	84.5	87.5	81.1	81.5	83.8[a]
Mean	81.6[a]	82.3[a]	83.7[a]	83.0[a]	82.2[a]	80.8[a]	ns
			(c)				
0	9.9	10.3	12.8	8.6	9.2	9.2	10.0[a]
0+	4.4	3.0	4.1	5.1	4.8	4.6	4.3
168	10.9	10.7	12.5	11.5	8.2	13.0	11.1[a]
Mean	10.4[a]*	10.5[a]	12.7[a]	10.1[a]	8.7[a]	11.2[a]	ns
			(d)				
0	46.0	56.5	41.3	47.2	47.3	45.9	45.9[a]
0+	40.9	41.2	38.7	40.5	38.3	38.7	39.7
168	44.6	47.8	46.4	45.8	43.2	43.7	45.3[a]
Mean	45.3[a]	47.2[a]	43.9[a]	46.5[a]	45.3[b]	44.8[a]	ns

[1] a= acid detergent fiber b= neutral detergent fiber
c= acid detergent lignin d= cellulose

+ values in the row are for leaf fraction

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b	c	d
SR	ns	ns	ns	ns
GD	ns	ns	ns	ns

spite of the variation from 8.7 to 12.7 % for the swards stocked at 36 and 24 sheep/ha respectively (Table 11.6c). The leaf was consistently less lignified than the stem component for the samples analysed at the beginning of the grazing period.

The mean stem cellulose content at the beginning of the grazing period and 168 days of grazing was similar (Table 11.6d). Increased stocking rate had no effect on the grass stem cellulose content. Grass leaf had lower cellulose contents than the stem when grazing started.

4.5.4. 1988-1989 grazing period (GP 4)

4.5.4.1. Crude protein content

Though the leaf had a higher CP content than the stem, CP values in both decreased significantly ($P< 0.01$) with increase in days of grazing but were unaffected by stocking rate (Table 12.1). Stem CP content at the beginning of grazing doubled that observed on the 126th day of grazing.

4.5.4.2. Phosphorus and potassium contents

Data on the effects of stocking rate on P nd K contents during the 1988-1989 grazing period are presented in Tables 12.2a and b. Differences among stocking rates were not significant for both elements in grass stem. Stem P tended to fall as days of grazing advanced. Similarly, the highest K value (0.87 %) at 42 days of grazing was not different from that on other days of grazing. Variations in K content occurred at 42 and 126 days of grazing over the stocking rates (Table 12.2b). At the beginning of the grazing period, mean leaf P content was 0.30 % while K content was 1.09 %.

Table 12.1:- Effect of stocking rate and grazing duration on C. gayana (a) stem and (b) leaf crude protein content (%) during the 1988 - 1989 grazing period.

GD	SR 12	18	24	30	36	Control	Mean
				(a)			
0	6.8	7.0	7.0	7.0	7.2	6.8	6.9[a]
42	4.4	4.8	4.4	4.8	4.2	4.0	4.7[b]
126	3.2	3.2	3.3	3.5	3.6	3.0	3.3[c]
Mean	4.8[a]	5.0[a]	4.9[a]	5.1[a]	5.0[a]	4.6[a]	
				(b)			
0	9.6	9.4	9.8	10.0	10.2	9.2	9.7[a]
42	7.0	7.0	6.8	7.2	7.0	6.8	7.0[b]
Mean	8.3[a]*	8.2[a]	8.3[a]	8.6[a]	8.5[a]	8.0[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05).

SED	a	b
SR	ns	ns
GD	0.34	0.21

Table 12.2 Effect of stocking rate and grazing duration on C. gayana stem and leaf(a) phosphorus (b) potassium (c) calcium and (d) magnesium contents (%) 1988-1989 grazing period.

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	0.23	0.18	0.28	0.28	0.21	0.22	0.23[a]
0+	0.26	0.32	0.32	0.28	0.27	0.32	0.30
42	0.18	0.13	0.16	0.26	0.28	0.20	0.20[a]
126	0.10	0.12	0.15	0.16	0.15	0.18	0.14[a]
Mean	0.17[a]	0.14[a]	0.20[a]	0.23[a]	0.21[a]	0.20[a]	
				(b)			
0	0.84	0.80	0.76	0.76	0.95	0.73	0.81[a]
0+	1.03	1.02	1.10	1.04	1.18	1.15	1.09
42	0.73	1.00	0.95	1.24	0.59	0.70	0.87[a]
126	0.65	0.81	0.78	1.03	0.84	0.78	0.82[a]
Mean	0.74[a]	0.87[a]	0.83[a]	1.01[a]	0.79[a]	0.74[a]	
				(c)			
0	0.26	0.30	0.31	0.22	0.25	0.22	0.26[a]
0+	0.31	0.30	0.31	0.29	0.29	0.30	0.30
42	0.21	0.17	0.14	0.15	0.16	0.17	0.17[b]
126	0.10	0.16	0.21	0.22	0.10	0.13	0.15b
Mean	0.19[a]	0.21[a]	0.22[a]	0.20[a]	0.17[a]	0.17[a]	
				(d)			
0	0.11	0.12	0.12	0.09	0.12	0.09	0.11[a]
0+	0.14	0.15	0.14	0.13	0.15	0.13	0.14
42	0.10	0.07	0.07	0.08	0.07	0.08	0.08[b]
126	0.07	0.09	0.11	0.10	0.10	0.11	0.10[a]
Mean	0.09[a]	0.09[a]	0.10[a]	0.09[a]	0.11[a]	0.09[a]	

+ Values in parenthesis are for leaf fraction.

* Means in the same row or column with different superscripts differ significantly at $P<0.05$.

SED	a	b	c	d
SR	ns	ns	ns	ns
GD	ns	ns	0.02	0.008

4.5.4.3. Calcium and magnesium contents

Stocking rate did not affect the calcium and magnesium levels in the stem (Table 12.2c and d). On the other hand, mean Ca content in the grass stem was significantly ($P< 0.01$) higher at the beginning of the grazing period. Thereafter, the difference between content at 42 and 126 days of grazing was not significant.

The level of Mg in the stem was also significantly ($P< 0.01$) affected by grazing days. Mean values at 0 and 126 days of grazing were similar and were higher than the value recorded at 42 days of grazing.

Calcium and Mg values in leaf of C. gayana were 0.30 and 0.14 % respectively at the beginning of the grazing period. The values were slightly higher than those of the stem.

4.5.5. 1989-1990 grazing period

4.5.5.1. Crude protein and phosphorus contents

Whereas CP and P contents of the grass were unaffected by stocking rate, it declined significantly ($P< 0.01$) as the grazing days increased (Tables 13a and b). Crude protein declined from 8.8-9.3 % at the beginning of grazing to 4.0 to 5.3 % at 84 days after. The highest and lowest P concentrations (0.33, 0.18 %) were obtained at 0 and 84 days of grazing, respectively.

4.5.5.2. Potassium, calcium and magnesium contents

Potassium content tended to increase ($P< 0.01$) as the stocking rates increased (Table 13.c). The grass shoot at 24 and 36 sheep/ha rates had higher K contents than at the other treatments. A decline in K values was observed from 0 to 84 days of grazing.

Table 13 Effect of stocking rate and grazing duration on C. gayana green shoot (a) crude protein, (b) phosphorus (c) potassium (d) calcium and (e) magnesium contents (%) during the 1989 - 1990 grazing period

GD	SR						
	12	18	24	30	36	Control	Mean
				(a)			
0	8.9	9.2	9.3	8.9	9.3	8.8	9.1[a]
84	4.0	4.0	5.3	4.5	4.4	4.4	4.4[b]
Mean	6.5[a*]	6.6[a]	7.3[a]	6.7[a]	6.9[a]	6.6[a]	
				(b)			
0	0.33	0.31	0.27	0.29	0.30	0.30	0.30[a]
84	0.23	0.21	0.18	0.18	0.18	0.23	0.20[b]
Mean	0.28[a]	0.26[a]	0.23[a]	0.24[a]	0.25[a]	0.27[a]	
				(c)			
0	1.60	1.68	1.68	1.70	1.80	1.72	1.70[a]
84	0.95	1.03	1.46	1.27	1.46	0.95	1.19[b]
Mean	1.28[b]	1.36[b]	1.57[a]	1.49[ab]	1.63[a]	1.34[b]	
				(d)			
0	0.28	0.32	0.28	0.32	0.34	0.30	0.31[a]
84	0.17	0.22	0.22	0.21	0.26	0.26	0.22[b]
Mean	0.23[a]	0.27[a]	0.25[a]	0.27[a]	0.30[a]	0.28[a]	
				(e)			
0	0.12	0.12	0.10	0.12	0.11	0.10	0.11[a]
84	0.08	0.08	0.08	0.09	0.10	0.09	0.09[a]
Mean	0.10[a]	0.10[a]	0.09[a]	0.11[a]	0.11[a]	0.10[a]	

* Means in the same row or column followed by similar superscripts do not differ significantly (P=0.05)

SED	a	b	c	d	e
SR	ns	ns	0.03	ns	ns
GD	0.50	0.008	0.01	0.008	ns

Stocking rate did not exert any influence on Ca and Mg contents (Tables 13d and e). With increase in days of grazing, there was a significant (P< 0.01) decline in Ca content. On the other hand, Mg content at 0 and 84 days of grazing are similar.

4.6. Sheep performance

4.6.1 1985-1986 grazing period (GP 1)

4.6.1.1 Daily liveweight gain

Data on daily liveweight gain (Table 14.1) indicated no significant effect (P> 0.01) of stocking rate. However, as the grazing days increased liveweight gain decreased. At the lowest stocking rate, daily weight gain was highest (26.7 g) while at the highest stocking rate sheep lost 0.7 g/hd/day on the average. Highest daily weight gain (128.6 g/hd) was obtained after 14 days of grazing. This declined to 7.1 g/hd after 98 days of grazing (28 Jan. 1986) after which weight loss commenced.

4.6.1.2. Cumulative liveweight gain per head

As grazing advanced up to 98 days, mean cumulative liveweight gain reached a peak of 5 kg/hd (Table 14.2). Thereafter, losses were recorded and the final (day 168) mean weight gain was 2.30 kg/hd. Liveweight gains were highest and not different (P>0.01) after 84 and 98 days of grazing. Liveweight gains when averaged over grazing days for stocking from 18 to 24 and 30 to 36 sheep/ha were similar.

4.6.1.3. Liveweight gain per hectare

The effect of stocking rate on the liveweight gain per hectare was not significant (Table 14.3). The trend as days of grazing increased was similar to that of the daily

Table 14.1: Effect of stocking rate on average sheep daily liveweight gain (g/hd/day) on C. gayana pasture during the 1985 -1986 grazing period.

Grazing days	Stocking rate 12	18	24	30	36	Mean
14	142.9	142.9	142.9	107.1	107.1	128.6^{a}
28	71.4	71.4	71.4	71.4	71.4	71.4^{b}
42	71.4	71.4	35.7	35.7	35.7	49.9^{bc}
56	71.4	35.7	35.7	35.7	0.0	35.7^{bcd}
70	71.4	35.7	35.7	35.7	35.7	42.8^{bcd}
84	35.7	35.7	35.7	0.0	0.0	21.4^{cd}
98	0.0	35.7	0.0	0.0	0.0	7.1^{def}
112	0.0	-35.7	-17.8	-35.7	-35.7	-24.9^{efgh}
126	-35.7	-35.7	-17.8	-35.7	-35.7	-32.1^{fgh}
140	-35.7	-35.7	-35.7	-35.7	-53.0	-39.2^{gh}
154	-35.7	-35.7	-35.7	-35.7	-53.0	-39.2^{gh}
168	-35.7	-44.6	-71.4	-71.4	-80.0	-60.6^{h}
Mean	26.7^{a*}	20.0^{a}	14.8^{a}	5.9^{a}	-0.7^{a}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05).

SED
SR = 9.0
GD = 5.8
SR x GD = 20.2

Table 14.2: Effect of stocking rate on cumulative sheep liveweight gain (kg/hd) on C. gayana pasture during 1985 -1986 grazing period.

Grazing days	Stocking rate 12	18	24	30	36	Mean
14	2.0	2.0	2.0	1.5	1.5	1.8^{i}
28	3.0	3.0	3.0	2.5	2.5	2.8^{h}
42	4.0	4.0	3.5	3.0	3.0	3.5^{ef}
56	5.0	4.5	4.0	3.5	3.0	4.0^{cde}
70	6.0	5.0	4.5	4.0	3.5	4.6^{abc}
84	6.5	5.5	5.0	4.0	3.5	4.9^{a}
98	6.5	6.0	5.0	4.0	3.5	5.0^{a}
112	6.5	5.5	4.8	3.5	3.0	4.7^{ab}
126	6.0	5.0	4.5	3.0	2.5	4.2^{bcd}
140	5.5	4.5	4.0	2.5	1.8	3.7^{def}
154	5.0	4.0	2.5	2.0	1.0	3.1^{fg}
168	4.5	3.4	2.5	1.0	-0.1	2.3^{hi}
Mean	5.04^{a*}	4.36^{b}	3.85^{b}	2.87^{c}	2.38^{c}	

*Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05).

SED
SR = 0.14
GD = 0.09
SR x GD = 0.32

Table 14.3: Effect of stocking rate on sheep liveweight gain (kg/ha) on C. gayana pasture during 1985 -1986 grazing period.

Grazing days	Stocking rate 12	18	24	30	36	Mean
14	24.0	36.0	48.0	45.0	54.0	41.4[a]
28	12.0	18.0	24.0	30.0	36.0	24.0[b]
42	12.0	18.0	12.0	15.0	18.0	15.0[bc]
56	12.0	9.0	12.0	15.0	0.0	9.6[cd]
70	12.0	9.0	12.0	15.0	18.0	13.2[c]
84	6.0	9.0	12.0	0.0	0.0	5.4[cd]
98	0.0	9.0	0.0	0.0	0.0	1.8[d]
112	0.0	-9.0	-6.0	-15.0	-18.0	-9.6[e]
126	-6.0	-9.0	-6.0	-15.0	-18.0	-10.8[e]
140	-6.0	-9.0	-12.0	-15.0	-26.7	-13.7[ef]
154	-6.0	-9.0	-12.0	-15.0	-26.7	-13.7[ef]
168	-6.0	-11.2	-24.0	-30.0	-40.3	-22.3[f]
Mean	4.5[a*]	5.1[a]	5.0[a]	2.5[a]	-0.3[a]	

*Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05).

SED
SR = 3.1
GD = 2.5
SR x GD = 7.7

liveweight gain per sheep. The 36 sheep/ha rate gave the highest liveweight gain per hectare up to 42 days of grazing. Total liveweight gains/period were 54.0, 60.8, 60.0,30.0 and -3.8 kg/ha,for 12, 18, 24, 30 and 36 sheep/ha,respectively.

4.6.1.4 Relationships between liveweight gains and stocking rate.

There was a significant ($P<0.01$) negative linear relationship between daily liveweight gain per anlmal (Ya) and stocking rate SR (x). The corresponding equation was:

$$Ya = 40.9 - 1.15x \quad (R^2 = 0.99)$$

The quadratic relationship between liveweight gain per hectare (Yh) and (x) was expressed as :

$$Yh = 6.44x - 0.17x^2 \quad (R^2 = 0.99)$$

The OSR, (a/2b) was 17.8 sheep/ha (Fig.1) and the calculated maximum Yh at this OSR was 61.2 Kg. The figure also indicated that at SR twice the OSR (1.0), Ya was negative.

4.6.2. 1986-1987 grazing period (GP 2)

4.6.2.1. Daily liveweight gain

Daily liveweight gain decreased significantly ($P<0.01$) with increases in grazing days and stocking rate (Table 15.1). Losses in liveweight at the 12 and 18 sheep/ha commenced on 4 Feb. 1987 (168 days of grazing). There were no differences in liveweight gains recorded from 98 to 154 and from 168 to 210 days of grazing. Daily liveweight gains at the 12,18, 24 and 30 sheep/ha were not significantly different. The highest weight gain of 154.0 g/hd/day was recorded at the 24 sheep/ha during the first 14 days of grazing.

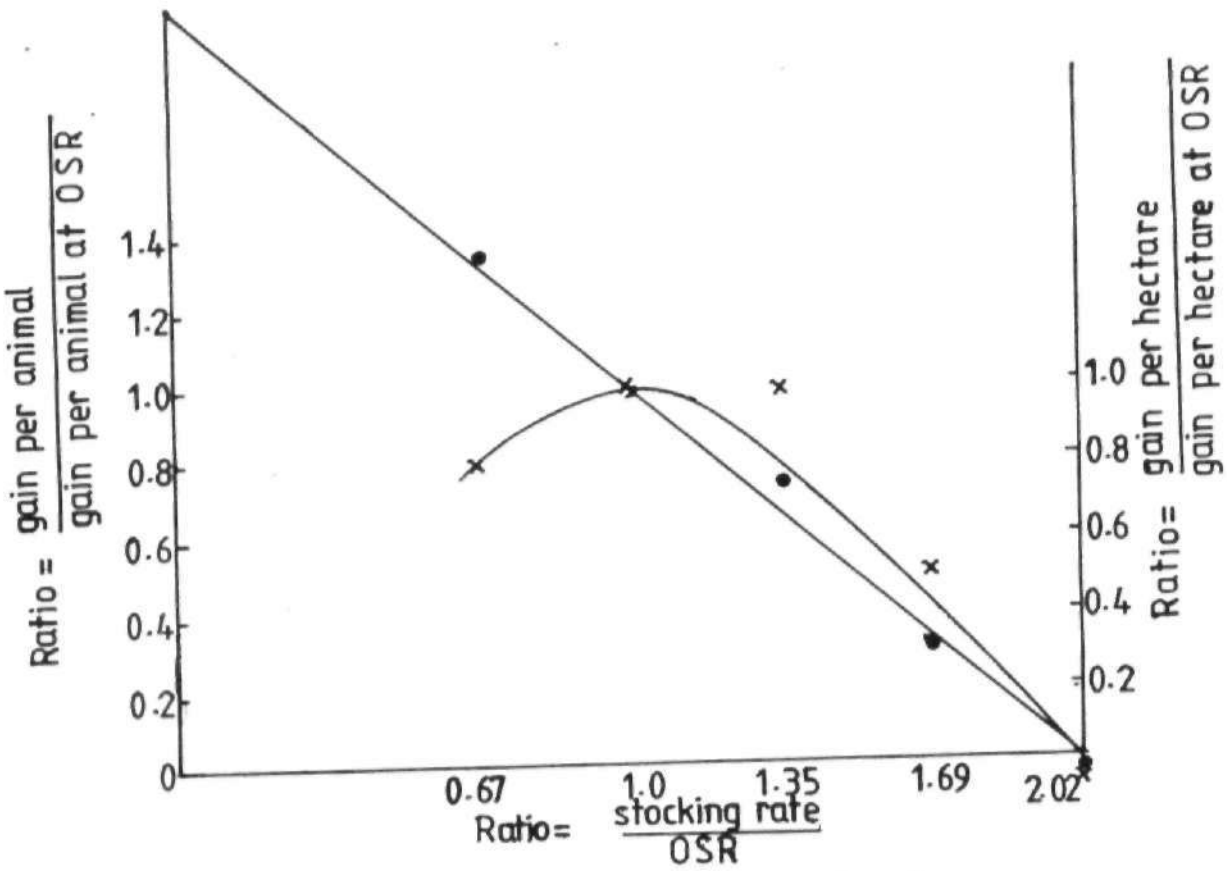


Fig.1 The relation between stocking rate and both gain per animal and gain per hectare during the 1985-1986 grazing period

Table 15.1: Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana -S. guianensis pasture during the 1986-1987 grazing period.

GD	SR 12	18	24	30	36	Mean
14	151.8	107.2	154.0	89.3	107.2	117.9^{a*}
28	134.0	125.1	98.2	71.4	98.3	103.6^{ab}
42	125.1	80.4	80.3	62.4	62.5	82.2^{abc}
56	80.3	71.4	71.4	62.4	44.6	66.0^{bcd}
70	89.3	62.5	62.5	62.4	35.7	62.5^{bcd}
84	71.4	53.5	62.5	35.7	35.7	51.8^{cde}
98	62.4	53.6	35.7	17.9	35.7	41.1^{def}
112	44.6	44.6	44.6	35.7	17.7	37.4^{def}
126	44.6	35.7	53.6	17.9	0.00	30.4^{def}
140	44.6	35.7	35.7	0.00	0.00	23.2^{ef}
154	35.7	26.8	0.00	-26.8	-17.9	3.6^{fg}
168	-17.9	-26.8	-8.9	-44.6	-53.6	-30.3^{gh}
182	-26.8	-35.7	-53.5	-44.6	-53.6	-30.3^{gh}
196	-26.8	-26.8	-62.5	-62.5	-62.5	-48.2^{h}
210	-26.8	-26.8	-62.5	-62.5	-71.4	-50.0^{h}
Mean	52.4^{a*}	38.7^{ab}	32.7^{ab}	14.3^{ab}	11.3^{b}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 9.6
GD = 5.5
SR xGD = 21.4

4.6.2.2. Cumulative liveweight gain per head

Production per head increased significantly ($P < 0.01$) up to 140 days of grazing but decreased subsequently (Table 15.2). The highest live weight gain attained during the grazing period at 12, 18, 24 30 and 36 sheep/ha were 12.50, 9.75, 9.00, 6.38 and 6.00 kg/hd, respectively. As stocking rate decreased cumulative live weight gain per animal increased. The differences in values at 18 and 24 and between 30 and 36 sheep/ha were not significant.

4.6.2.3. Liveweight gain per hectare

Liveweight gain per hectare declined as the days of grazing increased (Table 15.3). Higher production occurred at the 36 sheep/ha stocking rate up to 42 days of grazing. By day 168, all the animals had started losing weight: this was most pronounced at 36 sheep/ha. Overall liveweight gains from days 14 to 28, 42 to 70, 84 to 112 and 168 to 210, were not different from one another. At 36 and 24 sheep/ha mean values were least and highest respectively. The total liveweight gain per grazing period at 12,18,24,30 and 36 sheep/ha were 132.0, 146.6, 165.0, 90.0 and 85.5 kg/ha, respectively.

4.6.2.4. Relationships between liveweight gains and SR

The linear and quadratic relationship between Ya and SR and between Ya and SR, respectively were expressed as:

$Ya = 72.5 - 1.78x$ ($R^2 = 0.96$) and

$Yh = 14.65x - 0.35x^2$ ($R^2 = 0.98$)

Over the 210 days, the OSR was 20.4 sheep/ha (Fig. 2) while the maximum Yh was 155.4 Kg.

Table 15.2: Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (Kg/hd/) on C.gayana -S. guianensis pasture during the 1986-1987 grazing period.

GD	SR 12	18	24	30	36	Mean
14	2.13	1.50	1.88	1.25	1.50	1.65^{i*}
28	4.13	3.25	3.25	2.25	2.75	3.13^{h}
42	5.88	4.38	4.38	2.13	3.63	4.28^{g}
56	7.00	5.38	5.38	4.00	4.25	5.20^{f}
70	8.25	6.25	6.25	4.88	4.75	6.08^{ef}
84	9.25	7.00	7.13	5.38	5.25	6.80^{de}
98	10.13	7.75	7.63	5.63	5.75	7.38^{cd}
112	10.75	8.38	8.25	6.13	6.00	7.90^{abc}
126	11.38	8.88	9.00	6.38	6.00	8.33^{ab}
140	12.00	9.38	8.75	6.38	6.00	8.50^{a}
154	12.50	9.75	8.75	6.00	5.25	8.45^{a}
168	12.25	9.38	8.63	5.38	4.50	8.30^{abc}
182	11.88	8.88	7.88	4.75	3.75	7.43^{bcd}
196	11.50	8.50	7.13	3.88	2.88	6.78^{de}
210	11.13	8.13	6.25	3.00	1.84	6.08^{ef}
Mean	9.34^{a*}	7.12^{b}	6.70^{b}	4.56^{c}	4.28^{c}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 0.44
GD = 0.25
SR xGD = 0.98

Table 15.3: Effect of stocking rate and grazing duration on sheep liveweight ga (Kg/ha) on C.gayana -S. guianensis pasture during the 1986-1987 grazing period.

GD	SR 12	18	24	30	36	Mean
14	25.5	27.0	45.0	37.5	54.0	37.8^{a*}
28	22.5	31.5	33.0	30.0	45.0	32.4^{a}
42	21.0	20.3	27.0	26.2	31.5	25.2^{b}
56	13.5	18.0	24.0	26.2	22.5	20.8^{bc}
70	15.0	15.8	21.0	26.2	18.0	19.2^{bc}
84	12.0	13.5	21.0	15.0	18.0	15.9^{cd}
98	10.5	13.5	12.0	7.5	18.0	12.3^{de}
112	7.5	11.2	15.0	15.0	9.0	11.5^{de}
126	7.5	9.0	18.0	7.5	0.00	8.4^{e}
140	7.5	9.0	12.0	0.00	0.00	5.7^{ef}
154	6.0	6.8	0.00	-11.3	-9.0	-1.5^{f}
168	-3.0	-6.8	-3.0	-18.7	-27.0	-11.7^{g}
182	-4.5	-9.0	-18.0	-18.7	-27.0	-15.4^{g}
196	-4.5	-6.8	-21.0	-26.2	-31.5	-18.0^{g}
210	-4.5	-6.8	-21.0	-26.2	-36.0	-18.9^{g}
Mean	8.8^{a*}	9.8^{ab}	11.0^{a}	6.0^{b}	5.7^{b}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 2.0
GD = 1.3
SR xGD = 4.8

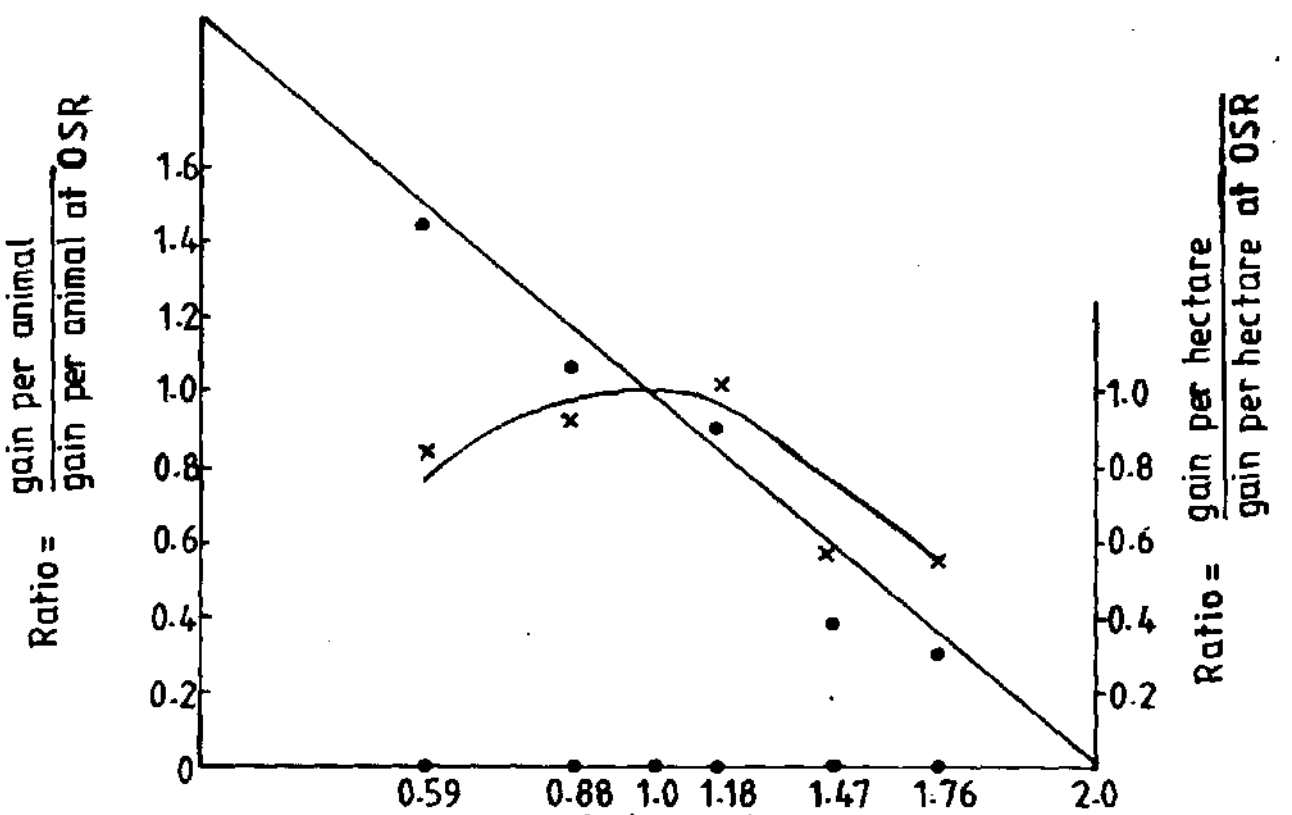


Fig. 2 The relation between stocking rate and both gain per animal and gain per hectare during the 1986-1987 grazing period

4.6.3. 1987-1988 grazing period (GP 3)

4.6.3.1. Daily liveweight gain

Daily liveweight gain declined as days of grazing and stocking rate increased (Table 16.1). Losses in daily liveweight gain commenced after 140 days of grazing (2 Jan. 1988). The mean liveweight gain of (60.6 g/hd/day) at 12 sheep/ha was significantly higher ($P< 0.01$) than that at 36 sheep/ha (23.0 g/hd/day) over the grazing period of 196 days. Liveweight gains at the other stocking rates were intermediate and not significantly different from the lowest and highest stocking rates. Sheep at the lowest and highest stocking rates recorded zero net gain in liveweight by 168 and 140 days of grazing respectively.

4.6.3.2. Cumulative liveweight gain per head

The effects of stocking rate and increase in the number of grazing days on cumulative liveweight gain per sheep are shown in Table 16.2. Mean values between 126 and 154 days of grazing were above 9.0 Kg/hd. The peak liveweights gained were 12.6 and 7.1 kg/hd at the 12 and 36 sheep/ha respectively. Average gain per head was higher in the least stocking rate than in the others. By the 168th day of grazing, animals stocked at 12 sheep/ha had put on twice as much weight as those at 36 sheep/ha).

4.6.3.3. Liveweight gain per hectare

Mean liveweight gain per hectare was positive up to 140 days of grazing (Table 16.3). Progressive decline in liveweight gain occurred thoughout the grazing period and values turned negative by 154 days of grazing except at the 12 and 18 sheep/ha rate. The 36 sheep/ha gave the highest

Table 16.1: Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana pasture during the 1987-1988 grazing period.

GD	SR 12	18	24	30	36	Mean
14	125.0	107.2	107.2	107.2	107.2	110.7^{a*}
28	137.5	98.2	80.3	98.3	98.2	100.7^{a}
42	116.1	107.2	89.3	80.3	80.3	94.6^{ab}
56	94.6	107.5	71.4	71.4	71.4	83.2^{abc}
70	80.3	71.4	71.4	71.4	53.6	69.6^{bcd}
84	80.3	71.4	62.5	53.6	44.6	62.5^{cd}
98	71.4	35.7	44.6	44.6	35.7	57.1^{cde}
112	71.4	35.7	44.6	44.6	26.8	44.6^{def}
126	53.6	44.6	35.7	17.9	8.9	32.1^{ef}
140	53.6	26.8	0.00	0.00	0.00	16.1^{fg}
154	8.9	0.00	-8.9	-9.0	-35.7	-8.9^{gh}
168	0.00	-17.9	-26.8	-35.7	-53.6	-26.8^{hi}
182	-17.9	-26.8	-35.7	-53.6	-53.6	-37.5^{i}
196	-26.8	-35.7	-53.6	-53.6	-62.5	-46.4^{i}
Mean	60.6^{a*}	47.2^{ab}	35.7^{ab}	30.6^{ab}	23.0^{b}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 6.5
GD = 3.9
SR xGD = 14.6

Table 16.2: Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (Kg/hd/) on C.gayana pasture during the 1987-1988 grazing period.

GD	SR 12	18	24	30	36	Mean
14	1.8	1.5	1.5	1.5	1.5	1.6^{h*}
28	3.7	2.9	2.6	2.8	2.9	3.0^{g}
42	5.3	4.4	3.9	3.9	4.0	4.3^{fg}
56	6.6	5.9	4.9	4.9	5.0	5.5^{ef}
70	7.8	6.9	5.9	5.9	5.8	6.4^{de}
84	8.9	7.9	6.8	6.6	6.4	7.3^{cd}
98	9.9	8.9	7.6	7.3	6.9	8.1^{abc}
112	10.9	9.4	8.3	7.9	7.3	8.7^{ab}
126	11.6	10.0	8.8	8.1	7.1	9.1^{a}
140	12.4	10.4	8.8	8.1	7.1	9.4^{a}
154	12.6	10.4	8.6	7.9	6.9	9.2^{a}
168	12.6	10.1	8.1	7.5	5.9	8.8^{ab}
182	12.1	9.8	7.6	6.8	5.1	8.3^{abc}
196	11.8	9.3	6.9	6.0	4.4	7.7^{bcd}
Mean	9.34^{a*}	7.12^{b}	6.70^{b}	4.56^{c}	4.28^{c}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 0.3
GD = 0.2
SR x GD = 0.7

Table 16.3: Effect of stocking rate and grazing duration on sheep liveweight ga (Kg/ha) on C. gayana pasture during the 1987-1988 grazing period.

GD	SR 12	18	24	30	36	Mean
14	21.0	27.0	36.0	45.0	54.0	36.6^{ax}
28	23.1	24.8	27.0	37.5	49.5	32.4^{ab}
42	19.5	27.0	30.0	33.7	40.5	30.1^{ab}
56	15.9	27.1	24.0	30.0	36.0	26.6^{bc}
70	13.5	18.0	24.0	30.0	27.0	22.5^{cd}
84	13.5	18.0	21.0	22.5	22.5	19.5^{de}
98	12.0	18.0	21.0	18.7	18.0	17.5^{de}
112	12.0	9.0	15.0	18.7	13.5	13.7^{ef}
126	9.0	11.2	12.0	7.5	4.5	8.8^{fg}
140	9.0	6.7	0.00	0.00	0.00	3.0^{g}
154	1.5	0.00	-3.0	-3.8	-18.0	-4.7^{h}
168	0.00	-4.5	-9.0	-15.0	-27.0	-11.1^{hi}
182	-3.0	-6.7	-12.0	-22.5	-27.0	-13.6^{i}
196	-4.5	-9.0	-18.0	-22.5	-31.5	-17.1^{i}
Mean	10.2^{a*}	11.9^{a}	12.0^{a}	12.8^{a}	11.6^{a}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 1.6
GD = 1.0
SR x GD = 3.4

gain during the first 56 days of grazing and the highest losses from 154 days onwards. As stocking rate increased beyond 12 sheep/ha, gains did not differ significantly. Over the grazing period of 196 days the highest gain (179.8 kg/ha) occurred at 30 sheep/ha and the lowest (142.5 kg/ha) at 12 sheep/ha. Values at 24,18 and 36 sheep/ha were 168.0, 166.6 and 162.0 kg/ha,respectively.

4.6.3.4 Relationship between liveweight gains and SR

The relationships between SR and Ya and between SR and Yh were linear and quadratic, respectively (Fig. 3). The equations are:

$Ya = 76.1 - 1.53x \quad (R^2 = 0.97)$

$Ya = 14.02x - 0.27x^2 \quad (R^2 = 0.97)$

The OSR occurred at 24.9 sheep/ha and the maximum Yh was 186.2 Kg over the 196 days of grazing.

4.6.4. 1988-1989 grazing period (GP 4)

4.6.4.1. Daily liveweight gain

There were no significant ($P > 0.05$) differences in daily liveweight gain between 28 to 56; 70 to 98 and 126 to 140 days of grazing (Table 17.1). Weight gain was reduced as the days of grazing increased while losses were recorded on day 126 (15 Feb. 1989) at 24, 30 and 36 sheep/ha. Daily liveweight gain at 56 days of grazing was half the value in the first 14 days. Daily liveweight gain per sheep was also significantly ($P < 0.01$) influenced by stocking rate. It averaged 60.1, 47.1, 26.0, 22.7 and 16.2 g/hd/day at 12, 18, 24, 30 and 36 sheep/ha respectively.

4.6.4.2. Cumulative live weight gain per head

Mean cumulative liveweight gain reached a peak on the

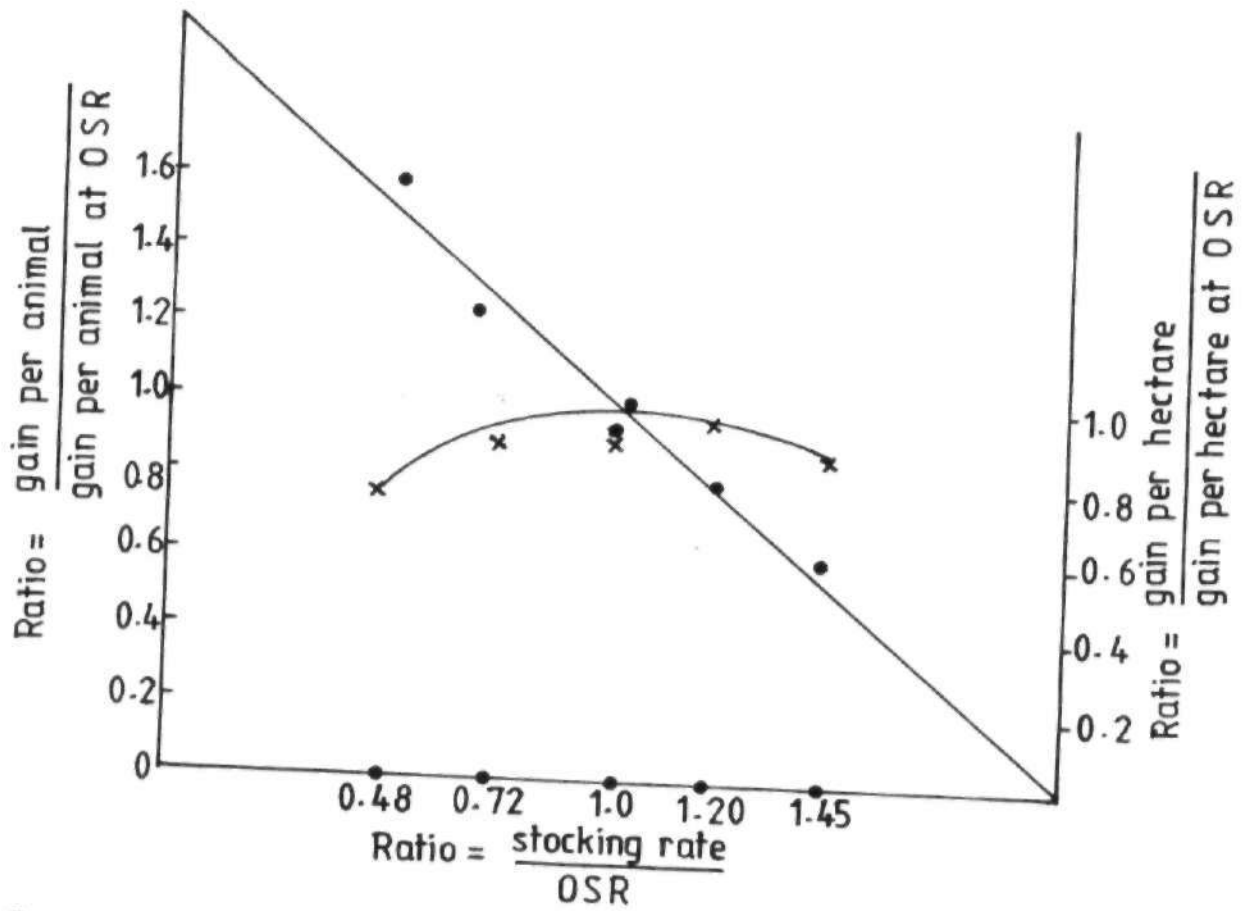


Fig. 3 The relation between stocking rate and both gain per animal and gain per hectare during the 1987-1988 grazing period.

Table 17.1: Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana pasture during the 1988-1989 grazing period.

GD	SR 12	18	24	30	36	Mean
14	178.6	142.9	178.5	142.9	107.1	150.0^{a*}
28	107.2	107.1	71.4	71.5	71.4	85.7^{b}
42	107.1	71.4	71.4	71.4	71.4	78.5^{b}
56	89.3	71.4	71.4	71.4	71.4	75.0^{b}
70	80.3	53.6	17.9	35.7	35.7	44.6^{cd}
84	62.5	71.4	35.7	35.7	35.7	48.2^{cd}
98	35.7	44.6	35.7	21.4	0.0	27.5^{de}
112	35.7	26.8	0.0	0.0	0.0	12.5^{e}
126	0.0	0.0	-35.7	-35.7	-35.7	-21.4^{f}
140	0.0	-26.8	-71.4	-71.4	-71.4	-48.2^{fg}
154	-35.7	-44.6	-89.3	-92.8	-107.2	-73.9^{g}
Mean	60.1^{a*}	47.1^{ab}	26.0^{bc}	22.7^{bc}	16.2^{c}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 6.9
GD = 4.7
SR xGD = 15.5

112th day of grazing and declined thereafter (Table 17.2). By the 126th day, sheep in the least stocked paddock gained twice the weight at the highest stocking rate. Averaged over all days of grazing, a significant ($P< 0.01$) decline in weight gain per animal was observed as stocking rate increased. The highest gain per animal (7.70 kg) was recorded at 12 sheep/ha while the lowest (4.10 kg) was observed at 36 sheep/ha.

4.6.4.3. Liveweight gain per hectare

Liveweight gain per hectare was not affected by stocking rate but it maximized at the highest stocking rate (36 sheep/ha) until the 70th day of grazing (Table 17.3). There was a general decline from the beginning to the termination of grazing. Gains were nil between 98 and 112 days at 36 sheep/ha. As observed for the previous grazing periods, mean liveweight losses were highest at the 36 sheep/ha. Total production were 130.5,111.0,104.0,96.0and 90.0 kg/ha at 18, 12, 30, 24 and36 sheep/ha,respectively.

4.6.4.4 Relationship between liveweight gains and SR

The linear regression equation obtained between Ya and SR was: $Ya = 79.3 - 1.87x$ ($R^2 = 0.93$).

On the other hand, the quadratic relationship between SR and Yh was: $Yh = 10.63x - 0.23x^2$ ($R^2 = 0.98$).

Figure 4 showed that OSR during this grazing period was 21.2 sheep/ha while the maximum Yh at this OSR was 129.4 Kg.

4.6.5 1989 - 1990 grazing period (GP 5)

4.6.5.1. Daily liveweight gain

Weight gain per head per day declined significantly ($P< 0.01$) with increase in stocking rate, averaging 61.8 to

Table 17.2: Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (Kg/hd/) on C.gayana pasture during the 1988-1989 grazing period.

GD	SR 12	18	24	30	36	Mean
14	2.5	2.0	2.5	2.0	1.5	2.1^{g*}
28	4.0	3.5	3.5	3.0	2.5	3.3^{f}
42	5.5	4.5	4.5	4.0	3.5	4.4^{e}
56	7.0	5.5	5.5	5.0	4.5	5.5^{d}
70	8.1	6.5	6.0	5.5	5.0	6.2^{cd}
84	9.0	7.5	6.5	6.0	5.5	6.9^{abc}
98	9.5	8.1	7.0	6.3	5.5	7.3^{ab}
112	10.0	8.5	7.0	6.3	5.5	7.5^{a}
126	10.0	8.5	6.5	5.8	5.0	7.2^{ab}
140	10.0	8.1	5.5	4.8	4.0	6.5^{bc}
154	9.5	7.5	4.5	3.5	2.5	5.5^{d}
Mean	7.7^{a*}	6.4^{b}	5.4^{c}	4.8^{cd}	4.1^{d}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 0.23
GD = 0.15
SR xGD = 0.50

Table 17.3: Effect of stocking rate and grazing duration on sheep liveweight ga
(Kg/ha) on C. gayana pasture during the 1988-1989 grazing period.

GD	SR 12	18	24	30	36	Mean
14	30.0	36.0	60.0	60.0	54.0	48.0^{a*}
28	18.0	27.0	24.0	30.0	36.0	27.0^{b}
42	18.0	18.0	24.0	30.0	36.0	25.2^{b}
56	15.0	18.0	24.0	30.0	36.0	24.6^{b}
70	13.5	13.5	6.0	15.0	18.0	13.2^{c}
84	10.5	18.0	12.0	15.0	18.0	14.7^{c}
98	6.0	11.3	12.0	9.0	0.0	7.6^{c}
112	6.0	6.8	0.0	0.0	0.0	2.6^{cd}
126	0.0	0.0	-12.0	-15.0	-18.0	-4.2^{d}
140	0.0	-6.8	-24.0	-30.0	-36.0	-19.4^{e}
154	-6.0	-11.2	-30.0	-40.0	-54.0	-28.2^{e}
Mean	10.1^{a*}	11.9^{a}	8.9^{a}	9.5^{a}	8.2^{a}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 2.5
GD = 1.6
SR x GD = 5.6

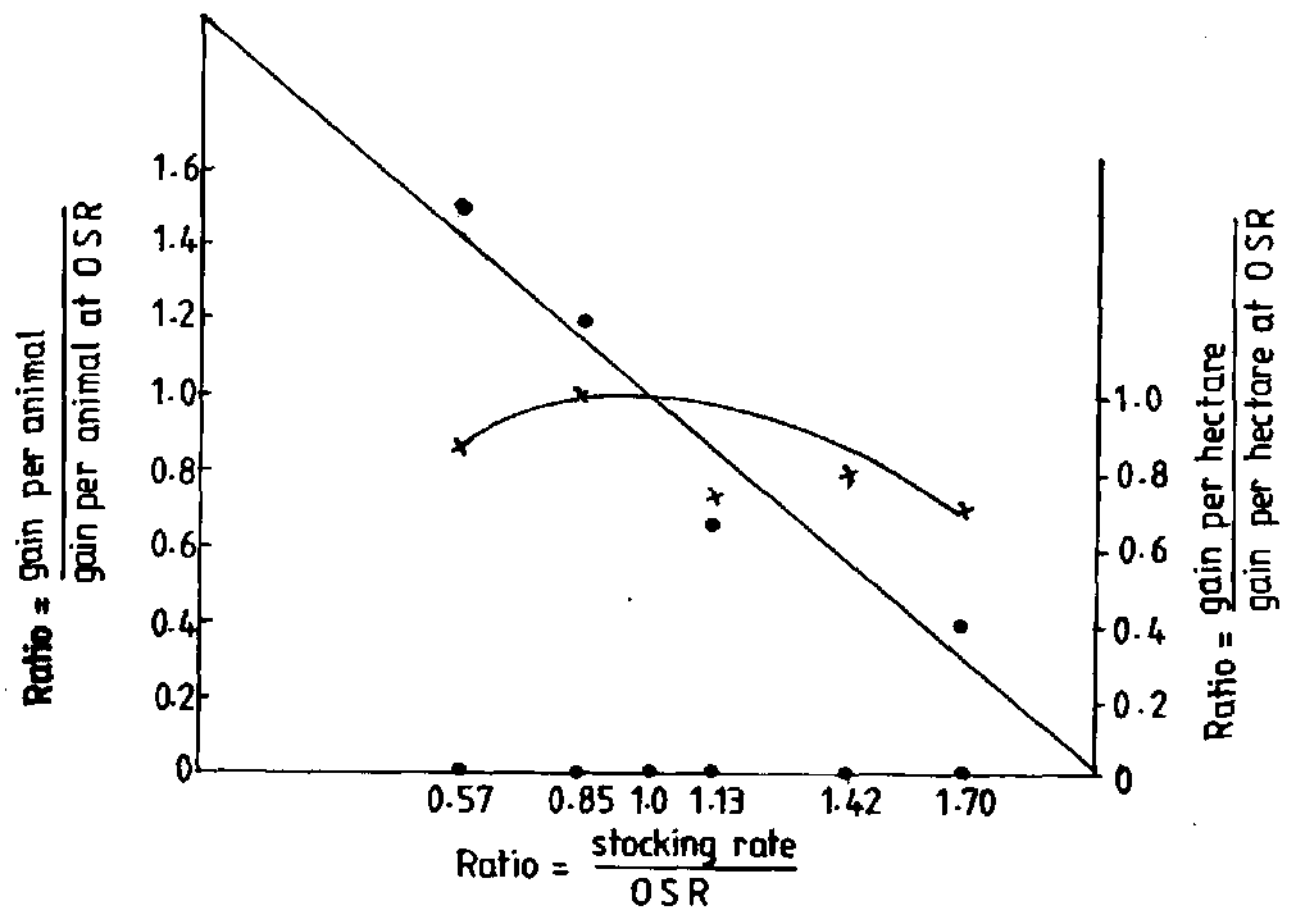


Fig. 4 The relation between stocking rate and both gain per animal and gain per hectare during the 1988–1989 grazing period

24.0 g for the 12 to 36 sheep/ha range studied (Table 18.1). Over the grazing period, liveweight gains between 12, 18, 24 and 30 sheep/ha were not significantly different ($P > 0.05$). Sheep recorded zero net gain at all stocking rates between 112 (26 Dec. 1989) and 154 (6 Feb. 1990) days of grazing. Losses in weight commenced after 126 (9 Jan. 1990) days of grazing at the highest stocking rate and after 154 days at the 12 and 18 stocking rates. Daily liveweight gain per head averaged 162.2 g at 14 days of grazing and fell to 82.1, 32.1, -19.6 and -50.1 g/hd/day, at 56, 112, 154 and 182 days of grazing respectively.

4.6.5.2. Cumulative liveweight gain per head

Mean cumulative liveweight gain per head was significantly ($P < 0.01$) higher at 12 and 18 sheep/ha than at any other stocking rates (Table 18.2). Weight gains per head between 24 and 30 sheep/ha did not differ significantly. Stocking at 12 and 36 sheep/ha produced (12.5 kg/hd) and (7.0 kg/hd) maximum liveweight gains, respectively. Liveweight gain per animal increased significantly as grazing days advanced up to 126 days across all stocking rates but the mean values from 98 to 168 days of grazing were similar.

4.6.5.3. Liveweight gain per hectare

Liveweight gain per hectare declined as the number of grazing days increased (Table 18.3). The pattern of weight change followed that of daily liveweight gain per animal. The 36 sheep/ha group gave the highest liveweight gain only up to 28th day of grazing. Over the entire grazing period, the liveweight gains per hectare for the 18 to 30 sheep/ha range was comparable and significantly exceeded that at 12 sheep/ha. Total production for the grazing period amounted

Table 18.1: Effect of stocking rate and grazing duration on average sheep daily liveweight gain (g/hd/day) on C.gayana pasture during the 1989-1990 grazing period.

GD	SR 12	18	24	30	36	Mean
14	178.6	203.6	142.9	142.9	142.9	162.2^{a*}
28	142.9	142.9	143.0	107.2	107.2	128.6^{ab}
42	125.1	107.1	107.1	107.1	71.4	103.6^{bc}
56	116.1	71.4	71.4	80.3	71.4	82.1^{cd}
70	98.2	80.3	71.4	71.4	53.6	75.0^{cd}
84	71.4	62.5	71.4	35.7	44.6	57.1^{de}
98	71.4	71.4	35.7	44.6	35.7	51.8^{de}
112	35.6	62.5	35.7	26.0	0.0	32.1^{ef}
126	35.7	35.7	0.0	0.0	0.0	14.3^{fg}
140	0.0	0.0	0.0	0.0	-35.7	-7.1^{gh}
154	0.0	0.0	-35.7	-26.8	-35.7	-19.6^{ghi}
168	-35.7	-26.8	-35.7	-35.7	-71.4	-41.1^{hi}
182	-35.7	-44.6	-26.8	-71.4	-71.4	-50.0^{i}
Mean	61.8^{a*}	58.9^{a}	44.7^{ab}	37.1^{ab}	24.0^{b}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 8.4
GD = 5.2
SR x GD = 18.7

Table 18.2: Effect of stocking rate and grazing duration on cumulative sheep liveweight gain (Kg/hd/) on C.gayana pasture during the 1989-1990 grazing period.

GD	SR 12	18	24	30	36	Mean
14	2.5	2.5	2.0	2.0	2.0	2.2^{hi*}
28	4.5	4.5	4.0	3.5	3.5	4.0^{g}
42	6.5	6.0	5.5	5.0	4.5	5.5^{f}
56	8.1	7.0	6.5	5.9	5.5	6.6^{e}
70	9.5	8.1	7.5	7.0	6.0	7.6^{d}
84	10.5	9.0	8.5	7.5	6.5	8.4^{bcd}
98	11.5	10.0	9.0	8.1	7.0	9.1^{ab}
112	12.0	11.0	9.5	8.5	7.0	9.6^{a}
126	12.5	11.5	9.5	8.5	7.0	9.8^{a}
140	12.5	11.5	9.5	8.5	6.5	9.7^{a}
154	12.5	11.5	9.0	8.1	6.0	9.4^{ab}
168	12.0	11.1	8.5	7.5	5.5	8.8^{abc}
182	11.6	10.5	8.1	6.5	4.0	8.1^{cd}
Mean	9.7^{a*}	8.8^{a}	7.5^{b}	6.7^{b}	5.4^{c}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 0.22
GD = 0.14
SR x GD = 0.49

Table 18.3: Effect of stocking rate and grazing duration on sheep liveweight ga (Kg/ha) on C. gayana pasture during the 1989-1990 grazing period.

GD	SR 12	18	24	30	36	Mean
14	30.0	51.3	48.0	60.0	72.0	52.3^{a*}
28	24.0	36.0	48.0	45.0	54.0	41.4^{ab}
42	21.0	27.0	36.0	45.0	36.0	33.0^{bc}
56	18.5	18.0	24.0	33.7	36.0	26.0^{cd}
70	16.5	20.2	24.0	30.0	27.0	23.5^{cd}
84	12.0	15.8	24.0	15.0	22.5	17.9^{de}
98	12.0	18.0	12.0	18.7	18.0	15.7^{de}
112	6.0	15.8	12.0	11.3	0.0	9.0^{ef}
126	6.0	9.0	0.0	0.0	0.0	3.0^{fg}
140	0.0	0.0	0.0	0.0	-18.0	-3.6^{gh}
154	0.0	0.0	-12.0	-11.3	-18.0	-8.3^{h}
168	-6.0	-6.8	-12.0	-15.0	-36.0	-15.2^{h}
182	-6.0	-11.2	-9.0	-30.0	-36.0	-18.4^{h}
Mean	10.4^{b*}	14.9^{a}	15.0^{a}	15.6^{a}	12.1^{ab}	

* Means in the same row or column followed by similar superscripts do not differ significantly (P= 0.05)

SED
SR = 2.0
GD = 1.5
SR x GD = 5.0

to 135.0, 157.6, 193.1, 195.0 and 202.4 kg/ha for pastures stocked at 36, 12, 18, 24 and 30 sheep/ha, respectively.

4.6.5.4 Relationship between liveweightgain and SR

A linear relationship expressed as :

$Ya = 84.3 - 1.62x$ ($R^2 = 0.97$) was observed between Ya and SR during the 182 days of grazing. However, a quadratic relationship was established between Yh and SR:

$Yh = 15.95x - 0.32x^2$ ($R^2 = 0.99$). The OSR and maximum Yh were 26 sheep/ha and 200.2 Kg, respectively(Fig.5)

4.7 Relationship between the liveweight gain (per head and per hectare) and grazing pressure.

The values of the constant (a) which represents the intercept were highest and least during 1987-1988 and 1985-1986 grazing periods respectively for each of the three plant variables used in expressing grazing pressure.(Tables 19 and 20). These values were negative for liveweight gain per head in all grazing periods but only during the 1985-1986 and 1986-1987 grazing periods for liveweight gain per hectare. The values of (b) and (c) in the equations were least and highest respectively for total herbage. The coefficient of determination (R^2) values were above 0.95 for liveweight gain per head while they ranged from 0.53 to 0.92 for liveweight gain per hectare. The least and highest R^2 values were recorded during 1988-1989 and 1985-1986 grazing periods respectively, (Table 20).

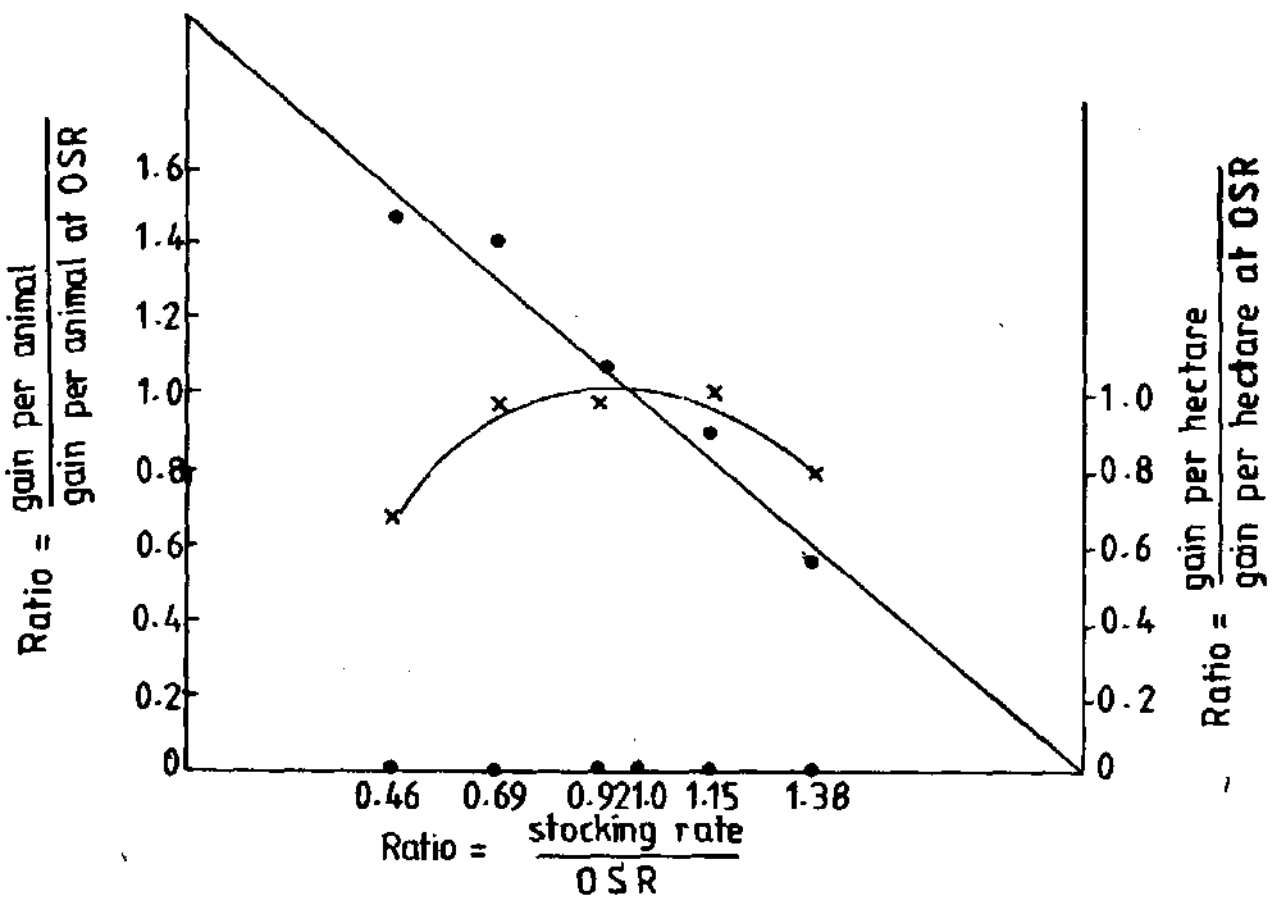


Fig. 5 The relation between stocking rate and both gain per animal and gain per hectare during the 1989–1990 grazing period

Table 19: Regression of mean daily liveweight gain per head (Ya) on grazing pressures+ during the grazing periods

Grazing period	Regression equations
1	$Ya = -32.6 + 168.4x_1 - 118.8x_1^2$ ($R^2 = 0.98$)
	$Ya = -34.9 + 183.4x_2 - 135x_2^2$ ($R^2 = 0.98$)
	$Ya = -30.9 + 129.2x_3 - 72.1x_3^2$ ($R^2 = 0.99$)
2	$Ya = -27.7 + 269.9x_1 - 227.4x_1^2$ ($R^2 = 0.96$)
	$Ya = -24.7 + 287.1x_2 - 268.7x_2^2$ ($R^2 = 0.96$)
	$Ya = -25.6 + 215.1x_3 - 147.9x_3^2$ ($R^2 = 0.96$)
3	$Ya = -5.5 + 175.3x_1 - 111.7x_1^2$ ($R^2 = 0.99$)
	$Ya = -7.7 + 202.4x_2 - 147.3x_2^2$ ($R^2 = 0.99$)
	$Ya = -4.9 + 147x_3 - 79.6x_3^2$ ($R^2 = 0.99$)
4	$Ya = -18.1 + 208.5x_1 - 130.1x_1^2$ ($R^2 = 0.97$)
	$Ya = -17.0 + 211.5x_2 - 133.9x_2^2$ ($R^2 = 0.97$)
	$Ya = -14.3 + 164.8x_3 - 83.2x_3^2$ ($R^2 = 0.97$)
5	$Ya = -24.4 + 354x_1 - 353.0x_1^2$ ($R^2 = 0.99$)
	$Ya = -28.2 + 391x_2 - 411.9x_2^2$ ($R^2 = 0.98$)
	$Ya = -22.9 + 303.4x_3 - 263.1x_3^2$ ($R^2 = 0.99$)

+ x_1 = total green material (kg/head)

x_2 = green shoot of C. gayana

x_3 = total herbage

R^2 = coefficient of determination

Table 20: Regression equations to data on mean liveweight gain per hectare (Yh) and grazing pressures+ during the grazing periods

Grazing period	Regression equations
1	$Yh = -79.4 + 518.3x_1 - 446.6x_1^2$ ($R^2 = 0.90$)
	$Yh = -85.0 + 556.2x_2 - 492.8x_2^2$ ($R^2 = 0.90$)
	$Yh = -76.1 + 404.0x_3 - 279.3x_3^2$ ($R^2 = 0.92$)
2	$Yh = -53.3 + 1042.0x_1 - 1249.6x_1^2$ ($R^2 = 0.71$)
	$Yh = -46.3 + 1150.5x_2 - 1579.1x_2^2$ ($R^2 = 0.69$)
	$Yh = -52.3 + 875.0x_3 - 892.1x_3^2$ ($R^2 = 0.70$)
3	$Yh = 149.9 + 144.0x_1 - 248.2x_1^2$ ($R^2 = 0.80$)
	$Yh = 146.1 + 176.1x_2 - 310.0x_2^2$ ($R^2 = 0.81$)
	$Yh = 149.5 + 124.7x_3 - 182.0x_3^2$ ($R^2 = 0.80$)
4	$Yh = 43.4 + 343.4x_1 - 377.2x_1^2$ ($R^2 = 0.55$)
	$Yh = 45.6 + 347.3x_2 - 399.8x_2^2$ ($R^2 = 0.53$)
	$Yh = 47.1 + 281.5x_3 - 266.3x_3^2$ ($R^2 = 0.57$)
5	$Yh = 80.34 + 713.6x_1 - 1056x_1^2$ ($R^2 = 0.83$)
	$Yh = 78.3 + 755.8x_2 - 1172x_2^2$ ($R^2 = 0.80$)
	$Yh = 84.0 + 602.7x_3 - 778.9x_3^2$ ($R^2 = 0.84$)

+ x_1 = total green material (kg/head)
x_2 = green shoot of C. gayana "
x_3 = total herbage "

CHAPTER FIVE

DISCUSSION

5.1 Soil chemical properties

The observed increase in soil total N after the four years of applying only single superphosphate to the pasture is in agreement with the findings of Peterson et al.(1956), Vallis (1972), Till (1975) and Okeagu (1989) that the recycling of nitrogen in faeces and urine in continuously grazed pastures increased soil nitrogen. The highest N content recorded at 36 sheep/ha (compared to the lower stocking rates) in this study conforms with the suggestion by Davidson (1964) that nitrogen level in the soil may be improved by high stocking rate. Okeagu (1989) reported a similar finding with soil under D. smutsii and B. decumbens pastures grazed by bulls.

The continuous application of single superphosphate in this study must have caused the increase in soil P level at all stocking rates. However, the level of Ca did not improve except at the highest stocking rate.

The fall in K and particularly Mg levels reported at the end of the four years of P application could be due to losses through removal of plant materials after cutting back at the end of each grazing period (Whiteman, 1980). Since the faeces were not removed, and erosion was not observed, the other avenue for loss of nutrient could have been through leaching.

5.2. Plant parameters

5.2.1 Botanical composition

Stylo persisted in the mixed pasture only up to the end of the 1986-1987 grazing period, a year after sowing. This result contrasts with the report by Winter et al. (1977a) that stable pastures of B. decumbens and P. maximum with S. guianensis cv. Endeavour were obtained after a three - year grazing period with cattle stocked at 0.7 to 2.2 animals/ha. In addition, the suppresion of stylo when it was first grazed in the second grazing period (1986-1987) in this study was not influenced by stocking rate as reported in other grazing studies with grass-legume pastures by sheep (Curll and Davidson, 1983; Curll et al., 1985) and by cattle (Stobbs, 1970; Shaw, 1978; Eng et al., 1978a).

C. gayana was more competitive than the stylo (11.2 % of the total pasture at the beginning of the 1986-1987 grazing period) which it eventually shaded out. Gutteridge (1985) reported a similar decline in the S. humilis, S. hamata and S. guianensis cv. Endeavour components of a mixture with bamboo grass (Arundinaria ciliata) where the ungrazed stemmy portion of the grass reduced the development of the legume. The grazing of stylo on a 24-hourly basis could also have suppressed the legume as observed by Blair Rains (1963) in Shika. It is not unlikely that stocking this pasture early in the season, such as in July, could have checked the grass growth and aided stylo development subsequently.

The resulting pure grass pasture after stylo was virtually eliminated remained stable in 1989 without nitrogen application. The result concurred with that of Addy and Thomas (1978) in which C. gayana pasture receiving 45 kg N/ha

annually remained stable up to the end of three wet season·s grazing by cattle at 2.50 to 7.50 LU/ha (I LU = 342 kg cow). The grass showed greater competition by its vigorous stoloniferous growth and shading effect which reduced the proportion of other species in the pasture in all the grazing periods. This result also confirmed that of Stobbs (1969a) of high competitive ability of C. gayana over weeds such as Sporobolus pyramidalis.

With the addition of nitrogen in 1989, the pasture was still C. gayana dominant. The proportion of other plant species during the grazing period did not exceed 4 % at all stocking rates. This observation is in line with other grazed, N fertilized P. clandestinum (Mears and Humphreys 1974a) and D. smutsii and B. decumbens pastures (Okeagu, 1989).

5.2.2. Dry matter yield

The increases in stem, green material, stem + leaf and total herbage yields observed at 42 days of grazing compared with day 0, especially at the 12, 18 and 24 sheep/ha and the control during grazing periods 2 and 3 might have been due to rapid regrowth (in response to additional rainfall) which was greater than herbage removal through grazing. During grazing periods 2 and 3 the rainfall, rainy days and extent of rainfall were higher than at other periods. In addition,grazing commenced earlier than at other periods. Although the extent of rainfall in grazing period 5 covered 41 days, the 11 rainy days were characterized by lower precipitation (145 mm) as recorded for that whole year (1989).Thus only total herbage and other species yields remained the same over the first 42 grazing days.The amount

of rainfall during grazing period 4 (88 mm), extent of rainy days (19) and rainy days (9) were least compared with other grazing periods except during GP 1 with no rains. Consequently yields of sown species fell during the first 42 days of grazing despite the annual rainfall (965.7 mm). Grazing commenced late (12/9/88) in the period compared with others (GP,2,3 and 5).

The decline in DM yield from the lowest to the highest stocking rate and as days of grazing increased were observed for the stem, leaf and green shoot of C. gayana, green material and total herbage. These results support earlier reports (Mears and Humphreys, 1974a; Chacon et al., 1978; Addy and Thomas, 1978; Watson and Whiteman, 1981; Tierney and Goward 1983a). According to Mears and Humphreys (1974a), the yield of green Kikuyu material was significantly reduced with increase in stocking rate at 336 and 672 kg/N/ha levels but was not significantly affected at the zero and 136 kg N/ha levels where the grass was less dominant. Watson and Whiteman (1981) reported that the green dry matter yields of mixed pastures of para grass, signal grass, centro, Sitratro and Endeavour stylo dropped as stocking rate increased from 1.8 to 4.5 cows/ha. They also found that green dry matter yields were reduced in the fourth year of grazing especially at the highest stocking rate.

Grass stem yield in the second grazing period was lower than in the third and fourth grazing periods.This could be due to the accompanying sown legume which reduced grass growth and the age of the pasture:first year after establishment. The lower grass leaf,green material,total herbage and other species yields in the fourth grazing period

was ascribed to low production of the grass pasture without a legume or N application for two years.The amount of rainfall and number of rainy days during the fourth grazing period were also less than during the second and third grazing periods.

It would appear that the annual application of 30 kg P/ha with or without nitrogen to the C. gayana pasture contributed to the high yields of stem, leaf, green material and total herbage. This is in agreement with the observation by Winter et al. (1977a), Curll (1977a) and Shaw (1978) that the application of 5.6 to 40 kg P/ha increased pasture yields at various stocking rates with sheep and cattle.

The reduction in yield of dead material as stocking rate increased in this study appears to corroborate data reported by Mears and Humphreys (1974a). This could have arisen from the removal of a high percentage of the green material and the consequent restriction of the formation of dead material (Greenwood and Arnold, 1968) and / or possibly the consumption of dead material, especially the leaf, at high stocking rates (Mears and Humphreys, 1974a).

The results indicate that across stocking rates and irrespective of grazing periods, yields of various components except dead material declined as the grazing days advanced. Other researchers (Addy and Thomas, 1978; Curll et al. 1985a) reported similar loss of herbage from swards grazed during and after the growing season. Furthermore, water stress during the dry season reduced regrowths and the leaf to stem ratio.

5.2.3. Height and bulk density

Height of C. gayana declined with increasing stocking rate, in keeping with the general findings of effect of stocking rate on grazed pastures (Chacon et al. 1978; Watson and Whiteman, 1981). Rise in grass height during the 1986-1987 and 1987-1988 grazing periods at 42 days of grazing compared with day 0 probably indicated higher response of pasture to additional moisture for growth. The mean grass height in this study was more than 1.0 m as a result of stocking the pasture when the forage was already mature and seeding.

The pattern of bulk density for green C. gayana in all the grazing periods did not match that of Chacon et al. (1978) that bulk density declined with increase in stocking rate. This may be explained in terms of the observed avoidance of the sheep to penetrate the dense sward during the early part of the grazing periods. Another factor may be the grass height which was beyond the reach of the animal. Possibly cattle another breed of sheep could have grazed better to give results similar to that of Chacon et al.(1978). No explanation could be given for the low bulk density value recorded in the 1987-1988 grazing period for the control compared with the grazed plots and other grazing periods.

In the present study grazing was mostly in the dry season when little or no grass growth occurred compared with longer grazing days covering all or most part of the year in earlier reports. The mean bulk density values (50-60 kg/ha/cm) were lower than the 60-90 kg/ha/cm for mixed grass-legume (Watson and Whiteman,1981) and 156-175 kg/ha/cm

for pure grass pastures (Chacon et al., 1978). Whiteman (1980) suggested (14- 200 kg/ha/cm). The low values in this study could have limited the ability of sheep to harvest adequate amount of material with each bite (Stobbs, 1975b). The leaf bulk density could have been more ideal but was not measured.

5.2.4. **Tiller density**

The report by Mears and Humphreys (1974a) that Kikuyu grass tillered more densely at 11.1 than at 2.2 animal/ha with or without nitrogen application is at variance with the data reported in the present trial. Perhaps,stocking the pasture with cattle would give similar results. The reduction in C. gayana tillers at higher stocking rate could be attributed to the effect of grazing during the late rainy and dry seasons when increase in plant growth was negligible. It would appear that no additional tiller formation occurred in C. gayana after heading. Similarly, Okeagu (1989) reported significant reduction in tillers of B. decumbens and D. smutsii stocked at 3 to 9 bulls/ha as grazing continued into the dry season.

5.2.5. **Chemical composition**

5.2.5.1. **Crude protein (CP) content**

C. gayana leaf had a higher CP content than the stem component. This is in agreement with the reports of Henzell and Oxenham (1964) for P. plicatulum, S. sphacelata and C. gayana and of Mears and Humphreys (1974a) for P. clandestinum. Crude protein content of both leaf and stem components of the grass declined from second to fourth grazing periods in the P fertilized pasture. Eng et al. (1978a) reported a similar decline for P. maximum from the

first to the third year of grazing but Watson and Whiteman (1981) observed no difference in CP content over the four years of grazing grass-legume pastures.

This study conforms with the data obtained by Bryan and Evans (1973) who indicated no difference in CP content between 1.23 and 2.47 steers/ha on a grass-legume mixture consisting of L. bainesii, T. repens, C. gayana cv. Pioneer, Paspalum spp and D. decumbens. These authors ascribed this to similar physiological stages of development of the pasture at the time of observation. Other contrary findings include not only those for mixed grass-legume (Winter et al., 1977a; Eng et al., 1978; Watson and Whiteman, 1981) but also grass-nitrogen pastures (Mears and Humphreys, 1974a; Chacon et al., 1978; Okeagu, 1989).

The decline in CP content as plant matured (advancement in days of grazing) is well documented in the literature. In this study, the pasture had started heading by the time each grazing period commenced. Thus further decline in grass and legume CP contents were expected from the end of the rainy season through the dry season.

This study indicated that dry matter intake must have been depressed as CP content of the stem dominated C. gayana was below the critical 7.0 % recommended (Milford and Minson, 1966). It suggested an overall reduction in nutritive value of the dry matter on offer (Laredo and Minson, 1973; Jones, 1979) as grazing days increased (Tierney and Goward, 1983b; Chen and Othman, 1986). The result thus conforms with the idea that intake of low protein feed has an indirect effect of depressing appetite, possibly a symptom of general animal ill health (Whiteman 1980). Had stylo persisted in the 1987-

1989 grazing periods, the nutritive value of the pasture would have increased thereby increasing the feed intake of sheep and hence promoting higher liveweight gains.

5.2.5.2. Phosphorus (P)

The results from this study confirmed those of Bryan and Evans (1973), Tierney and Goward (1983b) and Chen and Othman (1986) that stocking rate had no clear effect on P content of pasture on offer.

The reason provided by Bryan and Evans (1973) that at a similar physiological stage of development, stocking rate did not affect CP might also hold true for P content in the pasture. There are of course, other reports where P content increased with stocking rate (Winter et al., 1977a; Eng et al. 1978a; Watson and Whiteman, 1981). Winter et al. (1977a) observed higher P content with increased stocking rate mainly in the growing season during the second and third year of their studies on mixed B. decumbens and P. maximum, S. guianensis cv. Endeavour and M. atropupureum cv. Siratro pastures.

C. gayana stem and leaf phosphorus contents increased with annual application of single superphosphate from 1986-1990 when nitrogen fertilizer was also supplied. This trend is comparable to other studies reported (Whiteman, 1969; Bryan and Evans, 1973; Eng et al., 1978a). However, the effect of annual P application at 0 to 40 kg /ha did not change the P content of the grass-legume pasture (Winter et al., 1977a). On permanent pastures, Curll (1977a and b) observed no change in P content despite over 20 years of continuous single superphosphate application to grazed temperate pastures.

The level of P in D. smutsii was low in autumn - winter and high in summer (Tierney and Goward, 1983b). P content of many tropical grasses was also reported to decline with plant maturity (Reid et al., 1979). Results from the sole P fertilized pastures in this study are not in agreement with these reports. The level remained non-significantly different in the stem, leaf of C. gayana and stylo over the 1986 to 1989 grazing periods. This could be attributed to the mature stage of the pasture and the time of grazing (dry season mainly) when growth is limited. In addition, P is one of the most resistant to leaching of all elements. Therefore phosphorus remained virtually constant in the plant tissue (Turkey, 1970). However, the reduction in the P content of stem and leaf of C. gayana as grazing days and dry period increased in the N fertilized pastures (1985-1986 and 1989-1990 grazing periods) agrees with the report of Tierney and Goward (1983b).

Phosphorus content in the stem of grass fell short of the 0.16 % recommended for sheep (NRC, 1975) at the beginning of all grazing periods except 1988-1989 and in 1989-1990 when stem and leaf of C. gayana were analysed together. The content was however higher in the leaf, although it was below the NRC requirement in some treatments during the first (1985-1986) grazing period. With leaf yield declining as grazing days increased, it could be deduced that sheep would experience depressed feed intake because of P deficiency in the pasture.

5.2.5.3. Potassium (K)

The non significant effect of stocking rate on K contents of all pasture components in the sole phosphorus

fertilized swards may also be attributed to similar plant's physiological age of grazing (Bryan and Evans, 1973). Other reports that corroborate this are those on D. decumbens stocked at 4.94 to 9.90 steers/ha (Tierney and Goward, 1983b) and on D. setivalva stocked at 4 to 8 bulls/ha (Chen and Othman, 1986). However, it was observed in the N fertilized swards that stem and leaf K contents tended to decline with increase in stocking rate during 1985-1986 but during 1989-1990, K content increased with increasing stocking rate in the grass shoot. The result during 1989-1990 grazing period did not agree with the findings of Tierney and Goward (1983b) and Chen and Othman (1986) that stocking rate had no effect on K content of grazed grass pastures.

The present study indicated that K content declined as plants advanced in maturity during all but the second and fourth grazing periods. Gomide et al. (1969), Blue and Tergas (1969), Reid et al. (1979) and McCosker (1987) gave similar accounts for tropical grasses. A reduction in the leaf proportion could have contributed partly to the reduction in K content with plant age. The non significant change in K content during second and fourth grazing periods is not clear.

The stem and leaf K contents of C. gayana and stylo during three (1986 - 1989) grazing periods were above the 0.5 % required for sheep growth (NRC, 1975). However, the nutrient level in the stem of C. gayana at 126 days in the first grazing period was inadequate.

5.2.5.4. Calcium (Ca)

Irrespective of grazing period, stocking rate had no effect on Ca content of the grasses and stylo in the pasture.

Studies on N fertilized grass pastures by Tierney and Goward (1983b) and Chen and Othman (1986) indicated that stocking rate had no clear effect on Ca content of the herbage on offer.

Grass components Ca concentration (except the stem during 1986-1987 and 1987-1988 grazing periods) declined with advanced grazing days. The reasons of advanced stage of maturity and unfavourable weather for growth are generally associated with decline in nutritive value as observed by other workers (Metson and Saunders, 1978; Reid et al., 1979 and Tierney and Goward, 1983b). The reduction in leaf:stem ratio will have a similar effect on the herbage Ca content. C. gayana stem Ca level did not vary during the 1986-1987 and 1987-1988 grazing periods for unknown causes.

Compared over the three grazing periods when only P was applied to the pasture, there was no increase in Ca content of the components. This contrasts the reports of Bryan and Evans (1973) and Eng et al. (1978a) that Ca content increased slightly with consecutive grazing years.

The NRC (1975) has suggested 0.21 % Ca as the requirement for non lactating sheep. Satisfactory levels of Ca were found in grass leaf and stylo shoot at the times of sampling but mainly at the beginning of grazing in C. gayana stem. In the 1985-1986 grazing periods, C. gayana stem would be considered deficient in Ca for sheep apparently because grazing did not start until late October when the Ca level was 0.17 %. It is therefore advisable to supplement grazing sheep with Ca when the pasture becomes leafless especially in the dry season. The content of Ca in this study falls within the range 0.17 to 0.40 % for the tropical grasses examined by

Andrew and Robins (1971) and Marshall and Long (1971).

5.2.5.5. Magnesium (Mg)

The lack of a significant difference in Mg content among stocking rate is attributed to the same physiological stage of development of the sampled pasture components in grass-legume mixtures (Bryan and Evans, 1973) and in pure grass pastures (Tierney and Goward, 1983b; Chen and Othman, 1986).

Magnesium content in pasture components showed no changes with increase in grazing days in the first, third and fifth grazing periods. The variations observed in other grazing periods cannot be explained. Similar variations within season in Mg content have been reported in New Zealand for pastures periodically grazed down by sheep (Metson and Saunders, 1978).

A relatively constant level of Mg was recorded in the pasture components over the grazing periods. The average Mg levels for all components were adequate as they were higher than the 0.04 % recommended for non lactating sheep (NRC, 1975).

5.2.5.6. Acid detergent fibre (ADF)

The mean ADF contents were 44.6 and 55.7 % for the leaf and stem of C. gayana respectively at the beginning of 1987-1988 grazing period. These were higher than mean values recorded in B. decumbens (34.0 %) and D. smutsii (31.9 %) (Okeagu, 1989) in a grazing trial with cattle. In addition, the values in this study are higher than the 39.2 % recorded for most tropical grasses (Coward - Lord et al., 1974) in cutting experiments. This result was attributed to differences in the plant components analysed, management systems and stage of development when pasture was sampled.

The lack of responses as grazing days and stocking rate increased in ADF content is not in agreement with the report of Okeagu (1989) who reported an increase in ADF content with decrease in stocking rate and increase in grazing days. The results obtained in the present study can be explained in terms of the absence of new tillers as grazing advanced especially at the highest stocking rate and the non significant deposition of lignocellulose in the plants organs (Colburn and Evans, 1967).

5.2.5.7. Neutral detergent fibre (NDF)

The increase in NDF value as grazing days increased in the 1986-1987 grazing period is similar to observations made in cutting and grazing trials by Coward-Lord et al. (1974), Griffin and Jung (1981) and Okeagu (1989) and ascribed to decreased leaf : stem ratio and advanced plant maturity. During this same grazing period, NDF content increased as stocking rate increased, signifying the higher proportion of fibre in the herbage with increased grazing pressure. The results in the 1987-1988 grazing period when NDF percent was similar during the grazing period are at variance with the results of Okeagu (1989) and could be due to differences in plant species response to grazing. Neutral detergent fibre contents in this study (78.2 - 80.6 %) were higher than the 58 - 67 % and 57.3 - 71.0 % obtained by Okeagu (1989) for B. decumbens and D. smutsii, respectively. Coward-Lord et al. (1974) reported a range of 68.1-77.5 % in cutting trials.

5.2.5.8. Acid detergent lignin (ADL)

As against the increases in ADL content of plant shoot with advancing days of grazing (Okeagu, 1989) and in

cutting trials (McLeod and Minson, 1974; Griffin and Jung, 1981; Okeagu, 1989), ADL levels did not change in the present study. This seem to suggest that lignification process after seeding is relatively slow in the stem of C. gayana cv. Callide. The observed lack of significant changes in ADL levels with increase in stocking rate may be attributed to similar physiological age of C. gayana at sampling. The data deviate from earlier results of Okeagu (1989) which showed increase in ADL level as stocking rate decreased.

5.2.5.9. Cellulose

The non significant variations in cellulose content as certain tropical grasses matured (Gomide et al., 1969) is confirmed in this study particularly with regard to the stem component of C. gayana. That changes in cellulose content were not reduced despite the virtually leafless status of the pasture towards the end of the dry season agrees with the experiences of Bailey (1964) and Waite (1970). During the 1986-1987 grazing period, cellulose content at the 36 sheep/ha was significantly lower than at other stocking rates, thus corroborating the data of Okeagu (1989). The effect was not recorded in the next grazing period.

The present result indicated higher levels (43.9-49.0 %) of cellulose in C. gayana compared to 27.0 to 34.0 % in B. decumbens and D. smutsii (Okeagu, 1989) and 30.8 to 35.2 % (Coward-Lord et al., 1974). This result could be due partly to the absence of nitrogen fertilizer during the two grazing periods when cell wall components were analysed in agreement with Blake and Richards (1970), Bailey and Hunt (1973). Leaf also had less cellulose than stem of the pasture species reported.

In addition to the effects of stocking rate and grazing days, other factors were observed to have influenced the performance (survival and gain in weight) of sheep on the grazed pastures.

First, myasis, which is rarely reported in tropical breeds of sheep, occurred during the rains in the second and third grazing periods. The observed cases were independent of stocking rate but where closely associated with the humid condition of the dense, tall pasture and injuries sustained by sheep while jumping fences. No doubt, the condusive environment and open injuries encouraged the multiplication of the fly, C. regalis on the skin. Animals affected were not easily noticed while lying down except on close examination. The grazing of a less dense and shorter pasture in addition to close examination of sheep would prevent cases of myasis. In practice sheep will not be grazed in small paddocks as under experiment thus jumping of fence can be virtually eliminated.

Rams in the paddocks were also attacked at night by carnivorous animals such as cape hunting dogs. Usually these predators kill one out of the three rams in the same paddock, ate some parts and leave the carcass. With time, the security guards were able to prevent further attacks from the wild dogs by lighting open fire to indicate the presence of humans, thus scaring them away. With bleating ewes, such attacks will alert any guard. Furthermore, with more rams per paddock as practiced, the predators may not find it easy to attack a herd. Housing or kraaling the herd at night will reduce attacks from predators.

The initial liveweights of rams on entering the paddocks adversely affected their performance during the grazing periods. It was observed that yearling or 20 kg ram survived the grazing conditions better than younger or lighter animal. Perhaps, with a more favourable (less dense and shorter pasture) condition, weaners could be successfully grazed on pasture.

Lastly, animals especially new ones purchased from local markets which were not used to handling, are usually restless at the sight of people. They are late in adjusting to feed and also come down with diarrhoea more than rams that were raised within the station. Possible solution to aid future grazing trials will include raising the number of animals needed on station at least nine to twelve months before initiating a grazing trial. Allowing new rams to get adjusted to the forage diet for two to four weeks could also reduce problems of diarrhoea during the grazing period.

5.3.1. Daily liveweight gain

Daily liveweight gain of sheep was affected by stocking rate over all but the first grazing period when the pasture was grazed mainly in the dry season. Within grazing periods, daily liveweight gain declined as stocking rate increased in pastures whether fertilized with phosphorus only or (in the last grazing period) with nitrogen and phosphorus. Similar observations have been made in a number of grazing studies with sheep (Marsh and Laidlaw, 1978; Curll, 1977a; Curll et al., 1985a; Laws and Newton, 1987) and with cows (Jones, 1974; Edye et al., 1978; Watson and Whiteman 1981; Chacon et al., 1978; Okeagu, 1989) in both pure grass and grass-legume pastures. This result appeared to have arisen

from differences in the amount of herbage on offer (Arnold, 1962). In the present study, the amounts of green material, stem and leaf components of C. gayana which decreased as stocking rate increased affirm this result. Since the crude protein, the mineral and structural components of the herbage were not influenced by stocking rate, thus they cannot therefore be responsible for the lower daily liveweight gain recorded with increase in stocking rate. The higher amount of green material in the least stocking rates offered the sheep better opportunity to select herbage higher in CP and lower in fibre contents (Wilson and Lansbury, 1958; Weir and Torrell, 1959) and hence the higher liveweight gains. During the first and second grazing periods, grass stem sustained daily liveweight gains longer than other grazing periods because of the less advanced age .

The lack of significance in the daily liveweight gain of sheep as stocking rate increased in the 1985-1986 (GP 1) could be due to low quality of herbage on all plots before stocking. Better liveweight gains would have been achieved had grazing commenced June/July in all the periods. Consequently, the sheep would have stayed longer on the pasture, well into the dry season,before they experience weight losses. Sheep were introduced when the pasture had passed the nutritive peak although the DM on offer was high. This was attributed to the non availability of animals when the trial was designed to start. The probable solution would have been to cutback the pasture and graze the regrowth but again,farm equipment were engaged for other operations. Alternatively, use of cattle would probably have given better liveweight gain since they are able to consume more of coarse

material than sheep.

The decrease in daily liveweight gain as grazing days increased in all the grazing periods can be attributed to reduced nutritive value of pastures because of advanced maturity (Blunt, 1978), reduced proportion of leaf (Laredo and Minson 1973) and season (Bryan and Evans, 1973; Mears and Humphreys, 1974b; Okeagu and Akinola, 1982; Okeagu, 1989). These authors reported that animal performance is usually higher in summer, spring or wet periods than in other seasons. From the present study, when grazing commenced in August - September sheep recorded zero net weight gain between 112 and 154 days of grazing. These correspond to mid December and late January in the Northern Guinea Savanna zone of Nigeria. This study comformed with the linear relationship between SR and daily liveweight gain /hd as postulated by Mott (1960) and sipported in other grazing studies. Daily gain /hd was negative at 36 sheep/ha in the first grazing period in consonance with the proposal of Jones and Sandland (1974) for SR greater than twice OSR.

Sheep performance in this study at the stocking rate of 12 sheep per hectare from the sole P fertilized pastures were higher than the 32 and 30 g/day/year recorded for 2.73 and 4.35 sheep/ha, respectively on natural pastures in Kenya (Thairu and Tessema, 1987).

5.3.2. Cumulative liveweight gain per head

Animals at 12 sheep/ha gave the highest gains which were a reflection of higher daily gains. As indicated in the first grazing period, with some N application, the lowest stocking rate will support animals for longer period into the dry season. Similarly, animals at the 12 and 18 sheep/ha

were still in good body condition at the end of the fifth grazing period. Addy and Thomas (1978) in Malawi concluded that at 2.5 LU/ha (1 LU = 342 kg cow) there was sufficient C. gayana herbage available in the paddocks to carry animals throughout most of the dry season with only small losses in weight.

A uniform pattern can be described for the growth of sheep in this study. Liveweight gain per sheep gradually rose to a maximum before it declined and grazing eventually terminated. The initial period of much gain, followed by little gain and zero net gain appeared in all the grazing periods. These finally led to the period of losses in weight per head. The least gain per head occurred on the 36 sheep/ha and at the beginning of grazing in each period. This pattern agrees with the data from cattle on the same station (Okeagu, 1989).

The higher gain per head at the lower stocking rates can be related to higher herbage yields allowing for greater selection and intake (Jones, 1974; Bird et al., 1978; Eng et al., 1978b; Chacon et al., 1978; Watson and Whiteman, 1981).

Liveweight performance of unsupplemented animal during unfavourable periods and of low feed were accompanied by little gains and losses in liveweight. This effect is observed to be greater at the higher stocking rates and is in agreement with other studies (Evans and Bryan, 1973; Addy and Thomas, 1978; Tierney and Goward, 1983a; Walker et al., 1987; Okeagu, 1989). As observed for the daily liveweight gain, zero net gain in liveweight occurred between mid December and late January when grazing started in August/September. This was due to lower nutritive value of the herbage and increased

moisture stress as green materials declined with advanced days of grazing.

Sheep were maintained for longer days (70) after the peak liveweight gain on the pasture when stylo was present in 1986-1987 grazing period. Sheep at the highest stocking rate were first to show signs of ill health probably as a result of low intake of feed and essential nutrients for maintenance of body weight.

5.3.3. Liveweight gain per hectare

In agreement with the postulation by Mott (1960) and Jones and Sandland, (1974) this study suggested a curvilinear liveweight gain per ha.- stocking rate relationship in which liveweight gain declined above the optimum stocking rate. Similar relationships were demonstrated by Jones (1974), Curll *et al.* (1985a) for grass-legume mixtures and by Mears and Humphreys (1974b) and Silvey and Feraris (1987), for nitrogen fertilized grass pastures. Curll *et al.* (1985a) showed that liveweight gain/ha of Suffolk and Scottish wethers on a ryegrass - white clover pasture (not N fertilized) declined at stocking rates beyond 25 sheep/ha and losses were recorded at 55 sheep/ha.

Sumberg (1984) in the humid zone of Nigeria recorded a liveweight gain of 218 kg/ha from a natural grass fallow in alleys of *L. leucocephala* and *G. sepium* stocked at 8 ewes/ha (+ supplementary feed). The closest value in the present study was 202.4 kg/ha at the 30 sheep/ha during the fifth grazing period of about 6 months. This finding tend to support the importance of including legumes in feed of small ruminant during the dry season when animals grazed natural or sown pastures. This study indicated that at the highest

stocking rate,the pasture might not support maximum liveweight gain per hectare beyond seventy days if grazing commence just before the end of the rain.

It would be appropriate to supplement animals on reaching zero net weight gain/ha to ensure the maintenance or increased production during the remaining part of the dry season. The decline in liveweight gain per hectare observed during 1988-1989 grazing period suggested that the 3-year old pasture could no longer support the sheep without any management interventions. Options that could be utilized are, renovation of pasture to include legume(s), application of nitrogen fertilizer, introduction of supplementary feed, use of lower stocking rate or shorter (not exceeding December) duration of grazing. Further studies are needed to evaluate animal performance on variable versus fixed stocking rates and in feeding back preserved forages to grazing animals in the same paddock. Perhaps, the inclusion of a more persistent legume or two legume species in *C. gayana* cv. Callide pasture may sustain higher animal production in the savanna zone of Nigeria.

SUMMARY AND CONCLUSIONS

Herbage production and sheep performance on pastures of C. gayana cv. Callide with or without either S. guianensis cv. Cook or nitrogen fertilizer were investigated from late wet season to the dry season at Shika in the Northern Guinea Savanna of Nigeria. The pasture with or without the legume received only 30 kg P/ha/yr before the 1986-1989 grazing periods while the pastures with nitrogen received the same level of phosphorus and 200 kg N/ha/yr before the 1985-1986 and 1989-1990 grazing periods. Yankasa rams were set stocked at 12, 18, 24,30 and 36 sheep/ha, over the five grazing periods (1985-1990). The number of days spent on the pasture varied from 154 to 210 days in the grazing period.

The soil contents of total N, organic carbon, Ca, available P and cation exchange capacity increased over the four-year period in the P fertilized pasture. The relatively even distribution of dung and urine might have enhanced the availability of total nitrogen at the highest stocking rate.

In all the grazing periods, mean dry matter (DM) yield of total herbage and components of C. gayana declined as stocking rate and grazing days increased. Due to pasture maturity, moisture stress and reduced leaf content, these observations were expected. Mean leaf and total herbage yields did not exceed 1.0 and 10.0 t/ha, respectively in the pastures without N fertilizer application. Generally, the control plot has the highest amounts of total herbage and components of C. gayana which also declined with increase in

grazing days.

There was no significant effect of stocking rate on the DM yields of stylo and other plant species in pasture. On the other hand, yields declined noticeably as grazing days advanced. Mean yield of stylo in the second grazing period did not exceed 1.0 t/ha. Yields of other plant species were below 0.5 t/ha in all grazing periods. Further research is required to establish the compatibility of S. guianensis cv. Cook and / or other legumes with C. gayana cv. Callide under grazing.

The DM yield pattern of green material followed that of total herbage and components of C. gayana. The decline at higher stocking rate with a consequent reduction in dead material indicated that more green material were removed as stocking rate increased thereby limiting the formation of dead material.

Sward height diminished with increase in stocking rate and days of grazing. This study suggests that sheep should be introduced into C. gayana cv. Callide pastures before flowering or at a mean sward height below the animal's withers. The mean bulk density of C. gayana between 50 and 60 kg/ha/cm in this study was generally low. It fell with increase in grazing days but varied within stocking rates during the grazing periods.

There were no additional tillers in C. gayana cv. Callide during the grazing periods and the numbers were reduced more at the higher stocking rates.

There was no evidence that stocking rate influenced CP content of leaf and stem components of C. gayana. As expected, the quality of pasture decreased as age of plant increased in all grazing periods. Improvement in the CP content of pasture through management practices such as the maintenance of higher leaf content, inclusion of persistent legume(s) in the pasture or some nitrogenous supplementary feed will result in higher feed intake and sheep production.

Irrespective of grazing period, the contents of P, K, Ca and Mg in C. gayana and S. guianensis were similar at all the stocking rates. The effect on K however, was not clear when pasture received N fertilizer. Values of Ca, P and K declined with advanced grazing days while the content of Mg remained unchanged when N fertilizer was applied to the grass pasture. However, in the P fertilized pasture, values of P remained constant while the contents of K and Mg were not consistent with increased days of grazing. In addition, leaf Ca content declined with age while in the stem, values appeared to be constant. K and Mg levels in the herbage were satisfactory for the sheep growth during the grazing periods. On the other hand, P and Ca contents were usually not adequate. With ample supply of edible green leaves in the pasture, there may not be any need to supplement grazing sheep with P and Ca during the periods examined in this study.

There was no change in the contents of ADF, lignin and cellulose in the stem of C. gayana as duration increased

over the two grazing periods. Mean lignin contents were 10.7 and 10.5 % in the two grazing periods. Similarly stocking rate appeared to have no significant effect on the levels of these constituents in the stem. The only exceptions were for NDF and cellulose contents in the 1986-1987 grazing period when their levels at 36 sheep/ha exceeded those at 12 sheep/ha. These showed that at maturity structural components of C. gayana stem may be relatively unaffected under sheep grazing.

In agreement with the general concept of linearity, liveweight gain per sheep per day declined as a stocking rate increased. The effect of stocking rate was not significant in the first grazing period. The mean liveweight gain of 60-62 g/head/day was recorded at the 12 sheep/ha during the third to fifth grazing periods. The highest gain per head per day varied from 137.5 to 203.6 g at the beginning of the grazing periods and declined therafter presumably because of reduced pasture nutritive value, lower leaf content and intensifying dry season. Losses in daily liveweight gain on the pasture commenced from mid to late January at the highest and from early to mid February at the lowest stocking rate. The maximum liveweight gain per sheep at the least stocking rate was between 10 and 12 kg except during the first grazing period. Losses in liveweight per animal occurred at the same time as observed above - for daily liveweight gain and were most marked at the 36 sheep/ha treatment. During the grazing periods, the pattern of cumulative liveweight was a gradual

increase up to a maximum, levelling off for two to six weeks and finally the period of rapid weight losses. The result of liveweight gain per hectare in this study conformed with the curvilinear relationship between gain per hectare and stocking rate in many grazing trials. During the six months of grazing in the 1989-1990 period, the highest liveweight gain per hectare was 202.4 kg at the 30 sheep/ha. Further studies are needed to find out if this production level could be increased through the use of higher N levels or a mixture of more persistent legume(s) with C. gayana.

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APPENDIX 1

Analysis for crude protein content

Procedure	Chemical
Digestion:	Concentrated sulphuric acid with Copper sulphate - potassium sulphate mixture (1:20 w/w) as catalyst.
Distillation:	40 % w/w sodium hydroxide
Collection of distillate:	2 % boric acid containing 2-3 drops of 0.1 % methyl red - bromo crysol green solution as indicator.
Titration:	0.0244 N HCL

Calculation:

$$\% N = \frac{(\text{Sample titre} - \text{blank titre}) \times \text{Normality of acid}}{\text{Weight of sample (g)} \times \text{Aliquot of digest pipetted into distillation flask}}$$

$$\% CP = \% N \times 6.25$$

APPENDIX 2

Analysis for structural components.

Sample
0.5 g

NDF	ADF
Add 50 mi cold NDS[1]	Add 50 ml cold ADS[2]
Heat until boiling	Heat until boiling
Extract for 1hr	Extract for 1hr
Filter and wash 3 times with hot water and 2 times with acetone	Filter and wash 3 times with hot water and 2 times with acetone
Dry for 8 hrs at 100°C	Dry for 8 hrs at 100°C
Cool and weigh	Cool and weigh

$$\% \text{ NDF or } \% \text{ ADF} = \frac{\text{wt of crucible + residue} - \text{wt of crucible}}{\text{wt of sample 9DM)}} \times 100$$

ADF residue

Add approx. 25ml 72% H_2SO_4

Extract cold for 3 hrs
(stir once/hr)

Dry for 8 hrs at 100°C

Weigh and ash for 3 hrs at 500°C

$$\% \text{ ADL} = \frac{\text{wt of residue} - \text{wt after ashing}}{\text{wt of sample (DM)}} \times 100$$

Appendix 2 Cont.

1. Reagents used in the preparation of neutral detergent soluble (NDS) solution included:-

   - Sodium lauryl sulphate - 30 g

   - EDTA (Disodium ethylene diaminetetraacetate) - 18.61 g

   - Sodium borate decahydrate - 6.81 g

   - Disodium hydrogen phosphate (anhydrous) - 4.56 g

   - 2 - ethoxy - ethanol - 10 ml

3. Reagents used in the preparation of acid detergent soluble (ADS) solution consisted of:-

   - 1 N H_2SO_4 - 1 litre

   - CTAB (centhyl trimethyl ammonium bromide) - 20 g

   - Dekalin (antifoaming agent)

   - Acetone