EFFECT oF SEEDING RATIO, SOWING METHOD AND NITROGEN LEVEL ON THE GROWTH OF RHODES GRASS (Caloris gayana cv Callide)/ GTYLO (Stylosanthes guianensis cv Cook) MIXTURE IN NOTHERN NIGERIA

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THESIS APPROVAL

This Thesis by Sunday Olufemi ONIFADE, meets the regulations governing the degree, Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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DECLARATION

The candidate hereby declares that the whole of the work now submitted as Thesis for the Master of Science degree (Animal Science) of Ahmadu Bello University is the result of his investigation (except where reference is made to published literature and where assistance is acknowledged) and has not been part of any presentation for any other qualification.

Signature: ____________ Date 2/12/82

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ABSTRACT

The effect of seven grass/legume seeding ratios (10:0, 7:3, 6:4, 5:5, 4:6, 3:7 and 0:10), three sowing methods (i) grass and legume drilled in alternate rows, 30cm apart (ii) grass and legume mixed and broadcast (iii) grass and legume mixed and drilled within the same rows, 30 cm apart) and three arates of nitrogen application (0, 100 and 200 kg N/ha) on the growth of Rhodes grass (Chloris qayana cv Callide)/Stylo (Stylosanthes quianensis cv Cook) swards was studied in two experiments between 1979 and 1980 at Shika, in the Northern Guinea Savanna Zone of Nigeria.

In experiment I, the grass:legume seeding ratio used strongly influenced dry matter yield of the grass and legume components. The grass dry matter yield for the grass:legume seeding ratio 3:7 to 10:0 (pure grass sward) varied from 3.46t to 4.35t/ha in 1979 and 5.40t to 7.16t/ha in 1980, For the legume component, the seeding ratio of 7:3 to 0:10 (pure legume sward) produced 0.81t to 4.25t/ha in 1979 compared with 1.50t to 4.24t/ha in 1980. The mixed sward was clearly more productive than the sole grass or legume sward. Broadcast seeding resulted in higher dry matter yields than drilling. Over the two-year period, the highest mean dry matter yield of 7.4t/ha was obtained from the seeding ratio 3:7/broadcast seed combination.

Crude protein (CP) contents of the grass were higher while those of the legume were slightly lower in 1980, Whereas percentage CP increased as the proportion of legume seeded increased, sowing method did not exert any influence. The data suggested that nitrogen from the legume might have been utilized by the associated grass.

Nitrogen fertilization of a grass/legume sward increased total and grass but markedly reduced legume dry matter yields in experiment II, Application of nitrogen in July gave the highest and application in September the lowest yield with the sward growth uninterrupted. However, for the cut sward, nitrogen applied immediately after harvesting in August resulted in the highest dry matter yield. Herbage crude protein content increased with rise in nitrogen level and fell with deferment of cutting.

The need to further investigate the effect of different seeding ratios on the performance of the more promising and compatible native/introduced grasses and legumes was suggested.

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CHAPTER 1.

INTRODUCTION

The Nigerian Savanna has potential for profitable grassland farming (McIlroy, 1962). To a large extent, the low level of animal production from the Savanna is associated with the inability of the natural pastures to provide the energy and nutrient requirements of the grazing stock (Oyenuga, 1966; Ademosun, 1973; Akinola, 1974). Herbage quality declines rapidly with time in the Northern Guinea Savanna Zone. For example, Blair Rains (1963) indicated that the crude protein (CP) content of the new growth of perennial grasses decreased from 8% - 9% at the beginning of the rains when total dry matter (DM) yield was low, to 5% within two months; and that by the beginning of the dry season, the fibrous herbage contained barely 1.5 - 2.5% CP.

The plane of livestock nutrition can be improved considerably by establishing high yielding grasses, legumes and different grass/legume combinations, over-sowing the natural pastures with suitable legumes and/or adopting forage conservation procedures. Well managed sown grass/legume mixtures facilitate year-round grazing while sole legume pastures and forage, conserved as hay or silage, are invaluable in supplementing dry season grazing. These measures reduce the need for costly concentrates and ensure that the live weight gained during the rainy season is at least maintained during the dry season.

Grass/legume mixtures give higher pasture productivity than pure grass swards because of the vitally important role of the legume component. Since it increases the total sward DM yield, promotes a more uniform seasonal DM yield distribution and has a higher feeding value (DM digestibility, voluntary intake, content of CP, calcium, phosphorus and sulphur) than the associated grass, the legume helps to support higher stocking rates and increased animal production per hectare. In addition, the legume releases N to the soil system for uptake by the grass through the legume - Rhizobium symbiosis and the decay and mineralization of shed legume plant parts.

Intensified agronomic trials on several native and introduced pasture species, which commenced in Nigeria over three decades ago (Ahlgren, Adegbola, Eweje and Salami, 1959; Foster and Mundy, 1961; Blair Rains, 1963; Ademosun, 1973; Akinola, 1974) have identified various degrees of grass/legume compatibility. A relatively recent study showed Rhodes grass (Chloris gayana cv Callide)/ Stylo (Stylosanthes guianensis cv Schofield) associations to be promising (Haggar, 1971). However, no previous research has examined the seeding proportion or sowing method that would be needed to obtain optimum grass/legume balance.

The objective of this study was to evaluate the DM yield and CP content of C. gayana cv Callide/S. guianensis cv Cook established from different grass: legume seeding ratios and sowing methods. The effect of post establishment application of nitrogen on the performance of the grass/legume sward was also investigated.

CHAPTER 2.

LITERATURE REVIEW

2.1. Chloris gayana

Rhodes grass (*Chloris gayana* Kunth) was reported to have been first cultivated by Cecil Rhodes in South Africa in 1895 (Bogdan, 1969). The spread to other countries was rapid and it is now grown at experimental and large scale levels in many tropical, sub tropical and even warm temperate regions of the world (Bogdan, 1977). All the cultivars available in Nigeria were introduced from either central and eastern Africa (Blair Rains, 1963) or Queensland, Australia (Agishi, 1978). *C. gayana* gained importance because of its ease of establishment, creeping habit, drought resistance, soil salinity and light frost tolerance and high seed yield potential.

The productive life of *C. gayana* varies from 3 to 5 years, depending on the management (Bogdan, 1977). It persists under short term heavy grazing and gives good animal liveweight gain responses whether grown in pure stands or mixed with legumes during the wet season (Rensburg, 1969; Sheldrick and Goldson, 1978; Kretschmer Jr, 1975; Bogdan, 1969). Animals grazing *C. gayana* supplemented with legume or concentrate have also been reported to maintain their weight in the dry season.

2.1.1. Origin and Description

The cultivar Callide was introduced from Tanzania into Australia in 1953 and there released for commercial production as Giant rhodes grass in 1961. In 1963, it was distinguished from other giant forms of *C. gayana* then under test by being renamed "Callide" (Davidson, 1967). *C. gayana* is an aggressive and stoloniferous grass which spreads rapidly but does not suppress other companion species (Bogdan, 1977). This perennial grass grows erect up to a height of 2 meters in cultivation. The cultivars available commercially include Callide, Katambora and Samford which are characterized by being leafy, drought resistant, late flowering and palatable. All but cv Katambora are coarse stemmed and cv Callide can be distinguished by the long awns and long hairs on the spikelets. The seed of cv Callide is the most fluffy due to the tufted hairy glume (Cameron, 1967; Bogdan, 1977).

2.1.2. Establishment

2.1.2.1. Seedbed Preparation.

Seedbed preparation requires disc ploughing, harrowing once or twice and raking. These operations expose the roots and weeds and ease their removal. The soil may be lightly rolled after seed broadcast to increase the seed-soil contact and improve the reliability of establishment. Well prepared seedbeds support a better and more rapid pasture development which is needed to reduce weed competition.

2.1.2.2. Seeding Rate

Lower seed rates are necessary for pasture seed production than for herbage production (Humphreys, 1978) because the latter is expected to produce an effective competition with weeds, give good herbage yield and support reasonable grazing returns. However, low seeding rates may produce a successful establishment if land preparation and weed control are thorough right from the start and grazing is delayed until the end of the first growing season. Bogdan (1977), used seed purity - Pure Germinable Seed (PGS) - as a measure and recommended 0.5 - 1.0 kg PGS/ha for C. gayana seeding. In other words, seed containing 10% PGS could be sown at 5 - 10 kg/ha. Boonman (1972) indicated that seeding rate in the range of 0.2 to 1.8 kg PGS/ha was suitable for both herbage and seed production.

Blair Rains (1963) recommended seed rates of 5.6 to 11.2 kg/ha and 2.2 to 4.5 kg/ha of C. gayana sown, broadcast and drilled, respectively. In general, the seed rate for spreading type of grasses is usually lower than that of bunch-type grasses because the former are able to cover the ground more quickly by means of stolons and branches.

2.1.2.3. Time of Sowing

Humphreys (1978) suggested sowing early in the rainy season so as to obtain maximum growth and returns from the pasture in the year of establishment. In order to reduce weed infestation and produce high forage yield, Agishi (1971 a) observed that late June to mid July was the optimum time for planting pastures in the Northern Guinea Savanna Zone.

2.1.2.4. Methods of Sowing

In Queensland, *C. gayana* established reasonably well when the seed was broadcast on burned brigalow grassland (relatively infertile solodic soils) (Coaldrake and Russell, 1969). Kyneur and Tow (1958) mixed the seed with saw dust to allow free flow, planted with a cereal drill and covered by light chains attached to the drill. In small plot trials, seeds drilled by hand in shallow furrows made with hoes gave good establishment (Blair Rains, 1963). Both the broadcast and the drill methods proved effective when *C. gayana* was undersown in maize (Poultney, 1963; Goldson, 1967; Thomas, 1975) and bulrush millet (*Pennisetum typhoideum*) (Blair Rains, 1963).

In Tanzania, Owen and Brozostowski (1967) used cattle to trample a field which had not been burnt or heavily grazed before and after broadcast sowing of *C. gayana*. They observed that the sown grass content of the total herbage increased by 12% for the untreated plots and 27% and 31% for those trampled before and after sowing, respectively.

Blair Rains (1963) and Thomas (1976 a) suggested that *C. gayana* would require an inter-row spacing of at least 30 cm. This apparently agrees with the findings of Al-Noaim and Farnworth (1973) who reported DM yields of 32.7, 44.3 and 38.1 t/ha/yr from row spacings of 20, 30 and 40 cm apart, respectively. The widest spacing of 2.5 m appeared to be that used by Taerum (1970). *C. gayana* propagated vegetatively with plant parts such as cut stolons (Haggar, 1971) grows more rapidly and can be grazed earlier than C. gayana established from seed (Bogdan, 1969).

Little information is available on the depth of sowing of C. gayana. In a glasshouse trial, Bogdan (1961) recorded nil, 65% and 90% seedling emergence from C. gayana sown 5.0, 2.5 and 0.6 - 1.3 cm deep, respectively.

2.1.3. Crop Growth

2.1.3.1. Effect of Rainfall

Although C. gayana is drought resistant, its average annual rainfall requirement is in the range of 600 to 1200 mm (Bogdan, 1977; Humphreys, 1980). The amount of rainfall received in the Savanna Zone of Nigeria is sufficient for large scale C. gayana establishment but irrigation will be needed to supplement the low rainfall typical of the Sudan zone (Blair Rains, 1963; Agishi, 1980). C. gayana has been found to tolerate moderate, intermittent flooding of short duration (Humphreys, 1978). It could withstand flooding for 10 to 15 days but suffer from flooding of a longer duration (Bogdan, 1977).

2.1.3.2. Effect of Temperature

The optimum growth rate of grasses adapted to the warm environment occurs between 30 and 35°C whilst growth stops at 15°C and below (Cooper and Tainton, 1968). C. gayana is believed to grow well under a wide range of temperatures (Bogdan, 1977). C. gayana was the most cold tolerant of the tropical grasses studied under the day/night temperatures of 32/24°C and 26/15°C (t'Mannetje and Pritchard, 1974). The authors recorded that, of the two temperatures and two daylengths (14 and 11 hours) treatments applied, the DM yield of C. gayana was least at 26/15°C and 11 hrs daylength. A more recent study (Ivory and Whiteman, 1978 a) pointed out that the optimum temperature for cv Callide (total plant) growth was at day/night temperature of 34/29°C. Ivory and Whiteman (1978 b) also estimated the critical mean daily temperature that would cause cessation of growth of cv Callide to be 8°C. In Queensland, Jones (1969) reported C. gayana cv Pioneer to be tolerant to cold during a winter period when the lowest temperature was about - 3.9°C. The survival of the grass after the period was 97%.

2.1.4. Effect of Management on the Production of Pure Swards of C. gayana

2.1.4.1. Fertilizer Application

In general, most tropical soils are known to exhibit deficiencies in nitrogen (N) and phosphorus (P).

2.1.4.1.1. Nitrogen

The effect of nitrogen on production from C. gayana has been sought principally in terms of the rate and time of application. At Samford in Queensland, Henzell and Stirk (1963) observed that nitrogen deficiency limited the growth of C. gayana more than soil moisture shortage under natural rainfall conditions. These authors reported that four months after sowing, the yield of 11.2 t

DM/ha following the application of 30 kg N/ha was 4 to 5 times the yield without nitrogen. In South Africa, (Bogdan,,1977) 434 kg N/ha increased DM yield from 1.55 to 6.01t/ha. Clatworthy (1967) applied 0, 112, 224, 448 and 900 kg N/ha and obtained 7.0, 9.8, 12.2, 13.5 and 13.6t DM/ha, respectively. He concluded that 224 kg N/ha was the optimum required.

Nitrogen is usually applied at the beginning of the rains if it is to be used as a single dose. However, where rainfall intensity is high and leaching occurs to the extent of warranting high rates of nitrogen, split application is desirable. Research in the Reunion (Fritz, 1971; 1974) and under irrigation in Saudi Arabia (Al-Noaim and Farnworth, 1973) demonstrated that split nitrogen applications produced a higher DM yield than single application. Fritz (1974) indicated that nitrogen applied immediately after cutting or grazing gave higher DM yields than nitrogen applied at a later stage.

It may be deduced from Brockington (1962), Clatworthy (1967), Haggar (1971) and Olsen (1972) that nitrogen exerts a greater influence on CP than DM yield of C. gayana (Table 1). Milford (1960) recorded 13.4% and 8.1% CP for C. gayana fertilized with and without 224 kg N/ha, respectively and harvested at the pre-flowering stage. However, seven weeks later, at full flowering, the CP contents were almost identical (7.8% and 6.9%, respectively), indicating a fall in quality as the herbage matured.

Table 1. Effect of Nitrogen Level on DM and CP Yields of *C. gayana*

N levels (KgN/ha)	% increase on DM	yield	CP	yield	References
0	0	(2,24)*	0	(0,24)	
118	180	(4,04)	192	(0,47)	Brockington(1962)
235	240	(5,38)	308	(0,75)	in Namibia
353	280	(6,28)	425	(1,04)	
0	0	(7,08)	0	(0,78)	
224	173	(12,22)	234	(1,76)	Clatworthy (1967)
900	192	(13,56)	366	(2,75)	in Central Africa.
0	0	(7,2)	0	(0,29)	Haggar (1971)
300	188	(13,5)	486	(1,42)	in Nigeria.
0	0	(11,2)	0	(1,10)	
224	184	(20,7)	173	(1,90)	Olsen (1972)
448	219	(24,5)	255	(2,80	in Uganda
896	248	(27,8)	354	(3,90)	
1568	232	(26,0)	354	(3,90)	
2240	227	(25,4)	354	(3,90)	

*Figures in brackets are actual yields in t/ha.

2.1.4.1. Phosphorus

Investigations demonstrate that phosphorus fertilization does not always increase DM and CP yield. Although various grain legumes and cereal crops have been shown to respond markedly to phosphorus application on the soils of the Nigeria Guinea Savanna (Agboola, 1979), no information is available on the effect of phosphorus on grass swards in this environment. In a pot trial, Andrew and Robins (1971) applied the equivalent of 0, 12, 24, 48, 72, 96 and 144 kg P/ha to C. gayana cv Pioneer on a phosphate deficient soil and recorded yields 0.34, 0.89, 1.5, 2.2, 2.2, 2.6 and 2.4 t DM/ha respectively 57 days after sowing. The DM yield from C. gayana of 0.75 to 0.86t/ha with 0 to 40 kg P/ha (Stobbs, 1969) and 3.7 to 4.2t/ha with 0 to 60 kg P/ha (Barnes, 1960) would be regarded as marginal. Other tropical grasses revealed varied responses to phosphorus. Whilst 27 kg P/ha did not influence DM yield in buffel grass (Cenchrus ciliaris) (Faroda, 1974), up to 100 kg P/ha had little effect on pangola grass (Digitaria decumbens decumbens) (West and Prine, 1974). However, DM yield in napier grass (Pennisetum purpureum) given 0, 150 and 300 kg P/ha increased linearly with increase in phosphorus level (Herrera and Suarez, 1974).

The application of 0 to 60 kg P/ha did not significantly increase the CP yield of C. gayana cv Katambora (Barnes, 1960). Andrew and Robins (1971) observed that the addition to potted C. gayana cv Pioneer of equivalent rates of 0 to 114 kg P/ha and

112 kg N/ha at sowing and 56 kg N/ha four weeks after resulted in a decrease of herbage CP from 24.8% to 16.8%.

2.1.4.2. Effect of Cutting

The effect of cutting can be described in terms of its frequency and intensity. It is generally accepted that under normal circumstances herbage DM yield increases while CP content declines with longer intervals between cuts. Blair Rains (1963) suggested that C. gayana should not be defoliated before the dry season in the year of establishment to prevent the sward from deteriorating. This author recorded 10.5t and 16.1t DM/ha from C. gayana swards fertilized at 263 kg N/ha/3 yr and cut 11 and 6 times, respectively, compared with 7.7 t and 8.9t DM/ha for the unfertilized swards. Similarly, Minson and Milford (1967) observed that DM yield of C. gayana cvs Callide and Samford cut at intervals between 50 and 188 days increased from 5.8 to 13.5 t/ha and 5.4 to 6.9 t/ha, respectively.

Cultivar differences in time to mature may modify the effect of cutting frequency on sward CP content. Minson and Milford (1967) noted that the CP content of cv Callide cut every 50 to 188 days declined from 8.9% to 3.1% whilst that of Samford declined from 13.6% to 7.3%. The crude protein content of the same grasses, cut every 4 to 6 weeks in another experiment averaged 16% to 9.4% in Callide and 15% to 11.1% in Samford (Milford and Minson, 1968). Crude protein yield increases with less frequent cutting provided the sward is nitrogen fertilized (Blair Rains, 1963).

2.2. Stylosanthes guianensis

2.2.1. Origin and Description

Stylo or perennial stylo (*Stylosanthes guianensis*) originated from South America and is now grown throughout most of the tropical and the subtropical regions of the world. According to Humphreys (1978) *S. guianensis* cv Cook was introduced into Australia from Colombia (altitude 1,400 m above sea level 4,000 mm annual rainfall). *S. guianensis* cv Schofield reached Nigeria from Queensland, Australia in 1947 (Nwosu, 1960) whilst cv Cook and Endeavour were imported from the same environment in 1975 (Agishi, 1978). The different cultivars are adapted to varying climatic and edaphic conditions in the tropics and subtropics (Humphreys, 1980). *S. guianensis* cv Schofield has been studied to some extent in Nigeria where its inclusion in natural pastures has been found to increase not only the herbage yield and quality but also animal liveweight gains and soil nutrient status (Blair Rains, 1963; Adegbola, 1965; Haggar, de-Leeuw and Agishi, 1971).

S. guianensis is erect-growing although it produces lateral branches which radiate from a deep-rooted central axis and may creep along the ground surface. If left undefoliated, it may develop a dense leafy mat with thick and woody stems (Haggar, 1969). Table 2 described the principal differences in morphology and time to flower among the three *S. guianensis* cultivars available at Shika.

Table 2. Differences in morphology* and time to flower** among three S. guianensis cultivars.

Characters	Cultivars: Cook	Endeavour	Schofield
Seed germination	Good	Good	Good
Seedling establishment	Fast early growth	Slightly slower growth	Slowest growth
Growth habit	Semi-erect to erect	semi-erect densely branching	semi-erect
Leaflets	Green to bluish green, long and narrow	Green to light green, long and narrow	Green to dark green, shorter than others
Colour of stem/hair	Both are red	Both are light green	Both are green
Colour of flower parts:			
Standard	Orange	Yellow	Cream
Wings	Yellow	Yellow	Light yellow
Straie	Purple	Light purple	Purple
Colour of stipule	Red	Green	With some red
Colour of Seed	Olive green to yellow to yellow-brown	Orange to yellow-orange to brown	Yellow to yellow-brown to brown.
Flowering time			
1st year	Early October	From mid to late October	From December
2nd year	Early September	From mid to late September	From December

* Harding and Cameron (1972).

**Agishi, (1978).

2.2.2. Establishment

2.2.2.1. Seedbed preparation.

A good seedbed for S. guianensis cv Schofield was obtained at Shika by deep ploughing in June or early July, followed by disc-harrowing twice (Agishi, 1971 b). Foster (1961) noted that in the most rudimentary of seedbeds (handhoed strips or shallow grooves scratched by stick) S. guianensis gave an establishment count of about 24,000 stands/ha ten months after sowing which was significantly better than the treatment without any form of seedbed cultivation (9,600 stands/ha).

2.2.2.2. Seed treatment

Propagation is normally from seed. Due to hard-seededness, germination is usually low (5-10%) but when scarified mechanically with hot water or sulphuric acid, up to 100% germination could be obtained. Full germination occurred when the seeds were subjected to a temperature of $-13^{\circ}C$ for 48 hrs (Mastrocola and Lima, 1979). Under field conditions in Australia (Gardener, 1975) the hard seed content of cv Cook fell to almost zero after five months, storage (95% germination). Brolmann (1975) concluded that environmental stresses such as drought, heat and cold enhanced germination in the field. The author exposed stylo seeds for two weeks or longer to a dry heat treatment and a cold, followed by heat, treatment to obtain germinations of 87 - 90% and 75% respectively.

2.2.2.3. Seeding Rate.

Blair Rains (1963) and Haggar (1969) recommended 3.3 to 6.7 kg seed/ha for the treated seed and at least double this rate for the untreated seeds in the Guinea Savanna Zone of Nigeria. Since the seed is costly, Bogdan (1977) indicated the use of a low rate of 2-3kg/ha. In Avetonou in the Guinea Zone of Togo (1290 mm rainfall) Doppler (1980) reported a sowing rate of 15kg/ha.

2.2.2.4. Sowing Method.

Seed may be broadcast on cultivated seedbed and followed up by rolling. Olsen and Moe (1971) drilled the seed in 30 cm rows for the production of pure swards. Drilling in rows 45 to 60 cm apart facilitates inter row weeding (Bogdan, 1977). Sowing depth could vary between 1 cm (Olsen and Moe, 1971) and 2 cm (Bailey, 1965). On basalt and granite - derived soils in Australia, seedlings of S. guianensis cvs Oxley and Schofield and Townsville stylo (S. humilis) emerged best from 0.6 to 1.2 cm depth (Stonard, 1969).

2.2.3 Crop Growth

S. guianensis grows under a rainfall of 600 mm to 2,500 mm (Bogdan, 1977). Blair Rains (1963) reported that though the growth of cv Schofield under the 650 mm rainfall and a 5- to 6-month dry season condition is poor, the plant was adaptable to the environment. In a screening exercise involving several cultivars, Edye et al (1976) showed that S. guianensis was not well adapted to the sub-tropics of Queensland which received less than 1000 mm rainfall annually. Although S. guianensis tolerates some degree of water logging, the DM yield of cvs Cook, Schofield and Oxley, flooded in a glasshouse trial was reduced by 67, 60 and 39%, respectively (McIvor, 1976). The optimum temperature for the growth of most tropical legumes is 30°C (Humphreys, 1978) but S. guianensis tolerates cool weather and survives light frosts (Gilchrist, 1967; Bogdan, 1977).

The species are short-day plants and cv Schofield is reported to have flowered in the daylength range of 8 to 12 hrs (Okigbo, 1972). The critical photoperiods for cvs Cook, Endeavour and Schofield in Brisbane, Australia varied from 11.5 to 13 hrs in the field (Bryant and Humphreys, 1976). t'Mannetje (1965) reported that its growth habit was not affected by photoperiods but herbage yield was higher at longer (12 - 14 hrs) than at shorter (8 - 10 hrs) photoperiods. S. mucronata gave a higher DM yield only under a 14-hr photoperiod. In Dahomey, (Tuley, 1968) S. guianensis performed poorly when shaded by oil palm trees and its forage yield was reduced by about 75%.

2.2.4. Effect of Management on the Production of Pure Swards of S. guianensis

2.2.4.1. Effect of Fertilizer Application.

Phosphorus (P) is probably the most important major element required and needs to be applied on poor soils during establishment. At Serere in Uganda, Wendt (1970) applied 0, 33.5 and 67.0 kg P/ha/yr to S. guianensis and recorded 24.0, 26.2 and 28.6 t DM/ha, respectively from 15 cuts over a three-year period. Also in Uganda, (Olsen and Moe, 1971) application of 0, 50, 100 and 200 kg P/ha at establishment resulted in the yields of

30.4, 34.1, 33.4 and 33.6t DM/ha, respectively from eight harvests in two years. This probably indicates that the optimum level of P required for forage yield may not exceed 50 kg/ha.

2.2.4.2. Effect of Cutting

Cultivars vary in response to cutting. DM yield in the second year appears to supercede that in the establishment year and lenient defoliation results in higher yield than severe defoliation. In Malawi, Thomas (1976 b) recorded 6.0 and 5.2 t DM/ha for cvs Schofield and Endeavour, respectively, at the end of the first year. The second year forage cut four times yielded the corresponding values of 10.0 and 11.0 t DM/ha, respectively. Thomas (1976 b) reported the following CP yields (t/ha) of cvs Schofield and Endeavour over 4 years for different cutting frequencies:-

Year	1971/72	1972/73	1973/74	1974/74
No of cuttings	1	4	3	3
Schofield	0.90	1.20	0.08	0.14
Endeavour	0.80	1.50	0.06	0.14

The data indicated that differences in CP yield could be explained in terms of not only cultivar but also climate and the age of the sward.

It could be derived from Tuley (1968) that cutting lower than 15 cm above the ground level would cause deterioration of the stand. Cutting height and frequency may interact to influence the ultimate DM yield. For example, at Samford, Queensland, Cameron (1974) compared S. guianensis cvs Cook, Endeavour and Schofield cut at a height of 5 cm every 6 weeks (heavy) with 10 cm every 9 weeks (lenient) and obtained the DM yield figures below:-

	DM yield (kg/ha/2 yrs)	
Cultivars	Heavy	Lenient
Cook	11,450	14,970
Endeavour	8,300	10,540
Schofield	7,420	9,250

2.3 Production of C. gayana/S. guianensis Mixtures.

S. guianensis cv Schofield forms suitable mixtures with gamba (Andropogon gayanus) and C. gayana in the Northern Guinea Savanna and Sub-sudan Zones of Nigeria (Blair Rains, 1963; Haggar, 1971). Foster and Mundy (1961) recommended a centro (Centrosema pubescens) or S. guianensis/A. gayanus combination for the Derived and the Southern Guinea Savanna Zones. Here also, the same legumes in association with signal grass (Brachiaria decumbens) and green panic (Panicum maximum var Trichoglume) have resulted in highly productive swards (Akinola, personal communication). In the Forest Zone, C. pubescens has long been recognized as a suitable companion of elephant grass (Pennisetum purpureum), guinea grass (Panicum maximum), star grass (Cynodon spp), B. decumbens and other notable grass species (Ahlgren et al, 1959; McIlroy, 1962; Moore, 1962).

2.3.1. Establishment of Grass/Legume Mixtures.

Grasses are usually sown in alternate rows with

S. guianensis and when a rapidly establishing species like C. gayana is involved the legume is sown two weeks earlier (Bogdan, 1977). Seed rates of 1 to 6 kg and 2 to 5 kg/ha are used for pure swards of C. gayana and S. guianensis, respectively, higher rates being necessary for areas with greater rainfall (Humphreys, 1980) or situations that may result in a less reliable germination. It is only reasonable therefore, to expect that a lower seed rate of each would be needed for establishing their mixture. In dry areas like the semi arid regions and on poorer soils, lower grass and higher legume seed rates have been suggested since these would give an early legume dominance and maximum soil fertility building (Griffiths Davies and Hutton, 1970; Humphreys, 1980). The seeds are small sized and require shallow sowing depths - usually in the range of 0.5 to 1.3 cm. Pre-sowing seed treatment with insecticide/fungicide e.g. Aldrex-T safeguards against seed stealing by harvester ants and application of P is a prerequisite for rapid establishment.

2.3.2. Performance of Grass/Legume Mixtures.

In a 3-- year study of C. gayana/S. guianensis cut 2 times yearly (Haggar, 1971) the grass produced significantly higher DM yield in the first two years whilst the legume dominated in the third year. In this study, although C. pubescens and desmodium (Desmodium scorpiurus) did not perform as well as S. guianensis, their DM yields similarly increased progressively with time. From the trial, which further indicated hardly any effect of S. guianensis on the grass CP content (5.6% and 5.8% CP for the grass in pure and mixed stands, respectively), it was estimated that the legume contributed the equivalent of 84 kg N/ha in terms of DM yield, and 187 kg N/ha in terms of CP yield. Adegbola and Onayinka (1966) cut P. maximum, A. gayanus or Molasses grass (Melinis minutiflora)/S. guianensis every 6, 8 or 12 weeks over two seasons and recorded the highest overall DM yield from the A. gayanus mixture. Further local samples are difficult to obtain but Moore (1962), in South-Western Nigeria, recorded a fixation of 280 kg N/yr under a grazed C. pubescens/Cynodon nlemfuensis pasture.

2.3.3. Effect of N on Already Established Grass/Legume Mixtures.

Addition of mineral N stimulates the growth of the grass to a considerably greater extent than that of the legume and this results in an increased competitiveness of the grass for light, space, water and nutrient (Donald, 1963; Horrell and Court, 1965; Jones, 1970; Haggar, 1971). At high N rates, the legumes were eliminated (Jones, Griffiths Davies and Waite, 1969). If, however, the legume begins growth earlier in the season than the grass, the situation can be reversed with the legume taking up the applied N and dominating the association (Willoughby, 1954). Defoliation of a sward reduces competition for light and may produce a similar result. In N fertilized C.gayana/S. guianensis mixture at Shika, contribution of legume to yield rose as the cutting frequency increased (Haggar, 1971).

The suggestion might be that the grass:legume ratio obtaining prior to N application would, to a large extent, determine the subsequent yield response.

CHAPTER 3

MATERIALS AND METHODS

3.1 Experimental Site

3.1.1. Location

The experiment was sited at the National Animal Production Research Institute (N.A.P.R.I.), Shika, in the Northern Guinea Savanna Zone of Nigeria (latitude 11° 15'N, longitude 7° 32'E, altitude 610m above saa level), 22 km along Zaria - Sokoto road. The area is ecologically defined as *Andropogon gayanus*/ *Hyperrhenia rufa* dominant. Prior to cultivation, Block A, the trial site, was sown to Townsville stylo (*Stylosanthes humilis* cv Paterson) grazed by sheep.

3.1.2. Climate:

Shika climate is characterized by a well defined wet season which normally begins in April/May and ends in late September/early October. The dry season on the other hand lasts from October to April with a low relative humidity and a dry north-east wind. The total annual rainfall ranges from 727 mm to 1284 mm with an average of 1,025 mm. The highest mean maximum air temperature of 36.0°C is recorded in April while the lowest mean minimum temperature of about 11.5°C occurs in December/January. The weather observations during the experimental period are reported in Table 3.

Table 3: Weather Observations at Shika* in 1979 and 1980.

	Total rainfall (mm)			Mean daily temperature (°C)			
Month	1979	1980	1967-1980	1979		1980	
				Min	Max	Min	Max
January	-	-	-	13.9	30.2	13.2	31.2
February	-	-	-	15.8	36.6	15.8	32.4
March	6	6	4	19.8	35.2	18.0	35.4
April	16	-	43	21.3	35.8	21.9	36.5
May	77	132	113	21.1	32.8	21.3	33.0
June	205	68	147	20.5	30.1	19.8	30.3
July	390	227	255	19.4	28.9	19.6	28.7
August	225	178	255	19.7	28.8	19.4	28.1
September	133	73	172	18.9	29.6	19.4	30.6
October	29	50	35	18.1	32.1	18.8	32.0
November	9	-	-	15.1	32.3	13.9	31.9
December	-	-	-	12.2	28.3	11.7	28.4
Total	1090	727	1025				

*Temperature at Samaru, latitude 11° 11', longitude 7° 38'E, altitude 685 m above sea level.

3.1.3. Soil:

Shika soils have been classifidd as belonging to the ferruginous tropical soils derived from sandy parent material and crystalline acid rock (Klinkenberg and Higgins, 1968). Kowal (1968) has described the physical properties of the well - drained sandy loam soil of the trial site. The soil, with a clay fraction consisting mainly of kaolinite and small quantities of illite is known to be deficient in P and N.

3.2. Land Preparation

The experimental area was disc ploughed and harrowed twice to obtain a fine seedbed on 15/6/79. The plots were pegged out, levelled and raked on 23/6/79. A second raking the following day helped to work the broadcast 100 kg single superphosphate (9% phosphorus) per hectare. The same amount of phosphorus was similarly applied in June, 1980.

3.3. Experiment 1

The effect of grass/legume seeding ratio and sowing method on DM yield and CP content of C. gayana/S. guianensis swards.

3.3.1 Experimental Design

A split plot design with (7 x 3) treatment combinations in four replications was used. Seven grass:legume seeding ratios constituted the main plots and three randomly distributed sowing methods made up the sub-plots. The seven grass (C. gayana cv Callide): legume (S. guianensis cv. Cook) seeding ratios according to the replacement series technique of de Wit (1960) and Van den Bergh (1968) and based on the weight of their pure germinable seed (PGS) included:- 10:0, 7:3, 6:4, 5:5, 4:6, 3:7 and 0:10. The sowing methods comprised (i) grass and legume drilled in alternate rows, 30 cm apart (ii) grass and legume mixed and broadcast (iii) grass and legume mixed and drilled within the same rows, 30 cm apart. Each subplot was 6m x 4.5m with a path 50 cm wide between subplots.

3.3.2. Seeding:

The grass and legume (treated with hot water at 70°C for 10 minutes and sun-dried)seeds used were harvested at Shika and aged approximately nine and three months, respectively, at the time of sowing. One gram of both seed batches contained equal numbers of PGS. An equivalent of 10 kg PGS/ha (27gm/plot) for each ratio was sown on 26/6/79.

3.3.3. Estimation of Dry Matter Yield.

Sward dry matter yield was estimated from each of the four replicates by cutting with sickles at a height of 20 cm above ground level on the following dates:

Year	Date of sowing or Cutting back	Date of sampling	Age at Sampling (days)
1979	26/6/79	25/10/79	120
1980	16/6/80	13/10/80	120

On both harvesting occasions, samples were taken from four random (60 cm x 60 cm) quadrats per plot and sorted into the sown grass and legume components. Each component was weighed separately, dried in a Unitherm oven at 80°C for 48 hours and reweighed for estimation of dry weight hence DM yield per hectare.

3.4 Experiment II

Effect of rate and time of N application and of cutting in 1980 on DM yield and CP content of *C. gayana* cv Callide/*S. guianensis* cv Cook mixture established in 1979.

3.4.1. The Established Sward

The regrowth of *C. gayana* cv Callide/*S. guianensis* cv Cook sown by broadcasting at a seeding ratio of 5:5 on 26/6/79, and which received 9 kg P/ha at establishment and again in June, 1980 was used for this study. The sward was harvested for DM yield in October, 1979 at which time it consisted of 75% grass and 25% legume by weight. It was cut back again on 16/6/80 to promote uniform regrowth.

3.4.2. Experimental Design:

A split, split plot design with four replications was imposed on the established sward (see 3.4.1). The main plots were three levels of nitrogen:- 0, 100 and 200 kg N/ha in the form of calcium ammonium nitrate (26%N). The sub-plots were three times of nitrogen application viz 16/7/80 (July), 13/8/80 (August) and 10/9/80 (September). The sub-sub-plots were cut and uncut treatments (see 3.4.3 below). Each sub-sub-plot measured 3m x 4.5m.

3.4.3. Estimation of DM Yield:

The sampling procedure for DM yield involved cutting at a height of 20 cm above ground level on the following dates:- 16/7/80 (T1), 13/8/80 (T2), 10/9/80 (T3) and 7/11/80 (T4). These dates equalled 30, 58, 86 and 144 days after cutback, respectively. On T1, DM yield was estimated from the cut sub-sub-plots of all July treatments. On the same day N was applied to both the cut and uncut sub-sub-plots of all July treatments after dry matter estimation. The same procedure followed on T2 and T3 respectively for the August and September treatments. On the last sampling date (T4) both the cut and uncut sub-sub-plots were sampled for DM yield. The sample area was 2m x 3m. All plots were cutback to a uniform height of 20cm after all samplings. The fresh samples were weighed on sub-sub-plot basis. Two subsamples were taken after mixing thoroughly and sorted into the sown grass and legume components. Details of sampling and subsampling processes followed the description provided earlier (see 3.3.3. above).

3.5 Chemical Analysis

The oven dried grass and legume components were ground with Christy and Norris Laboratory mill using a 1mm mesh. Herbage N content (%) was determined on DM basis according to the standard kjeldahl method (AOAC, 1970). This consisted of the following:-

Procedure	Chemical used.
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 crysol green solution as indicator.
Titration	0.0244N hydrochloric acid.

Standard protein contains approximately 16%N (6.25), therefore multiplying the total N obtained from kjeldahl method by 6.25 gives the herbage percentage crude protein CP %).

3.6. Statistical Analysis

The experimental data were subjected to statistical analysis of variance and differences between means were compared using the Duncan's New Multiple Range Test as described by Steel and Torrie (1960).

CHAPTER 4

RESULTS

4.1. Experiment 1: Effect of Seeding Ratio and Sowing Method on Dry Matter Yield of *C. gayana* cv Callide/*S. guianensis* cv Cook Sward.

4.1.1. 1979 Growing Season.

Grass (G):legume (L) seeding ratio and sowing method influenced the DM yield of *C. gayana* cv Callide (grass), *S. guianensis* cv Cook (legume) and their total (Table 4). The DM yield of the grass component declined gradually as the seeding ratio decreased whilst the reverse was true for the DM yield of the legume component.

However, whereas the DM yield of the sole grass sward differed only marginally from that of the grass in the mixtures, the DM yield of the sole legume sward significantly ($P < 0.01$) superceded that of the legume in any of the mixtures. The highest total sward DM yield of 5.10t/ha resulted from seeding ratio 3:7 but this was not markedly different from the DM yield for seeding ratio 7:3 to 4:6. The pure grass and pure legume swards produced significantly ($P < 0.01$) lower DM yields than any other sward.

Broadcast sowing resulted in significantly ($P < 0.01$) higher DM yield than sowing by any other method in terms of the grass component and total (grass + legume). For the legume component DM yield, the broadcast sowing was superior only to sowing in alternate rows.

Table 4: Effect of Seeding Ratio and Sowing Method on DM Yield (t/ha) of C. gayana cv Callide/S. guianensis

Sowing Method	G:L Seeding Ratio 10:0	7:3	6:4	5:5	4:6	3:7	0:10	Mean
	a) C. gayana cv Callide							
Alternate	4.09	3.79	3.66	3.41	3.43	3.22	-	3.60b
Broadcast	5.03	5.02	5.44	3.89	3.92	3.84	-	4.52a
Mixed	3.92	3.27	3.06	3.35	3.25	3.31	-	3.36b
Mean	4.35a*	4.03ab	4.06ab	3.55ab	3.52b	3.46b	-	
	b) S. guianensis cv Cook							
Alternate	-	0.73	0.90	1.09	1.25	1.29	3.88	1.52b
Broadcast	-	0.68	0.60	1.21	1.27	1.75	5.17	1.78a
Mixed	-	1.02	1.15	1.31	1.67	1.89	3.70	1.79a
Mean	-	0.81e	0.88de	1.20cd	1.40bc	1.64b	4.25a	
	c) Total (Grass + Legume)							
Alternate	4.09	4.52	4.56	4.50	4.68	4.51	3.88	4.39b
Broadcast	5.08	5.70	6.05	5.09	5.18	5.58	5.17	5.40a
Mixed	3.92	4.29	4.21	4.65	5.01	5.20	3.70	4.43b
Mean	4.35c	4.83abc	4.94ab	4.75abc	4.96ab	5.10a	4.25c	

* Means in the same row or column not followed by similar letters differ significantly at P< 0.05 according to Duncan's New Range Test.

The interaction between seeding ratio and sowing method was non-significant. Disregarding the pure stands, the highest grass and legume component DM yields of 5.44t/ha and 1.90t/ha resulted from the seeding ratio 6:4/broadcast and 3:7 / mixture within row combinations, respectively. The corresponding lowest values of 3.06t/ha and 0.60 t/ha occurred with seeding ratio 6.4/mixture within row and 6:4/ broadcast combinations, respectively. On total plot yield basis the highest and the lowest DM yields of 6.05t/ha and 3.70t/ha, respectively were obtained from associations involving seeding ratio 6:4/broadcast and 0:10/mixture within row sowing.

4.1.2. <u>1980 Growing Season</u>.

The pattern of DM yield response to different seeding ratios for the October 1980 harvest was similar to that of October, 1979 (Table 5). Grass component DM yield declined from the highest value for the sole grass plot to the lowest value for the mixture sown at the seeding ratio 3:7. The sole legume and the legume component of the mixture established at the seeding ratio 7:3 gave the highest and the lowest legume DM yields respectively. Significant differences did not exist between the mean yields of the mixtures. The sole grass sward yielded lower than any mixed sward but the sole legume sward produced significantly the least yield.

The main effect of sowing method was such that the broadcast technique produced (i) non-significantly ($P > 0.05$) the lowest grass DM yield pooled over all the grass components, (ii) significantly ($P \angle 0.01$) the highest legume

Table 5: Effect of Seeding Ratio and Sowing Method on DM Yield (t/ha) of C. gayana cv Callide/S. guianensis cv Cook Sward in 1980.

Sowing Method	10:0	7:3	6:4	5:5	4:6	3:7	0:10	Mean
		G:L Seeding Ratio						
	a) C. gayana cv Callide							
Alternate	7.46	6.96	6.84	6.87	6.46	6.12	-	6.75a
Broadcast	6.77	6.46	6.34	6.06	5.92	5.11	-	6.11a
Mixed	7.26	6.83	6.81	6.49	6.07	4.95	-	6.40a
Mean	7.16a*	6.75ab	6.67ab	6.41ab	6.15bc	5.39c	-	
	b) S. guianensis cv Cook							
Alternate	-	1.37	1.36	1.68	1.90	2.38	3.03	2.15b
Broadcast	-	1.58	2.15	2.40	2.61	4.12	4.71	2.93a
Mixed	-	1.53	1.60	1.87	1.88	3.15	3.98	2.33b
Mean	-	1.49d	1.77cd	1.98c	2.13c	3.21b	4.24a	
	c) Total (Grass + Legume)							
Alternate	7.46	8.33	8.40	8.37	8.35	8.49	4.03	7.63a
Broadcast	6.77	8.04	8.52	8.46	8.53	9.23	4.71	7.75a
Mixed	7.26	8.36	8.41	8.36	7.96	8.10	3.98	7.49a
Mean	7.16b	8.24a	8.44a	8.39a	8.28a	8.61a	4.24a	

* Means in the same row or column not followed by similar letters differ significantly at P $\angle$ 0.05 according to Duncan's New Multiple Range Test.

DM yield and (iii) non-significantly ($P > 0.05$) the highest total (grass + legume) yield.

Seeding ratio and sowing method did not interact significantly. The highest DM yield, 9.23t/ha, was obtained from the seeding ratio 3:7 /broadcast mixture whilst the row sown pure legume sward resulted in the lowest, 4.03t/ha. No mixture produced less than 8t DM/ha. It would be observed that in all cases (except the broadcast sole legume) DM yields in 1980 exceeded those of 1979 for comparable treatments.

4.1.3. Effect of Seeding Ratio and Sowing Method on Mean Dry Matter Yield (t/ha) of *C. gayana* cv Callide/*S. guianensis* cv Cook Sward over the 1979 and 1980 Growing Seasons.

The mean grass DM yield over the two growing seasons differed significantly ($P < 0.01$) among seeding ratio and followed the pattern 10:0 ≥ 7:3 = 6:4 ≥ 5:5 = 4:6 > 3:7 (Table 6). Broadcast sowing gave the highest yield which, however, was not significantly ($P > 0.05$) different from yield for any other method. The broadcast sole grass sward gave the highest yield (5.96 t/ha) while the least yield (4.13t/ha) resulted from seeding ratio 3:7 sown in mixture within the row. The seeding ratio x sowing method interaction was non-significant.

The effect of seeding ratio and sowing method on mean legume DM yield was highly significant ($P < 0.01$). The pure sward and the seeding ratio 7:3 produced the highest and the least DM yields respectively.

Table 6: Effect of Seeding Ratio and Sowing Method on Mean DM Yield (t/ha) of C. gayana cv Callide/S. guianensis cv Cook Sward over the 1979 and 1980 Growing Seasons.

Sowing Method	G:L Seeding Ratio 10:0	7:3	6:4	5:5	4:6	3:7	0:10	Mean
	a) C. gayana cv Callide							
Alternate	5.77	5.38	5.25	5.05	4.94	4.67	-	5.18a
Broadcast	5.96	5.74	5.89	4.97	4.92	4.47	-	5.33a
Mixed	5.59	4.82	4.94	4.42	4.66	4.13	-	4.76a
Mean	5.78a*	5.31ab	5.36ab	4.81bc	4.84bc	4.42c	-	
	b) S. guianensis cv Cook							
Alternate	-	1.05	1.22	1.38	1.57	1.85	3.96	1.84c
Broadcast	1	1.13	1.38	1.81	1.94	2.93	4.94	2.35a
Mixed	-	1.27	1.37	1.59	1.78	2.52	3.84	2.06b
Mean	-	1.15d	1.32d	1.59c	1.76c	2.44b	4.24a	-
	c) Total (Grass + Legume)							
Alternate	5.77	6.24	6.48	6.43	6.52	6.52	3.96	6.01ab
Broadcast	5.96	6.87	7.27	6.78	6.86	7.40	4.94	6.58a
Mixed	5.59	5.49	6.31	6.00	6.44	6.65	3.84	5.76b
Mean	5.78b	6.26ab	6.69a	6.40ab	6.60a	6.86a	4.24c	

*Means in the same row or column not followed by similar letters differ significantly at $P < 0.05$ according to Duncan's New Multiple Range Test.

The broadcast method gave the highest yield and sowing on alternate rows the least. The seeding ratio x sowing method interaction in respect of S. guianensis, unlike that of C. gayana, was highly significant. The broadcast pure legume plot produced 4.94t DM/ha (highest) while the seeding ratio 7:3 sown in alternate rows yielded 1.05 t DM/ha (least).

For the two-year period, the mixed (grass + legume) swards were significantly more productive than the sole grass or legume swards. The data also suggested that broadcast sowing resulted in significantly ($P < 0.05$) higher yields than any other method. The seeding ratio 3:7 and 6:4/broadcast combinations produced the highest yields (7.40t and 7.27t DM/ha) and the drilled, pure legume, the poorest yield (3.84t DM/ha).

4.1.4. Effect of Seeding Ratio and Sowing Method on Crude Protein (CP) Content of C. gayana cv Callide/S. guianensis cv Cook Sward.

4.1.4.1. October 1979

With a decline in the proportion of grass in the seed mixture sown, CP content of each of the grass and legume components of swards increased, culminating in a significant ($P < 0.01$) seeding ratio effect (Table 7). The CP content of grass for seeding ratio 10:0 and 7:3 was significantly lower than that for 4:5 and 3:7 while the values for 6:4 and 5:5 were intermediate. Legume CP content was significantly lowest for seeding ratio 7:3 and highest for 0:10, values for other seedings being only marginally different from one another. There was no marked effect of sowing method on the CP content of either component and the seeding ratio x sowing method interaction was non-significant.

Table 7: Effect of Seeding Ratio and Sowing Method on CP Content of C. gayana cv Callide/S guianensis cv Cook Sward in 1979.

Sowing Method	G:L Seeding Ratio 10:0	7:3	6:4	5:5	4;6	3:7	0:10	Mean
a) C. gayana cv Callide								
Alternate	3.21	3.19	3.39	3.44	3.50	3.66	-	3.40a
Broadcast	3.25	3.30	3.43	3.55	3.63	3.70	-	3.48a
Mixed	3.31	3.44	3.49	3.65	3.78	3.80	-	3.58a
Mean	3.26c*	3.31c	3.43bc	3.55ab	3.64a	3.72a	-	-
b) S. guianensis cv Cook								
Alternate	-	9.68	10.20	10.56	10.53	10.83	10.83	10.44a
Broadcast	-	9.83	10.57	10.60	10.64	10.68	11.58	10.65a
Mixed	-	10.31	10.44	10.25	10.56	10.59	10.60	10.58a
Mean	-	9,94c	10.40bc	10.47abc	10.58ab	10.70ab	11.00a	-

*Means in the same row or column not followed by similar letters differ significantly at p/ 0.05 according to Duncan's New Multiple Range Test.

4.1.1.2. October, 1980

The effect of seeding ratio on the CP content of the sward in 1980 was similar to that of 1979 (Table 8) except that the level of significance attained varied from $P < 0.05$ for the grass to $P < 0.01$ for the legume component. While the percentage CP of the grass increased, that of the legume tended to have decreased relative to the 1979 values. The effect of sowing method was non-significant ($P > 0.05$) for either the grass or the legume. The grass CP content varied from 3.19% (seeding ratio 7:3, alternate rows) to 3.80%(seeding ratio 3:7, mixture within the row) in 1979 and from 3.37% (seeding ratio 10:0) to 4.02% (seeding ratio 3:7) both from mixture within the row in 1980. The legume, on the other hand contained between 9.68% (seeding ratio 7:3, alternate rows) and 11.58% CP (seeding ratio 0:10, broadcast) in 1979 compared with 9.53% (seeding ratio 7:3, mixture within the same) to 10.68% (seeding ratio 0:10, broadcast) in 1980.

4.2. Experiment II

4.2.1. Effect of Rate and Time of Nitrogen Application and of Cutting in 1980 on DM Yield of *C. gayana* cv Callide /*S. guianensis* cv Cook Sward Established in 1979.

4.2.1.1. The Grass Component

Nitrogen (N) increased grass DM yield although the differences between N levels were not statistically significant at $P > 0.05$ (Table 9). On the other hand,

Table 8: Effect of Seeding Ratio and Sowing Method on CP Content of C. gayana cv Callide/S.guianensis cv Cook Sward in 1980.

Sowing Method	G:L Seeding Ratio 10:0	7:3	6:4	5:5	4:6	3:7	0:10	Mean
	a) C. gayana cv Callide							
Alternate	3.42	3.50	3.57	3.64	3.70	3.71	-	3.59a
Broadcast	3.44	3.53	3.65	3.74	3.77	3.80	-	3.66a
Mixed	3.37	3.61	3.67	3.71	3.80	4.02	-	3.69a
Mean	3.41b*	3.55ab	3.63ab	3.70ab	3.75a	3.85a	-	-
	b) S. guianensis cv Cook							
Alternate		9.68	9.63	9.71	9.86	10.05	10.29	9.87a
Broadcast		9.61	9.61	9.76	9.82	9.90	10.68	9.90a
Mixed		9.53	9.57	9.55	9.75	9.86	10.09	9.73a
Mean		9.61b	9.61b	9.67b	9.81b	9.94b	10.35a	

*Means in the same row or column not followed by similar letters differ significantly at P ≤ 0.05 according to Duncan's New Multiple Range Test.

Table 9: Effect of Rate and Time of Nitrogen Application and of Cutting in 1980 on Grass DM Yield (t/ha) of *C. gayana* cv Callide/*S. guianensis* cv Cook Sward Established in 1979.

Time of N application	N levels (kg/ha) 0	100	200	mean
July	6.52	7.03	7.71	7.09a
August	6.41	6.90	8.11	7.14a
September	6.23	6.73	6.50	6.49b
Mean	6.39a*	6.89a	7.44a	

Cutting	N levels (kg/ha) 0	100	200	mean
Cut	6.11	6.59	6.86	6.52b
uncut	6.66	7.19	8.02	7.29a
Mean	6.39a	6.89a	7.44a	

Cutting	Time of N Application: July	August	September	Mean
Cut	6.22	7.07	6.26	6.52b
Uncut	7.95	7.21	6.71	7.29a
Mean	7.09a	7.14a	6.49b	

* Means in the same row or column not followed by similar letters differ significantly at $P < 0.05$ according to Duncan's New Multiple Range Test.

cutting during the growing season caused considerable reduction in herbage yield. Deferment of nitrogen application beyond August resulted in a lower yield than nitrogen application made earlier.

Regardless of cutting, the non-fertilized grass produced the least DM yield (6.23t/ha) while that given 200 kg N/ha gave the highest yield (8.11t/ha). Yields for the no nitrogen cut grass and from the 200 kg N/ha uncut grass amounted to 6.11 and 8.02t DM/ha, respectively. The uncut grass which received 200kg N/ha in July was the most productive.

4.2.1.2. The Legume Component

Addition of nitrogen resulted in a significant ($P < 0.05$) reduction of legume DM yield (Table 10). Regardless of nitrogen level, August yield was significantly ($P < 0.01$) higher than yields in July and September. The non-fertilized plot yielded highest(3.04 t/ha) while the lowest yields (1.53 - 1.62 t/ha) were produced by plots which received 200 kg N/ha in July or September. The uncut legume generally yielded lower than that cut back although the difference was not significant ($P > 0.05$). The interaction between cutting and time of nitrogen application was significant.

4.2.1.3. Total Sward Yield

Although there was a tendency for nitrogen to increase total sward DM yield, the differences between the three levels of application were not significant at $P < 0.05$ (Table 11). Yield due to August application of nitrogen was significantly higher than that of September while

Table 10: Effect of Rate and Time of Nitrogen Application and of Cutting in 1980 on Legume DM Yield (t/ha) of *C. gayana* cv Callide/*S. guianensis* cv Cook Sward Established in 1979.

Time of N application	N levels (kg/ha) 0	100	200	Mean
July	2.11	1.84	1.53	1.83b
August	3.04	2.38	2.12	2.52a
September	2.38	2.08	1.62	2.03b
Mean	2.51a*	2.10b	1.76bc	

Cutting	N Levels (kg/ha)			
Cut	2.51	2.19	1.88	2.19a
Uncut	2.52	2.01	1.64	2.06a
Mean	2.51a*	2.10b	1.76bc	

Cutting	Time of N application			
	July	August	September	Mean
Cut	1.52	2.55	2.50	2.19a
Uncut	2.13	2.48	1.56	2.06a
Mean	1.83b	2.52a	2.03b	

* Mean in the same row or column not followed by similar letters differs significantly at $P < 0.05$ according to Duncan's New Multpile Range Test.

Table 11: Effect of Rate and Time of Nitrogen Application and of Cutting in 1980 on total DM Yield (t/ha) of C. gayana cv Callide/S. guianensis cv Cook Sward Established in 1979.

Time of N Application	N levels (kg/ha) 0	100	200	Mean
July	8.63	8.27	9.23	8.91ab
August	9.46	9.28	10.24	9.66a
September	8.61	8.82	8.12	8.51b
Mean	8.90a*	9.00a	9.20a	

Cutting	N levels (kg/ha) 0	100	200	Mean
Cut	8.62	8.77	8.73	8.71a
Uncut	9.18	9.21	9.66	9.35a
Mean	8.90a	9.00a	9.20a	

Cutting	Time of N Application July	August	September	Mean
Cut	7.74	9.63	8.76	8.71a
Uncut	10.08	9.69	8.27	9.35a
Mean	8.91ab	9.66a	8.51b	

Means in the same row or column not followed by similar letters differs significantly at $P < 0.05$ according to Duncan's New Multiple Range Test.

July application had an intermediate effect.

The difference between the yields of the cut and uncut swards was not significant ($P > 0.05$). Total DM yields, averaged over time of N application followed the order August > September > July for the cut and July > August > September for the uncut sward.

4.2.2. Effect of Rate and Time of Nitrogen Application and of Cutting in 1980 on CP Content of _C. gayana_ cv Callide/_S. guianensis_ cv Cook Sward Established in 1979.

4.2.2.1. The Grass Component

Grass CP content rose significantly with increase in nitrogen fertilization and delay in time of application (Table 12). The data showed a variation in CP values from about 3.86% without N to 5.08% with 200 kg N/ha applied in September. The CP content of the uncut grass was significantly lower than that of its cut counterpart.

4.2.2.2. The Legume Component.

The addition of up to 200 kg N/ha raised the percentage CP of the legume although not to a significant extent (Table 13). Similarly, time of nitrogen application had a clear cut effect on this attribute. However, interrupting growth by cutting resulted in a considerable rise in CP per unit plant dry weight. The legume contained at least 8.07% (uncut, no N) and up to 10.79% CP (cut, + 200 kg N/ha).

Table 12: Effect of Rate and Time of Nitrogen Application and ..of Cutting in 1980 on Grass CP Content of C. *gayana* cv Callide/S. *guianensis* cv Cook Sward Established in 1979.

Time of N application	N Levels (kg/ha) 0	100	200	Mean
July	3.94	4.13	4.44	4.17b
August	3.94	4.25	4.50	4.23ab
September	3.86	4.67	5.08	4.54a
Mean	3.91c*	4.35b	4.67a	

Cutting	N Levels (kg/ha)			
Cut	4.28	4.63	4.97	4.63a
Uncut	3.54	4.08	4.38	4.00b
Mean	3.91c	4.35b	4.67a	

Cutting	Time of N application July	August	September	Mean
Cut	4.66	4.54	4.69	4.63a
Uncut	3.68	3.93	4.39	4.00b
Mean	4.17b	4.23ab	4.54a	

*Mean in the same row or column not followed by similar letter differs significantly at P ∠ 0.05 according to Duncan's New Multiple Range Test.

Table 13: Effect of Rate and Time of N Application and of Cutting in 1980 Legume CP Content of *C. gayana* cv Callide/*S. guianensis* cv Cook Sward Established in 1979.

Time of N Application	N levels (kg/ha) 0	100	200	Mean
July	8.90	9.76	9.72	9.46a
August	9.44	9.27	8.93	9.21a
September	8.52	9.55	9.79	9.29a
Mean	8.95a	9.52a	9.48a	

Cutting	N Levels (kg/ha) 0	100	200	Mean
Cut	9.84	10.07	10.79	10.23a
Uncut	8.07	8.98	8.18	8.41b
Mean	8.95a	9.52a	9.48a	

Cutting	Time of N application July	August	September	Mean
Cut	10.28	10.17	10.25	10.23
Uncut	8.64	8.26	8.33	8.41b
Mean	9.46a	9.21a	9.29a	

*Mean in the same row or column not followed by similar letters differ significantly at $P < 0.05$ according to Duncan's New Multiple Range Test.

CHAPTER 5

DISCUSSION

Experiment I

Dry Matter Yield

Over the two growing seasons DM yield for the grass and legume components were highest with the grass: legume seeding ratio 10:0 and 0:10, respectively, sown broadcast. However, whilst the grass component produced the least DM yield from seeding ratio 3:7 in mixture within the row, the lowest legume DM yield resulted from seeding ratio 7:3 established on alternate rows. The most productive plot was the grass/legume mixture established from the seeding ratio 3:7/broadcast sowing combination. This was followed closely by other mixtures sown by broadcasting, then mixtures with the species sown on alternate rows, mixtures seeded within the row, the pure grass swards and the least production was the pure legume sward.

The data seemed to suggest the need for a greater proportion by weight of legume than grass (for instance 30% grass + 70% legume) at seeding. This supported not only the highest protein-rich legume component but also the most productive legume based on total sward herbage yield per unit area. There is little information in the literature regarding the effect of grass/legume seeding ratios on sward performance. However, Griffiths Davies and Hutton (1970) and Humphreys (1980) suggested that the legume content at seeding should be increased to facilitate rapid legume establishment particularly on poor soils and in low rainfall situations.

The yield superiority of broadcast over the row sowing method, and of the grass/legume mixtures over sole grass or legume swards is in agreement with the finding in this (Akinola, 1981) and other environments (Horrell and Court, 1965; Lowe and Bowdler, 1977). The lower yield recorded for drilling could be attributed to inter or intra-species competition for light, water, space and soil nutrient in the alternate row and within-row sowing methods, respectively.

Total rainfall at the experimental site was considerably higher in 1979 than in 1980. However, the grass, legume and total yields were higher in 1980. The lower yield in 1979 could be due to failure of the sward to achieve complete ground cover in the year of establishment.

Crude Protein Content

As would be expected, the legume was richer in CP than the grass. The rise in the grass component CP content from the pure grass plot (least % CP) to the highest CP content for grass established in association with the greatest proportion of legume suggested that nitrogen from the legume might have been utilized by the companion grass. Akinola (1981) reported a similar finding on *B. decumbens* grown with each of eight different tropical pasture legumes. However, Haggar (1971) obtained a somewhat different result with *C. gayana*/*S. guianensis* cv Schofield mixture and explained the failure of the grass to use nitrogen from the legume in terms of arrest of grass growth by the overpowering legume.

Percentage CP in grass was higher in 1980 than 1979. The reverse was, however, true for legume, the lower 1980 values being ascribed to the more advanced age of the legumes.

The study suggested that C. gayana cv Callide and S. guianensis cv Cook could grow as compatible companions and produce high yields of forage containing satisfactory levels of CP.

Experiment II

Dry Matter Yield

Nitrogen increased total (grass + legume) and grass DM yields, though to a non-significant extent, but markedly decreased legume yield. It would seem that the grass grew rapidly in response to applied nitrogen and subsequently suppressed the companion legume. This is in agreement with the findings of Horrell and Court (1965), Jones et al (1969), Jones (1970) and Haggar (1971) that legume growth could be hindered by the increased competitiveness of the grass in the mixture due to nitrogen application.

When sward growth proceeded uninterrupted, application of nitrogen in July resulted in the highest grass and grass + legume DM yield followed by that of August while September application produced the least yield. The deduction was that nitrogen added to a relatively young sward in July was probably more effective in stimulating rapid DM accumulation than nitrogen applied at a later stage in August or

September. The imposition of cutting compounds the response of the sward to nitrogen. Nitrogen appeared to be best applied after cutting in August. Cutting in July, barely a month after the general harvesting in June, probably reduced sward regrowth potential and hence its ability to respond well to nitrogen fertilization. Furthermore, nitrogen might have been lost through erosion or leaching since cutting presumably removed the foliage needed to intercept the heavy July rainfall. Nitrogen applied following cutting in September was of limited value due to shortage of soil moisture. In general, cutting curtailed grass aggressiveness thereby enhancing legume growth and increasing sward legume content (Haggar, 1971).

Crude Protein Content

Although the grass and the legume contant rose with increasing level of applied nitrogen, the differences in CP content of legume in the range of 0-200 kg N/ha were not significant. The latter situation could be explained in terms of the observed considerable shading of legumes by grass and the resultant severe loss of lower leaves of the legumes. The percentage CP of the cut sward was significantly higher than that of the uncut sward, thus supporting earlier reports (Blair Rains, 1963; Minson and Milford, 1967; Akinola, 1981) that herbage CP content decreased with increasing intervals between cuttings.

The dearth of information on the effect of grass: legume seeding ratios on sward and pasture performance is indicative of the need to investigate this subject further. Particular attention should be focussed on the comparison between *S. guianensis* cvs Cook and Endeavour and *S. hamata* cv Verano (Caribbean stylo) in mixture with productive native grasses such as *A. gayanus* and adapted, introduced species like buffel grass (*Cenchrus ciliaris*) and green panic (*Panicum maximum* var *Trichoglume*). A range of phosphorus levels should be applied to grass/legume mixtures to ascertain optimum phosphorus requirements. The cost of nitrogen fertilizer is high and on this basis an appraisal of the economy of nitrogen fertilization on pure and mixed swards is considered to be worthwhile.

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