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EFFECT OF MATURITY ON DRY MATTER ACCUMULATION AND QUALITY OF FORAGE FROM NATURAL GRASSLAND AND THREE INTRODUCED GRASSES IN THE ACCRA PLAINS, GHANA

A Thesis

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ABSTRACT

EFFECT OF MATURITY ON DRY MATTER ACCUMULATION AND QUALITY OF FORAGE FROM NATURAL GRASSLAND AND THREE INTRODUCED GRASSES IN THE ACCRA PLAINS, GHANA

Francis Kwasivie Fianu,
University of Guelph, 1977

Supervisor:
Dr. J.E. Winch

Two studies were conducted in Legon, Ghana, in 1974 and 1975 to characterize the dry matter accumulation and quality of a natural grassland sward (dominated by Sporobolus and Heteropogon) and of introduced giant star grass (Cynodon plectostachyus (K. Schum) Pilger), buffel grass (Cenchrus ciliaris L. cv. biloela) and pangola grass (Digitaria decumbens Stent.).

The natural grassland study was a split plot experiment with pretreatment slashing, grazing and burning in the main plots and ten harvest dates during the major rainy season in the subplots. Each of the ten subplots was subdivided into three parts and harvested sequentially at the end of the rainy season, mid-dry season and at the end of the dry season.

Pretreatments did not affect the botanical composition, dry matter accumulation during the growing season or regrowth during the ensuing dry period. Sporobolus pyramidalis Beauv. grew faster than Heteropogon contortus (L.) Beauv. at the early stages, dominated the sward and flowered at 3-6 weeks. Heteropogon initially grew slowly and flowered from week 6. By week 7 Heteropogon became the dominant species of the sward. Cenchrus sp., Bothriochloa sp. and Setaria sp. flowered within 4-8 weeks but gamba grass (Andropogon gayanus Kunth.) did not

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flower during the study. Dry matter accumulation in the natural grassland sward and its dominant species continued after flowering until the end of the rainy season.

Leaf production, and the In Vitro digestibility as well as nitrogen content of Sporobolus and Heteropogon were not affected by pretreatment. While Sporobolus maintained a high percentage of leaf throughout the growing season, leaf proportions dropped in Heteropogon at the mature stages.

Leaves were more digestible and contained more nitrogen than stems in both species. Heteropogon tended to be more digestible than Sporobolus. The two species were similar in leaf and whole plant nitrogen, but Sporobolus stems contained more nitrogen than those of Heteropogon.

In the study on introduced grasses, giant star and buffel were harvested at ten dates during the minor rainy season of 1974 (September 16 - December 31); during the major rainy season of 1975, pangola grass was included in the experiment.

Pangola was sensitive to moisture stress during early growth and failed to grow during the minor rainy season of 1974. Buffel, on the other hand, was drought tolerant and grew even under light showers. Buffel flowered from week 3 in both seasons while giant star flowered only during the minor rainy season at week 6, and pangola flowered in week 6 during the major rainy season. Growth continued in all three grasses after flowering. In buffel, senescent leaves were retained on the plant whereas in the stoloniferous grasses, they were stripped off by rainfall.

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During the minor rainy season, giant star and buffel produced similar dry matter yields. In the major rainy season, however, buffel was superior in yield to the prostrate grasses which showed np consistent differences.

Leaf dry matter yield increased until week 8-9. Buffel and giant star produced more leaf dry matter than pangola grass. Leaf proportions in the plant declined steeply with maturity in buffel grass but slowly in the prostrate grasses. During the minor rainy season, whole plant In Vitro digestibility and nitrogen were similar in giant star and buffel during the minor rainy season, but buffel had the highest whole plant digestibility followed by pangola and giant star was the least digestible. The leaves were more digestible than stems, this difference being most striking in mature buffel grass.

Leaf nitrogen levels were higher than stem nitrogen levels in all the grasses but species differences in nitrogen content were not consistent. The nitrogen content of whole plants would probably be adequate for the maintenance requirements of a steer until week 7 during the minor rainy season and week 11 in the major rainy season. In Vitro digestibility was highly correlated with nitrogen content of leaves, stems and whole plants of all species except giant star stem.

It would appear that buffel grass should be harvested at 5 weeks and giant star at 7 weeks during the minor rainy season. In the major rainy season buffel would be harvested at 9 weeks and giant star and pangola at 8 weeks for optimum combination of nutrient yield during the rainy season and regrowth during the ensuing dry period.

The natural grassland species and the introduced grasses were similar in digestibility at the early stages but the erect grasses -

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natural and introduced - declined more rapidly than the prostrate introduced ones.

For high animal performance both the natural and the introduced species would have to be supplemented with concentrates.

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To the memory of the late

Reverend Samuel Yameke Brew

of the Methodist Mission, Nyakrom, Ghana

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GENERAL INTRODUCTION

Livestock raising in Ghana is primarily associated with the savanna areas which account for about two-thirds of the country's land area. About 70% of the sheep and goats and almost all the cattle in the country subsist on the natural grazing in these savannas. These grasslands have been designated the Guinea Savanna Zone and the Coastal Grasslands and Thickets (Taylor 1952). The Accra Plains are located in the Coastal Grassland and Thickets Belt.

The Accra Plains contain about 240,000 hectares of savanna grassland located about 10 km west of the city of Accra extending to the Volta Estuary in the East and from the Akwapim Hills in the North, to the Atlantic Ocean on the South. The area is an undulating plain less than 80 m above sea level except for a few isolated rocky hills up to 300 m above sea level (Brammer 1967). The soils which vary from clay to sand are deficient in nitrogen and phosphorus (Nye and Bertheux 1957, Brammer 1956, 1962, 1967).

Precipitation in the Accra Plains varies from 650 mm to 1000 mm per year with peaks in June, during the major rainy season, and September during the minor rainy season (Walker 1962). This low rainfall regime limits forage quality and yields, particularly during the dry season (Blair 1963).

For this reason losses of up to 11% of liveweight during the dry season is one of the major problems confronting the livestock industry of Ghana (Rose Innes 1961). Such losses are not uncommon in the tropics and in some areas the losses during the dry season are as high as wet season gains (French 1939) and result in the delay of over two

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years in the maturity of cattle. The contention that quantity and quality of forage impose a severe limitation on livestock growth is supported by findings from work underway at the University of Ghana's Kade Agricultural Research Station. In that study, yearling Nungua Blackhead Sheep, raised on cover crops under plantation tree crops, gained weight equivalent to that of three year olds of the same breed raised on savanna grassland (Oppong, private communication).

In attempts to find higher yielding and better quality fodder, many species of forage have been introduced into Ghana since the late 1920's (Gold Coast Department of Agriculture Annual Reports 1931-1943; Kannegieter 1961, 1965, Rose Innes 1966). Among the species thought to be adapted to Ghanaian conditions on the basis of their vigour are buffel grass (Cenchrus ciliaris L.), giant star grass (Cynodon plectostachyus Pilger) and pangola grass (Digitaria decumbens Stent.) (Evans 1961, Thompson 1961, Asare 1972).

Information is scarce on the dry matter accumulation of native and introduced forage grasses, as they grow during the rainy season in Ghana. Dry matter accumulation in natural grassland in the Accra Plains was reported by Lansbury, Rose Innes and Mabey (1965). Yields increased to 3000 kg/ha during the major rainy season and the herbage contained 1.6% N which fell to 0.42 - 0.54% by the beginning of the dry season. Similar deterioration in nitrogen content was reported by Sen and Mabey (1965). These studies did not involve digestibility or leaf production of the individual species, and there have been no such studies on the introduced species.

The objective of the work undertaken herein was to assess the dry matter accumulation, leaf dry matter production, nitrogen content

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and digestibility of the major components of a natural grassland during the major rainy seasons of 1974 and 1975, and of introduced pangola (Digitaria decumbens Stent.), giant star (Cynodon plectostachyus (K. Schum.) Pilger) and buffel grass (Cenchrus ciliaris L.) during the minor rainy season of 1974 and the major rainy season of 1975. In both natural grassland and introduced species, the amount of dry matter accumulated after the rainy season harvests was estimated at the end of the rainy season, the mid-dry season and the end of the dry season. The study was conducted at the University of Ghana, Legon, in the Accra Plains.

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GENERAL LITERATURE REVIEW

The vegetation of the Accra Plains consists of clumps of broken thickets (Loxton 1955) and has been described by Rose Innes (1962) as "peppercorn tree savanna". The woody species include *Grewia carpinifolia*, *Fagara xanthoxyloides*, *Gardenia ternifolia*, *Clausena anisata*, *Dichrostachys glomerata* and several others. The dominant grasses vary from *Andropogon gayanus* and *Hyparrhenia* spp. in less disturbed upland areas, to *Vetiveria fulvibarbis* in the rolling plains. Short perennials such as *Heteropogon contortus*, *Sporobolus pyramidalis*, *Cenchrus ciliaris*, *Bothriochloa bladhii* and *Brachiaria falcifera* as well as such annuals as *Eragrostis* spp. and *Aristida* spp. replace *Vetiveria* where there is excessive grazing, trampling, burning and other forms of disturbance to the vegetation. *Panicum maximum* occurs in pure stands on the more humid verge of this zone and stretches into the contiguous moist forest belt to the north (Brand and Brammer 1956, Brammer 1967, Rose Innes 1962).

Little is known about the effect of maturity on dry matter accumulation and quality of these species, during the rainy season or during the dry season. Lansbury *et al*. (1965) studied two grassland communities on the Accra Plains, one on clay soil dominated by *Vetiveria fulvibarbis* (Trin.) Stapf., *Andropogon canaliculatus* Schumach., and *Heteropogon contortus* (L.) Beauv. ex Roem et Schult; the other was on sandy soil and the major species were *Schizachyrium schweinfurthii* (Hack.) Stapf., *A. canaliculatus*, *V. fulvibarbis*, *Setaria sphacelata* (Schumach.) Stepf. et Hubbard, *Sporobolus pyramidalis* Beauv. and *H. contortus*. Harvesting the plots at stages of development varying

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from 2 to 32 weeks of growth during the major and minor rainy seasons (May to November), they found that total nitrogen was over 1.6% at the start of the growing season but fell to 0.42% in the sandy soil and 0.54% in clay soil. Dry matter yields in the sandy communities tended to be higher than in the clay soil. Sen and Mabey (1965) also reported similar deterioration in quality with maturity in the grasslands of the Accra Plains.

Little information is available concerning the growth and development of cultivated grasses introduced into Ghana to help solve the deficiencies in natural grassland species. However in Rhodesia, Brockington (1961) studied the growth of twelve cultivated species including buffel grass and giant star grass. He reported that buffel commenced growth before the rains, and continued growing during early flowering and seed setting until seed shedding. In contrast with the bunch type grasses such as buffel grass, giant star grass had a continuous cycle of initiation and replacement of aerial shoots. After flowering, vegetative growth continued in both giant star and buffel but no new shoots developed. Similar findings have been made by Virguez (1965) on pangola grass in Brazil, and by Taerum (1970a,b,c) on buffel in Kenya.

During early vegetative growth, the grasses are succulent, leafy, high in nitrogen content and low in fibre (French 1957, Sen and Mabey 1965, Arias and Butterworth 1965). As growth proceeds, the cells undergo secondary thickening and the cell walls increase at the expense of the nitrogen-rich protoplasm and other components of the neutral detergent solubles. The thickened walls contain more cellulose and because of increased lignin content, are less digestible (Klock,

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Schank and Moore 1975, Sullivan 1969, 1973).

Vicente-Chandler et al. (1959a,b) in Puerto Rico, attributed much of the lowering of nutrient value as herbage matures, to the fall in leafiness and corresponding increase in the less nutritious stems. They reported that elephant grass (Pennisetum purpureum) had 55, 42 and 30% leaf at 40, 60 and 90 days respectively while guinea grass (Panicum maximum Jacq.) had 53, 53 and 36%. Similar trends have been reported by Arias and Butterworth (1965) in Brazil for elephant grass and for buffel grass by Juko and Bredon (1961) in the Caribbean, Taerum (1970a,b,c) in East Africa and Burton (1976) in Georgia. On the other hand, Vicente-Chandler et al. (1959a,b) reported that pangola grass cut at 30, 45 and 60 days contained 38, 39 and 40% foliage respectively and varied little in leafiness during growth over the 30 to 60 day period. The differences between pangola and the former group can be attributed to differences in growth habit. Pangola is stoloniferous and develops new foliage continually if growth conditions are favourable. Initially, it has a high proportion of stem and this proportion does not change with age because leaves arise every few centimetres along stolons. On the other hand, the stool forming bunch grasses of the former group are initially leafy and develop stems with maturity. The decline in leafiness of these stool forming grasses is most rapid just before inflorescence emergence.

Nitrogen levels in tropical forages have received much attention: French (1939) in East Africa studied giant star grass, Paterson (1933, 1935, 1938) in The West Indies examined guinea grass and elephant grass, among others; while in Ghana, Lansbury et al. (1965) and Sen and Mabey (1965) investigated several natural grassland

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species including buffel and guinea grass. However few of these studies involved separate leaf and stem fractions. It is apparent from the data of Vicente-Chandler et al. (1959a,b), Norman (1963) and Arias and Butterworth (1965) that despite the growth differences among grasses, and even though nitrogen is higher in the leaf than in the stem, the rate of decline is the same in both. In pangola grass, guinea grass and elephant grass, the leaf nitrogen fell from 2.45% at 30 days to 1.5% at 90 days while the stem decreased from 1.68% to 0.8% at 30 and 90 days respectively (Vicente-Chandler et al. 1959a,b). Similarly Arias and Butterworth (1965) reported that elephant grass had leaf and stem nitrogen content averaging 3.37% and 2.76% respectively at 20 days but these dropped to 1.14% and 0.45% respectively by the 90th day; the decrements being 2.23 percentage points in the leaf and 2.31 in the stem.

Changes in cell wall components by detergent fibre analysis in tropical grasses have been reported by Johnson, Guerrero and Pezo (1973) in Peru, by Olubajo and Van Soest (1974) in Nigeria, Klock et al. (1975), Ventura et al. (1975) in Florida, and by Reid, Post and Olsen (1975) in Uganda. Although differences in the proportions of the various fibre components occurred among species, cellulose and lignin increased sharply with plant maturity whereas silica and hemicellulose were erratic. Kamstra, Stanley and Ishizaki (1966) reported that percent cellulose rose from 33% to 36% and hemicellulose from 30 to 37% in the tops of Kikuyu grass (*Pennisetum clandestinum*) during a 10 week growth period. Van Biljohn and LeRoux (1969) in South Africa, obtained an increase of 25 to 33% in foliage cellulose of *Themeda triandra* during maturation in the rainy season. Gomide et al. (1969) in Brazil reported

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two groupings of species in the rate of change of fibre. Melinis minutiflora Beauv. (molasses grass), elephant grass and guinea grass increased sharply from 25 to 40% in cellulose in 36 weeks. Whereas only slight increases occurred in the procumbent species pangola, Kikuyu, and Cynodon dactylon (Bermuda grass): 36 to 40%, 20 to 30% and 31 to 32% respectively. Percent lignin in the leaves underwent very little change with maturity whereas stem lignin soared from about 7.5% at 30 days to 12.5% at 90 days (Vicente-Chandler et al. 1959a,b).

Digestibility of forages declines as the herbage matures (Duckworth 1946, Minson and McLeod 1970, Danley and Vetter 1973, Mba, Oke and Oyenuga 1973, Engdahl and Ellis 1974, Olubajo and Van Soest 1974, and Chenost 1975). The main cause of this decline is thought to be the increase in ligno-cellulose as the plant matures (Crampton and Maynard 1938, Drapala, Raymond and Crampton 1947, Kamstra et al. 1958, Sullivan 1959, 1964, Butterworth 1967, Moore and Mott 1973, Cross, Smith and DeBarth 1974, and Johnson and Pezo 1975). However this contention has been challenged by Kayongo-Male and Thomas (1972), OLubajo et al. (1973) and Olubajo and Van Soest (1974), who have found low correlations between fibre components and digestibility, and Garza, Hertel and Jolliff (1976) who found inconsistent relations between cell wall and digestibility in Cynodon sp.

Silica has been implicated in the decline of digestibility with age in tropical herbage (Minson 1971, Van Soest, Arroyo-Aguilu and Tessema 1974, Johnson and Pezo 1975). However, recent work by Olubajo and Van Soest (1974), Johnson and Pezo (1975) and Ventura et al. (1975) suggest that silica cannot be the sole factor responsible for decreases in digestibility because silica levels are erratic with herbage maturity.

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Similarly, the reduction in leafiness cannot fully explain decreases in digestibility as the leaf is not always more digestible than the stem; Raymond (1969) found immature stems more digestible than leaves in Lolium perenne.

A further complication in attempting to explain the causes of the decline in digestibility with growth arises from the fluctuations during the maturation process. Johnson and Pezo (1975) working with Brachiaria reported that digestibility decreased from 82% at 2 to 4 weeks to 64% at 10 weeks but rose to 71% at 12 weeks, down to 64% again at 13½ weeks and up to 67% at 17½ weeks. In the same study, the digestibility of Hyparrhenia at 2 weeks was 79%; this fell to 75% at 8 weeks but rose to 79% at 12 weeks to fall again to 74-79% at 13½ to 17½ weeks (Reid et al. 1973).

Weather changes could complicate the effect of growth on the changes in quality. A severe dry spell during the growing season may temporarily arrest growth and cause premature senescence of lower leaves, thus reducing leafiness. There may also be a drop in cell solubles and an accelerated secondary thickening, both of which would tend to reduce digestibility (Haggar and Ahmed 1970, 1971). On resumption of the rains, growth would commence, leafiness would increase, soluble cell contents would rise, cell expansion would occur and digestibility could increase.

In contrast with the reduction of digestibility with age, Grieve and Osbourne (1965) working on pangola grass, reported that digestibility increased with maturity. They found a rise in digestibility from 58.8% at 3 weeks to 62.4% at 4 weeks and 64.5% at 5 weeks. Butterworth and Butterworth (1965) found the same trends from preflowering

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to flowering in pangola grass. This may be due to changes in the polymers of hemicellulose in the cell walls, since the different polymers of hemicellulose have different digestibilities (Bailey 1973). Another possible factor may be a change in the physical configuration of the cell wall constituents in the rapidly expanding stem cells, such that they became more susceptible to effective enzyme attack. Such wall "loosening" is known to occur (Brady 1973) but has not been linked with digestibility. During maturation, as the cells become thickened, they would decline in digestibility.

With the exception of silica, all the forage quality parameters being investigated herein are usually affected by growth. Hemicellulose may change little in quantity but undergoes changes in monoglyceride composition (Bailey 1973). Cellulose and lignin increase with maturity, but silica rises and falls erratically while leafiness declines as the plant matures. Digestibility generally declines as the plant matures but there are differences due to species and environmental changes, particularly moisture supply to the plant.

Both introduced and natural grassland species behave similarly as regards the effects of maturity and plant part on herbage quality but the introduced grasses, because of better nurture under cultivation and possibly because they have been selected for these characteristics, tend to outyield and are higher in nitrogen, leafiness and digestibility. Thus, these introduced species may be used to replace the natural grassland species which have poor dry matter yield and quality.

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GENERAL MATERIALS AND METHODS

To assess the productivity and quality of a natural grassland and the three introduced grasses - pangola, giant star and buffel - in Ghana, two experiments were undertaken. One, on a natural grassland site located at the University of Ghana, Legon and the other on the introduced grasses cultivated at the University of Ghana Research Farm, Legon. Each experiment was conducted in 1974 and 1975. The results are reported in four separate papers: 1. Dry matter accumulation in natural grassland in the Accra Plains; 2. The effect of maturity on the quality of *Sporobolus pyramidalis* and *Heteropogon contortus* in the Accra Plains; 3. Dry matter accumulation in pangola, giant star and buffel grasses in the Accra Plains; 4. The effect of maturity on the quality of pangola, giant star and buffel grasses in the Accra Plains.

Natural Grassland

For the natural grassland trial, a split plot design was used. Three pretreatments (slashing, grazing and burning) formed the main plots and the harvest dates constituted the subplots. There were four replications. The pretreatment slashing was conducted with machettes, the herbage being cut to a stubble height of about 5 cms. For grazing, 80 wethers from the University of Ghana Agricultural Research Station, Legon, grazed the appropriate plots for 12 hours. Burning was applied by an oxyacetylene torch. These pretreatments were imposed at the start of the main rainy season (April 1, 1974, April 9, 1975 (Table 0.1). At each of the ten weekly harvesting dates, the appropriate plots were

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Table 0.1. Schedule of activities in the study of natural grassland.

Item	Dates 1974	Herbage maturity in weeks	Dates 1975	Herbage maturity in weeks
Pretreatment	April 1		April 9	
Fertilization	April 11		April 12	
Harvest 1	April 29	4	May 21	6
2	May 6	5	May 28	7
3	May 13	6	June 4	8
4	May 20	7	June 11	9
5	May 27	8	June 18	10
6	June 3	9	June 25	11
7	June 17	11	July 3	12
8	July 1	13	July 16	14
9	July 15	15	July 28	16
10.	July 29	17	August 13	18
Regrowth to end of rainy season	July 29		August 13	
Regrowth to mid dry season	August 12		August 27	
Regrowth to late dry season	August 26		September 10	

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mowed by means of a Jari mower with a 92 cm sickle bar attachment. Harvesting commenced when the herbage was about 10 cm high. To estimate recovery yields for dry season use, the subplots were subdivided randomly into three sections and cut at three dates to span the ensuing dry period: the end of the major rainy season (July 29 and August 13 in 1974 and 1975 respectively), the middle of the dry period (August 12 and 27, 1974 and 1975, respectively) and end of the dry period (August 26 and September 10, 1974 and 1975, respectively).

Composite soil samples of each main plot were sent to the Department of Land Resource Science, University of Guelph, for analysis. Fertilizer was broadcast at 50 kg N, 40 kg P and 50 kg K per hectare after the pretreatments.

In the repeat experiment in 1975, the pretreatments and harvesting order were applied to the same plots to which they had been assigned in 1974.

Introduced Grasses

Two trials were established in March-June, 1974 (Table 0.2) one for harvesting during the minor rainy season 1974 (September 17 - December 31) and the ensuing dry period (December 31 - May 5), and the second for the major rainy season (April 29 - August 12) 1975 and the ensuing dry period (August 12 - September 9, 1975). Pangola and giant star grasses were planted from sprigs, while buffel grass (variety Biloela*) was seeded. Fertilizer was broadcast at planting, at the

* Buffel grass (variety Biloela) from Australia by courtesy of the Director of Veterinary Services, Accra.

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Table 0.2. The schedule of activities in the study of introduced grasses.

Item	1974	1975
Slashing	September 16	April 29
Soil sampling and fertilizing	September 17	April 30
3 week harvest	October 8	May 20
4 week harvest	October 15	May 27
5 week harvest	October 22	June 3
6 week harvest	October 29	June 10
7 week harvest	November 5	June 17
8 week harvest	November 12	June 24
9 week harvest	November 19	July 1
11 week harvest	December 3	July 15
13 week harvest	December 17	July 29
15 week harvest	December 31	August 12
Regrowth to start of dry season	December 31	August 12
Regrowth to middle of dry season	March 4	August 26
Regrowth to end of dry season	May 5	September 9

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rate of 50 kg N, 40 kg P and 80 kg K per hectare; when full ground cover had been achieved, a further 50 kg N/ha was applied.

The plots were subdivided into ten subplots randomly assigned to ten weekly harvest dates. To estimate regrowth yields from these harvests, three recovery cuts were taken as in the natural grassland trial. In the first trial these were cut on December 31, March 4 and May 5, while in the major rainy season trial, they were cut on August 12, August 26 and September 9, 1975.

Sampling

Two samples of herbage were taken along the length of each harvested plot, and weighed together with the remaining harvest for the fresh yield, in all experiments. The first sample was weighed fresh and dried at 80°C for 48 hours in a forced draught oven, for dry matter determination. The second sample was stored at -4°C and later fractionated into leaf and stem portions of each species. The separated samples were dried as before and all dried samples were ground in a Wiley mill using a 1 mm mesh screen.

Data gathered included rainfall from a rain gauge on site, phenotypic notes at harvesting, dry matter yield of each plot at each harvest, species composition of the natural grassland, the yield of leaf dry matter of each species, percent total nitrogen (N) content and percent In Vitro dry matter digestibility (IVD) of the two dominant species in the natural grassland (Sporobolus and Heteropogon) and of the introduced species over the ten initial cuts. IVD was determined using the Tilley-Terry method modified by Mowat et al. (1965). N was determined using a Technicon Autoanalyzer.

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PAPER 1: DRY MATTER ACCUMULATION IN NATURAL GRASSLAND IN THE ACCRA PLAINS

Abstract

In order to study the accumulation of dry matter of a natural grassland community in the Accra Plains and the effect of time of cutting on the availability and growth of sward during the ensuing dry period, a four replicate split plot trial with three pretreatments and ten harvest dates was conducted during the major rainy seasons of 1974 and 1975. The regrowth from each harvest date was harvested at three times, end of rainy season, mid-dry season and end of dry season.

Slashing, grazing and burning at the beginning of the rainy season, did not affect botanical composition or dry matter accumulation during development. Dry matter yield increased from 24 kg/ha at week 4 to 5003 kg/ha at week 18.

Regrowth following the rainy season harvests was also not affected by pretreatment. Recovery yields increased with increasing regrowth periods up to 10-12 weeks to the end of the rainy season, 13-14 weeks to mid-dry season and 12-16 weeks to the end of the dry season.

The major components of the sward were Sporobolus pyramidalis Beauv., and Heteropogon contortus (L.) Beauv., while small erratic proportions of other grasses included guinea grass (Panicum maximum Jacq.), buffel (Cenchrus ciliaris L.), gamba (Andropogon gayanus Kunth), Bothriochloa sp. Kuntze, Setaria sphacelata (Schumach) Stapf and Hubbard, Vetiveria fulvibarbis (Trin.) Stapf. Sporobolus started growth and flowered at 3-6 weeks and dominated the community until week

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7 when Heteropogon became dominant. Heteropogon grew slowly and flowered from week 6. Buffel, Bothriochloa sp. and Setaria sp. flowered within 4-8 weeks but gamba grass did not flower during the study. Dry matter accumulation continued after flowering until the end of the rainy season.

Introduction and Literature Review

The Accra Plains of Ghana is composed of approximately 242,000 hectares of rolling savanna grassland and is located in the south-eastern region of Ghana. This natural grassland area provides the only source of feed for about 60,000 cattle.

Although many trees and forbs, including several legumes, are present throughout this area, grasses are the main source of feed (Fianu 1966, B.Sc. Dissertation, University of Ghana, Legon). The dominant grasses include Vetiveria fulvibarbis (Trin.) Stapf., Andropogon spp. L., Schizachyrium spp. Nees., Hyparrhenia spp. Anderss ex Fourn., Sporobolus spp., R. Br., Cenchrus spp. L., and Heteropogon contortus (L.) Beauv. (Loxton 1955, Rose Innes 1962, Brammer 1967).

The inadequate distribution of production from these species throughout the year is one of the major problems confronting the livestock industry in Ghana and indeed in most tropical areas. A cyclic pattern of live weight gain during the wet season followed by a loss during the dry season results in prolonged animal maturity (Lansbury 1960, Rose Innes 1961).

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Two peaks of herbage production occur: in May-June during the major rainy season and in September and October, during the minor rainy season. Lansbury, Rose Innes and Mabey (1965) found the growth of the natural grassland from the beginning of the major rainy season (May) through to the end of the minor rainy season (November) to be from 2400 to 3000 kg/ha.

There is little information on dry matter accumulation in the species that compose the sward, and the effect of harvest management during the rainy season on sward regrowth for use during the dry period. However Lansbury (1960) and Blair (1963) noted that production during the dry season is grossly deficient in supply and quality. As a result, herds are most frequently driven to distant areas in search of ungrazed herbage. Such unused herbage is coarse, dry and of poor quality (Blair 1963, Rose Innes 1963). Frequently, burning of the ungrazed and also the grazed areas is practised during the dry season to stimulate new growth (Hopkins 1963, Rose Innes 1971).

Although the use of stored feed during the dry season has been suggested as a means of overcoming the problem of feed supply and quality (Lansbury 1960) the use of aftermath pasture should be considered, as suggested by Whyte, Moir and Cooper (1959). The provision of aftermath pasture is a function of cutting or grazing practises that are employed during the rainy season and the species of grasses in the sward.

The present study was undertaken to study the accumulation of dry matter of a natural grassland community in the Accra Plains and the effect of time of cutting on the availability and growth of the sward during the ensuing dry period.

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Materials and Methods

The site chosen for the experiment was a relatively uniform area of natural grassland on the campus of the University of Ghana. The soil was coarse in texture and the pH varied from 5.5 to 6.1 with a low phosphorus content (4-6 ppm) and a high potassium level (125-236 ppm). Fertilizer at the rates of 50 kg N/ha, 40 kg P/ha and 50 kg K/ha was applied after pretreatments had been imposed.

The experiment was conducted throughout the major rainy seasons (April - August) of 1974 and 1975 and the ensuing dry seasons (August - September). It consisted of: three pretreatments (slashing, grazing and burning) applied at the beginning of each rainy season (April 1, 1974; April 9, 1975) to ascertain their effects on subsequent species composition and production; ten cutting dates during the major rainy season (4-17 weeks in 1974, 6-18 weeks in 1975) to determine the accumulation of dry matter and changes in species composition; and three recovery harvests, one at the end of the major rainy season (July 29, 1974; August 13, 1975), the second at the middle (August 12, 1974; August 26, 1975) and the third at the end of the ensuing dry season (August 26, 1974; September 10, 1975) to assess the effect of time of cutting during the rainy season on the herbage regrowth in the subsequent dry season.

A four replicate, split-split plot design was employed where pretreatments formed the main plots (20 m x 8 m) separated by paths 2 m wide. The ten cutting dates were randomly assigned to 2 m x 8 m subplots. Each subplot was further divided into three sections 2.67 m x 8 m each, corresponding to the three recovery harvests.

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For the pretreatments of slashing and burning, machettes and an acetylene torch were used respectively. West African Forest wethers which had been fasted for 24 hours were used for the grazing pretreatment. Twenty wethers were permitted to graze the respective main plot for a period of 12 hours.

At each harvest date, the paths were cleared and the appropriate plots were harvested with a Jari mower. Using a 92 cm sickle bar attachment to the mower, a swath was cut throughout the length of each plot. Prior to raking and weighing the cut material, two samples of herbage were taken along the length of the cut area. These samples were weighed with the remaining harvest. One sample was stored in a freezer at - 4°C and later separated into the various grass species components. The second sample was dried at 50°C for 48 hours in a forced draft oven and used for dry matter determinations.

All data are presented in kilograms per hectare of dry matter. The total yield of the natural grassland, the contribution of species and regrowth yields were analyzed across harvest dates as well as within harvest dates. Differences among means were tested with Duncan's Multiple Range Test (Steele and Torrie 1960).

Results and Discussion

In 1974, 730 mm of rain fell during the major rainy season (April 15 to July 29) whereas in 1975, 400 mm fell from May 21 to August 13 (Appendix LIX and LX). In the dry season of 1974 (July 29 to August 26) a total of 12 mm rain fell, all of which occurred in the week of

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August 5 to 12. In 1975, the total rainfall during the dry period, August 13 to September 10, was 6 mm. In both years, rainfall increased to a peak in June and declined sharply in July.

The data obtained from this study (Table 1.1, Appendices IV and V) tend not to support the contention that burning of natural grassland increases yield (Doyne 1937, Semple 1970). Only during the 11th and 14th weeks of 1975 was the result of burning superior to slashing or grazing. Burning, likewise, did not affect the species composition (Appendices I, II, III, IV and V). Birch (1960) and Daubenmire (1968) attribute the superiority of burning to enhanced nitrification by briefly exposing the soil to drying. All pretreatments in this study possibly received this exposure which may explain the lack of differences.

In both years, growth commenced following the onset of rains at the beginning of the major rainy seasons (Fig. 1.1, Appendices IV and V). Initially growth was relatively slow in both years but a marked increase occurred from week 4 (24 kg/ha in 1974 and 268 kg/ha in 1975) through to week 13 in 1974 (3839 kg/ha) and week 14 in 1975 (3870 kg/ha). These progressive increases contrast with reports of Lansbury et al. (1965) in the Accra Plains, Norman (1963) in North Australia and Cassady (1973) and Taerum (1970a,b,c) in East Africa. They reported that herbage growth was erratic as dry matter accumulation was interspersed with dry matter losses as the rainy season progressed. They attributed this to soil moisture depletion during intervening brief dry spells (Cassady 1973, Taerum 1970a,b,c), to senescent leaves being pounded off by heavy rainfall (Cassady 1973) and to plot variability (Lansbury et al. 1965).

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Table 1.1. Analyses of variance of yield of dry matter from natural grassland during the major rainy seasons of 1974 and 1975.

Source	1974 Degrees of freedom	1974 Sums of squares x 10^4	1975 Degrees of freedom	1975 Sums of squares x 10^4
Reps	3	301.4	3	239.6
Pretreatment	2	287.7	2	284.0
Error (A)	6	113.2	6	416.6
Dates	7	18,349.0**	9	28,302.0**
Pretreat. x dates	14	287.6	18	933.1
Error (B)	63	1,174.0	81	3,723.0

** Significant ($P < 0.01$).

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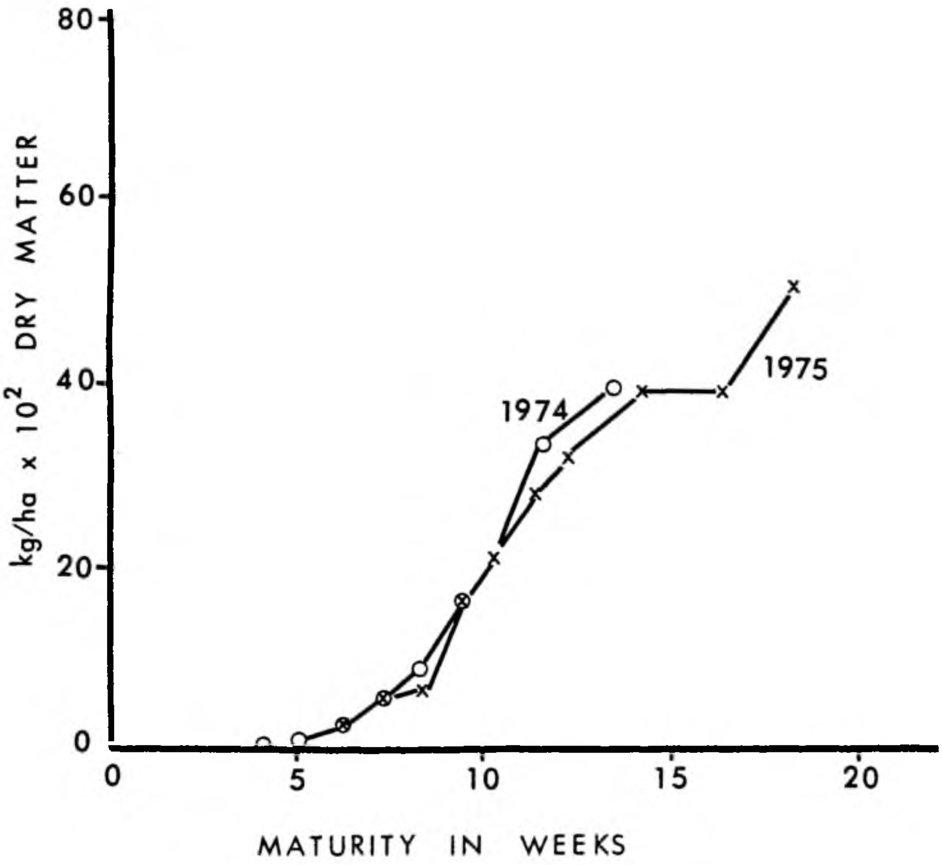

Fig. 1.1. Dry matter accumulation during the major rainy seasons of 1974 and 1975 in natural grassland in the Accra Plains.

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The natural grassland in this study consisted largely of Sporobolus pyramidalis and Heteropogon contortus (Figs. 1.2 and 1.3, Appendices IV and V). There were several minor components that were classified as 'others'. The contribution from each of: Panicum maximum Jacq. (guinea grass), Andropogon gayanus Kunth., (gamba grass), Vetiveria fulvibarbis (Trin.) Stapf., Bothriochloa spp. Kuntze., Setaria sphacelata (Schumach) Stapf. et Hubbard., Pennisetum pedicelatum Trin., Galactia tenuifolia (Willd) Wight et Arn and Uraria picta Jacq. was variable throughout the major rainy seasons of both years.

Sporobolus dominated the community at the early growth stages (up to seven weeks), in both 1974 and 1975 (Figs. 1.2 and 1.3, Appendices I, II, IV and V). This species matured early and had flowered and set seed within 3 to 6 weeks. However by the 7th and 8th weeks Heteropogon had become dominant. It started blooming from the 6th week. Both species continued to accumulate dry matter after flowering as Brockington (1961) observed in various tropical grasses in Rhodesia. The yield of Sporobolus increased from 13 kg/ha at 4 weeks to 1212 kg/ha at 13 weeks in 1974 and 1975 from 158 kg/ha at 6 weeks to 1009 kg/ha at 18 weeks. In contrast, Heteropogon contributed 5.6 kg/ha at week 4 and increased to 2156 kg/ha at week 13 in 1974 and 46 kg/ha at week 6 to 2558 kg/ha at week 18 in 1975. Among the other species, Cenchrus, Bothriochloa and Setaria flowered within 4 to 8 weeks but Andropogon did not flower during the observation period and Vetiveria was not found in mature samples. The main forbs found were the legumes Uraria, Galactia and Rhynchosia which did not occur in mature samples. Loxton (1955) also found these species in a survey of the natural grassland near the Agricultural Research Station, Nungua.

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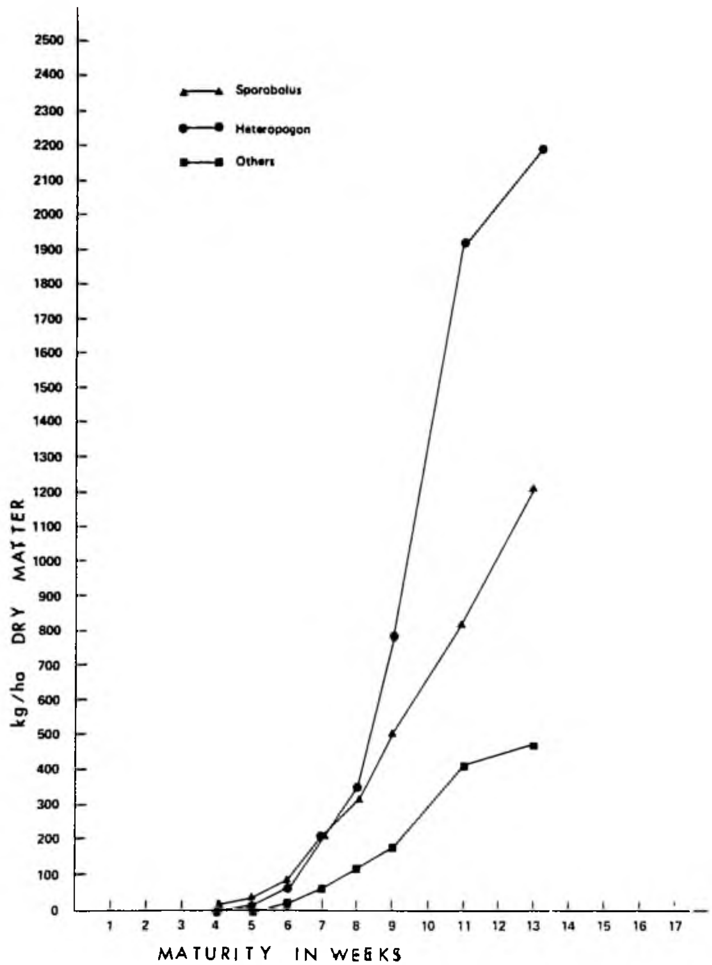

Fig. 1.2. Accumulation of dry matter of species components in natural grassland during the major rainy season of 1974 in the Accra Plains.

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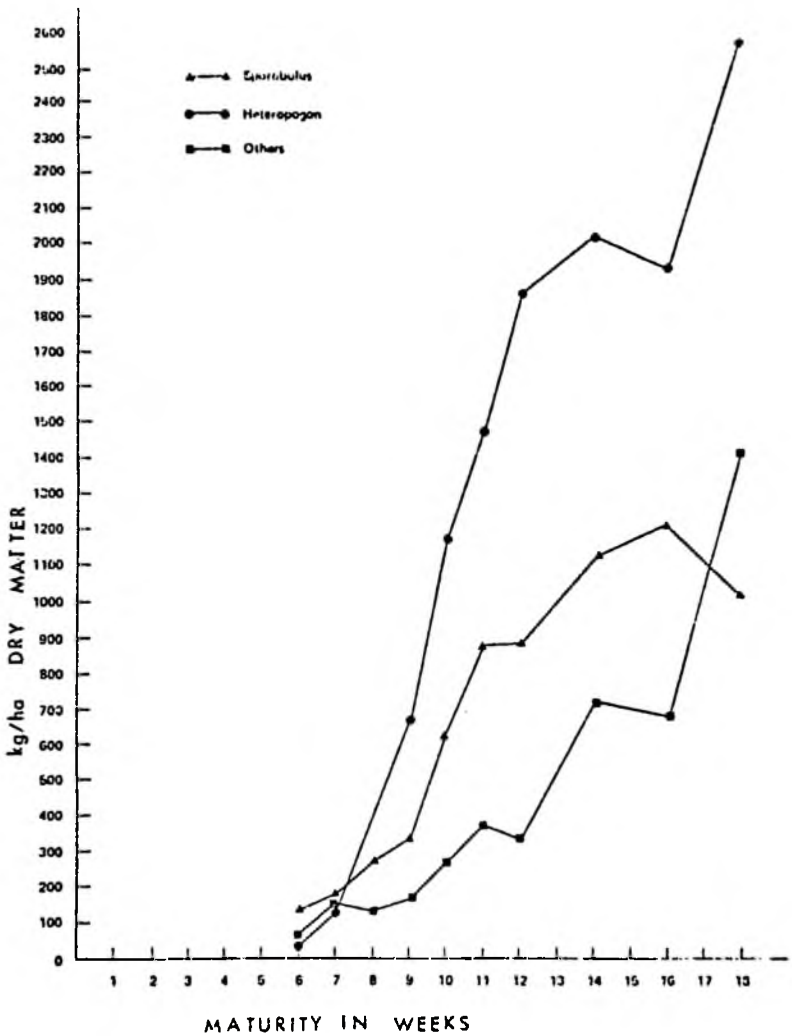

Fig. 1.3. Accumulation of dry matter of species components in natural grassland during the major rainy season of 1975 in the Accra Plains.

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The regrowth yields following the major rainy season harvests are shown in Tables 1.2 and 1.3 and Appendices VI, VII, VIII, IX and X. The greatest amount of regrowth of herbage at the end of the 1974 rainy season (July 29) was obtained from rainy season harvests of April 29 (5367 kg/ha) and May 6 (3927 kg/ha) after 12 and 13 weeks of recovery respectively (Table 1.2). The highest mid-dry season regrowths in 1974 also came from harvests of April 29 and May 6 and amounted to 5796 and 5163 kg/ha respectively, the recovery period being 14-15 weeks. Recovery to the end of the dry season, on the other hand, was greatest for harvests of April 29 to June 3 (with the exception of May 13) and the dry matter regrowth ranged from 4047 kg/ha to 5221 kg/ha (except May 13) for the regrowth periods of 12-17 weeks. In contrast with these trends, the 1975 recovery yields to the end of the rainy season (August 13) was greatest for harvests of May 21 to June 4: 3098 to 3489 kg/ha for recovery periods of 10-12 weeks (Table 1.3). Mid-dry season recovery yields from May 21 and 28 were the greatest: 5083 kg/ha and 4747 kg/ha for 14 and 13 weeks recovery respectively while end of dry season recovery from May 21 was the greatest recovery yield: 6107 kg/ha for 16 weeks recovery. Over the two years, it would appear that for the highest dry matter accumulation up to the beginning of the dry season, a minimum of 10-12 weeks should be allowed, while for regrowth up to the middle of the dry season at least 13 to 14 weeks recovery period is required and maximum recovery to the end of the dry season requires 12 to 16 weeks.

Growth occurred in both years during the dry period, this being more pronounced in 1975 (Tables 1.2 and 1.3). In the first half of the dry period of 1974 (July 29 - August 12) growth was erratic but

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Table 1.2. Regrowth yield from natural grassland during the dry period (July - August) 1974.

(Kg/ha dry matter)

Harvest date in rainy season	End of rainy season (July 29)		Mid dry season (Aug. 12)		End of dry season (Aug. 26)	
	Recovery+	Yield	Recovery+	Yield	Recovery+	Yield
April 29	13	$5367^{a\,o}_{xy}$	15	$5796^{a\,o}_{x}$	17	$4499^{a\,o}_{y}$
May 6	12	3927^{a}_{y}	14	5163^{a}_{x}	16	5221^{a}_{x}
May 13	11	2362^{b}_{x}	13	2153^{d}_{x}	15	1399^{c}_{y}
May 20	10	2951^{b}_{x}	12	3357^{bc}_{x}	14	4350^{a}_{x}
May 27	9	2093^{b}_{y}	11	4322^{c}_{x}	13	4145^{a}_{x}
June 3	8	2123^{b}_{y}	10	2894^{d}_{y}	12	4047^{a}_{x}
June 17	6	923^{c}_{y}	8	1724^{d}_{y}	10	3875^{b}_{x}
July 1	4	548^{c}_{y}	6	1723^{d}_{xy}	8	2955^{b}_{x}
July 15		--	4	655d	6	1678c
July 29		--		--	4	1623c

+ Weeks from date of harvest during the major rainy season.
o Data followed by the same letter are not different ($P > 0.05$): columns - a,b,c,d; rows - x,y.

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Table 1.3. Regrowth yield from natural grassland during the dry period (August - September) 1975.

(Kg/ha dry matter)

Harvest date in rainy season	End of rainy season (Aug. 13)		Mid dry season (Aug. 27)		End of dry season (Sept. 10)	
	Recovery+	Yield	Recovery+	Yield	Recovery+	Yield
May 21	12	3489^{a}_{z} [o]	14	5083^{a}_{y} [o]	16	6107^{a}_{x} [o]
May 28	11	3456^{a}_{y}	13	4747^{a}_{x}	15	5071^{b}_{x}
June 4	10	3098^{a}_{z}	12	3947^{b}_{y}	14	5090^{b}_{x}
June 11	9	2226^{b}_{y}	11	3016^{c}_{y}	13	5110^{b}_{x}
June 18	8	1266^{c}_{y}	10	2501^{c}_{x}	12	2819^{c}_{x}
June 25	7	895^{c}_{z}	9	1837^{d}_{y}	11	2384^{c}_{x}
July 3	6	575^{d}_{y}	8	978^{e}_{y}	10	2233^{cd}_{x}
July 16	4	321^{d}_{z}	6	811^{e}_{y}	8	2042^{cd}_{x}
July 28		128^{d}_{z}	4	690^{e}_{y}	6	1342^{de}_{x}
August 13		—		—	4	690e

+ Weeks from date of harvest during the major rainy season.
o Data followed by the same letter are not different ($P > 0.05$): columns - a,b,c,d,e; rows - x,y,z.

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in the second half (August 12 - 26), there was growth in herbage harvested after June 3 (Table 1.2). Thus herbage that was 9 weeks or less in maturity, continued to grow during the second half of the dry season. In 1975, growth occurred throughout the dry period (Table 1.3) although there was less rainfall during the 1975 dry period (6 mm) than in the 1974 dry period (12 mm). This difference may be related to the lower rainfall during the major rainy season of 1975 (400 mm) than in 1974 (730 mm). In 1975 the herbages may have been conditioned to grow with low rainfall whereas in 1974 they may have been conditioned to grow with high moisture supply.

Dry matter losses occurred in some instances during the dry season. In 1974, following the harvest of April 29, a loss of 1297 kg/ha occurred between the middle and the end of the dry season. Also after the May 13 harvest, 754 kg/ha of dry matter was lost. These losses may be related to the induction of senescence by dry spells during the rainy season and the stimulation of growth during the dry season by light rainfall. The rapid decline of precipitation following the higher rainfall regime during the major rainy season 1974 may have induced senescence in the mature herbage during July - August. As rainfall in 1975 was lower during the major rainy season than it was in 1974, the plants may have been conditioned to moisture stess in 1975. Thus, the light showers of the dry season of 1975 may have been better utilized by the herbage for growth than in 1974. These fluctuations in dry matter yield in response to drought spells alternating with rainfall are in agreement with reports of Cassady (1973) and Taerum (1970a,b) in East Africa and Lansbury _et al_. (1965) in the Accra Plains.

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Table 14. Seasonal total yield from natural grassland during 1974 (upper) and 1975 (lower).

(Kg/ha dry matter)

1974

	Maturity							
	4+ Apr. 29‡	5 May 6	6 May 13	7 May 20	8 May 27	9 June 3	11 June 17	13 July 1
Main season + end of rainy season	5391a°	3979bc	2528e	3438cd	2886de	3598bcd	4084bc	4387b
Main season + mid dry season	5820a	5215ab	2329d	3844c	5115ab	4396bc	4885ab	5562a
Main season + end dry season	4523b	5273b	1575c	4837b	4938b	5522b	7036a	6794a

1975

	Maturity									
	6+ May 21‡	7 May 28	8 June 4	9 June 11	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Main season + end of rainy season	3757bc°	3954bc	3800bc	3695bc	3352c	3633bc	3603bc	4191b	3974bc	5003a
Main season + mid dry season	5351a	5245ab	4649abc	4485bc	4587abc	4575abc	4006c	4681abc	4536abc	5003ab
Main season + late dry season	6375ab	5569bcd	5792abcd	6579a	4905d	5122cd	5261cd	5819abc	5188cd	5688bcd

\+ Weeks from pretreatment: April 1, 1974, April 9, 1975.
‡ Harvest date during the major rainy season.
o Data followed by the same letter are not different ($P > 0.05$): rows – a,b,c,d.

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Summary

Slashing, grazing and burning pretreatments did not affect yield of species composition of the sward during the major rainy season, nor did they affect herbage recovery after harvesting in the major rainy season.

Growth was slow initially until week 9, at which stage 1400 kg/ha of dry matter had been accumulated. This period of grand growth continued until week 13 in 1974 when dry matter accumulation amounted to 3838 kg/ha. In 1975, the grand growth period continued until week 18 and 5003 kg/ha of dry matter accumulated.

Sporobolus dominated the community at the early stages in both years; from week 7 *Heteropogon* became dominant. *Sporobolus* flowered in week 6. Dry matter accumulation continued after flowering. Several minor species occurred in erratic minute quantities in the sward. Among these were *Cenchrus ciliaris*, *Bothriochloa bladhii*, and *Setaria sphacelata*, which flowered in 4-8 weeks; and *Andropogon gayanus*, which did not flower during the observation period.

Regrowths following the rainy season harvests amounted to about 3000 - 5300 kg/ha at the end of the rainy season, 4700 - 5800 kg/ha by the middle of the dry period and 4000 - 6000 kg/ha at the end of the dry period. During the dry period (August) 1974 herbage growth ceased after 8-9 weeks of regrowth whereas in 1975 growth continued during the dry period.

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PAPER 2: EFFECT OF MATURITY ON QUALITY OF SPOROBOLUS PYRAMIDALIS AND HETEROPOGON CONTORTUS IN THE ACCRA PLAINS

Abstract

The effects of slashing, grazing and burning pretreatments and ten sampling dates on leaf production, In Vitro dry matter digestibility (IVD) and nitrogen (N) of leaves, stems and whole plants of Sporobolus pyramidalis Beauv. and Heteropogon contortus (L.) Beauv. during the major rainy seasons of April 1 - July 29, 1974 and April 9 - August 13, 1975 were studied in Legon, Ghana.

The pretreatments did not affect leaf production, IVD or N. Leaf production increased with maturity, reaching a plateau between 11 and 13 weeks in 1974; in 1975, Sporobolus increased in leaf production until 16 weeks, while Heteropogon reached a plateau at week 10. During the early stages of growth Sporobolus produced more leaf dry matter than Heteropogon but between the 8th and 9th weeks of maturity, this was reversed. Sporobolus tended to have a higher proportion of leaves than Heteropogon, particularly at the mature stages. Heteropogon was higher in whole plant IVD (57.0 - 62.0% in weeks 7-9, falling to 27.0 - 38.0% in weeks 17-18) than Sporobolus (51.6 - 59.0% declining to 29.8 - 34.3%). Leaves were more digestible than stems in both species.

Nitrogen declined with maturity in leaves, stems and whole plants. Leaves contained more N (1.80 - 2.00% at 7-9 weeks to 0.88 - 1.00% at 17-18 weeks) than stems (0.82 - 1.74% at 7-9 weeks to 0.34 - 0.48% at 17-18 weeks). Species differences in whole plant and leaf N content were not consistent but Sporobolus stems were higher in N than

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Heteropogon stems. The correlation between IVD and N was 0.61. This was significant.

Introduction and Literature Review

The rapid deterioration in quality of tropical natural grassland species as the herbage matures has been reported by Paterson (1933) and Anon. (1941) in the West Indies, French (1957) in East Africa, and Rose Innes (1961) and Blair (1963) in Ghana, and Miller (1960) in Nigeria. Such decreases in quality pose one of the problems confronting the livestock industry in Ghana (Lansbury, Rose Innes and Mabey 1965).

In Ghana, Sen and Mabey (1965) reported that the nitrogen (N) content of Sporobolus pyramidalis Beauv. decreased from 2.29% at 4 weeks to 0.69% at 36 weeks maturity. The decrease in N content however may not be constant, for with Heteropogon contortus (L.) Beauv., they reported that N decreased from 1.15% at 4 weeks to 1.01% at 8 weeks and increased to 2.50% at 36 weeks. They attributed this to high rainfall.

In temperate forages, the importance of leafiness of species to quality of forages has been documented (Mowat et al. 1965) because the leaves contribute a large fraction of digestible nutrients. Few reports of the importance of the role of leafiness on tropical natural grassland species are available. Norman (1963) in Northern Australia, reported a decline in leafiness from 58% and 74% at 6 months for Themeda triandra Forsk., and Chrysopogon sp. Trin., respectively, to 38% and 42% at 8 months. The importance of leaf proportion to quality

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was not outlined. Likewise information on the digestibility of leaves and its importance to total quality of tropical species is limited.

Falvey (1977) in Northern Australia, compared *in vitro* dry matter digestibility (IVD) of natural grassland species with that of introduced ones and found that the native species were lower in digestibility than the introduced species. Also, Gohl (1975) reporting work on *Sporobolus pyramidalis* in Rhodesia, gave the dry matter digestibility as 63.4%, but the stage of maturity was unspecified. No research has been conducted on the changes with maturity in the digestibility of the dominant grasses in the natural grasslands of Ghana, nor has the importance of leaf to quality been investigated in Ghana.

This study examined the changes in quality of *Sporobolus pyramidalis* Beauv., and *Heteropogon contortus* (L.) Beauv., two dominant species in a natural grassland community in the Accra Plains, during growth and development, in the major rainy seasons of 1974 and 1975. The parameters investigated included leaf production, IVD, and N content.

Materials and Methods

The study was conducted at the University of Ghana in the major rainy seasons of 1974 and 1975. A four replicate, split plot design was used with three pretreatments: slashing, grazing and burning forming the main plots and ten weekly harvesting dates the subplots. Pretreatments were applied on April 1, 1974 and April 9, 1975. Cutting began on the 4th week following application of pretreatments and continued through to the 17th week in 1974 and in 1975 began on the 6th week and

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terminated on the 18th week.

At each of these cutting dates, the appropriate subplots were cut to about 5 cms stubble height, using a Jari mower with a 92 cm sickle bar attachment. Samples of the cut material were taken at random along the length of the subplots. Each sample was separated into three groups - Sporobolus, Heteropogon and other species. Sporobolus and Heteropogon were further separated into leaf and stem fractions. These fractions were dried in a forced draught oven at 80°C for 48 hours, weighed to determine leaf-stem proportions and ground using a Wiley mill with a 1 mm screen. The leaves included sheaths while the inflorescence and seeds were included in the stem portions.

In Vitro dry matter digestibility (IVD) and total nitrogen (N) were determined on the leaves and stems of Sporobolus and Heteropogon at the Crop Science Department, University of Guelph. A modified Tilley and Terry method (Pritchard, Folkins and Pigden 1963, Mowat et al. 1965) and a Technicon autoanalyzer were used for the IVD and N respectively. Owing to small sample sizes, N determinations were not conducted on the first three cutting dates. The data were analyzed as a split plot design (Steele and Torrie 1960). The analyses of variance were conducted on the dates, plant part or species separately to bring out differences across dates, between species and between leaf and stem fractions. Regressions of % IVD and % N on maturity dates were calculated and the lowest order equations of best fit at the 5% level adopted.

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Results and Discussion

The dry matter yield of the leaves of *Sporobolus* and Heteropogon at each harvest date did not appear to be affected by the pretreatments of slashing, grazing and burning (Appendices XIII and XIV). In 1974, the yield of leaf progressively increased reaching 878 kg/ha and 1315 - 1360 kg/ha for *Sporobolus* and *Heteropogon* respectively, between 11 and 13 weeks (Table 2.1). In 1975, however, the highest leaf yield was attained for *Sporobolus* and *Heteropogon* in the 11th and 9th weeks, respectively, reaching a plateau of yield that extended to the 18th week (Table 2.2). *Sporobolus* appeared to have a higher leaf percentage in its dry matter yield than *Heteropogon*, especially at the mature stages. In 1974, leaf dry weight, as a percentage of dry matter yield fell from 85 at week 4 to 72 at week 13 in *Sporobolus* and from 83 to 63 in *Heteropogon*. In 1975, leafiness declined from 92% at 6 weeks to 74% at week 18 in Sporobolus while in *Heteropogon* it decreased from 100% to 47%.

IVD was not affected by pretreatment in a consistent manner (Appendices XV, XVI, XVII, XVIII, XIX, XX, XXI, XXII, XXIII and XXIV). In 1974, burning resulted in higher IVD values than slashing and grazing in *Sporobolus* whole plants in weeks 8, 9 and 11 whereas in *Heteropogon*, grazing gave superior IVD's in weeks 8 and 15. There were no pretreatment effects in the other weeks. In 1975, there were no significant IVD differences among the three pretreatments. Therefore the IVD averages of each species for all pretreatments were used to determine the effect of maturity on IVD of leaves, stems or whole plants separately.

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Table 2.1. Yield of leaves of Sporobolus and Heteropogon during the major rainy season of 1974.

(Kg/ha dry matter)

Maturity[+]	Sporobolus	Heteropogon
4	11 d[o]	5 c
5	27 d	8 c
6	75 d	61 c
7	172 cd	203 c
8	247 cd	337 bc
9	394 bc	677 b
11	554 b	1315 a
13	878 a	1360 a

+ Weeks from pretreatment: April 1, 1974
o Data followed by the same letter are not different ($P > 0.05$): columns - a,b,c,d.

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Table 2.2. Yield of leaves of Sporobolus and Heteropogon during the major rainy season of 1975.

(Kg/ha dry matter)

Maturity+	Sporobolus	Heteropogon
6	137 e. o	46 c
7	188 e	130 c
8	260 de	290 bc
9	302 cde	650 ab
10	484 cde	978 a
11	704 abcd	1095 a
12	725 abc	1187 a
14	917 ab	1195 a
16	1006 a	1036 a
18	821 abc	1221 a

\+ Weeks from pretreatment: April 9, 1975

o Data followed by the same letter are not different ($P > 0.05$): columns - a,b,c,d,e.

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The leaves of both Sporobolus and Heteropogon were generally more digestible than their stems (Figs. 2.1 and 2.2). This agrees with reports by Tilley and Terry (1963) and Mowat et al. (1965) on mature temperate grasses and by Laredo and Minson (1973) on Panicum coloratum and P. maximum, in Australia. The contention that stem digestibility is higher than leaf digestibility at very early growth stages as reported by Mowat et al. (1965) in orchard and brome grasses could not be fully confirmed in this study because of inadequate stem tissue at the early stages. However the higher values for stem IVD than leaf IVD in Heteropogon at weeks 7, 9 and 11 in 1974 and at weeks 10 and 11 in 1975 (Figs. 2.1 and 2.2, Appendices XXII and XXIII) tend to confirm this contention at least for some species.

The digestibility of the leaves of the two species did not differ consistently until weeks 7 and 9 in 1974 and 1975 respectively. From then on, the Heteropogon leaves tended to be more digestible than those of Sporobolus. The stems of Heteropogon, however, tended to be more digestible than those of Sporobolus at all harvest dates in both years. Heteropogon whole plant IVD tended to be higher than whole Sporobolus throughout the growing season (Table 2.3, Appendix XXIV), this apparently being a reflection of the higher proportion of stem tissue in Heteropogon than in Sporobolus and the higher IVD of Heteropogon stems.

With advancement in maturity, IVD of leaf and stem and whole plants declined (Figs. 2.1 and 2.2, Table 2.3). This observation agrees with those of Reid et al. (1975), Johnson and Pezo (1975), Danley and Vetter (1973) and Moore and Mott (1973). However, there was an increase in leaf IVD at the early stages of growth in 1974 (Fig. 2.1) before the

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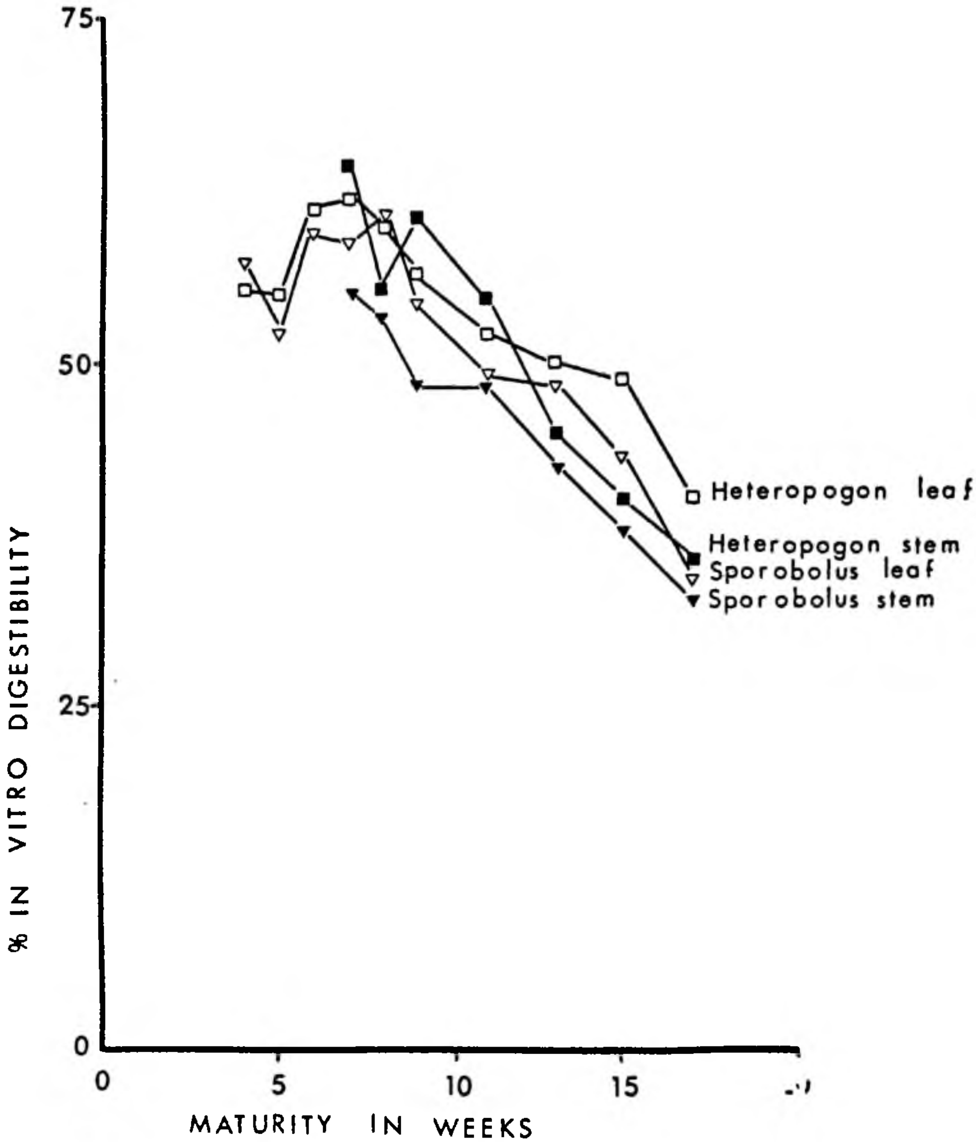

Fig. 2.1. Percent In Vitro dry matter digestibility of leaves and stems of Sporobolus and Heteropogon during the major rainy season of 1974.

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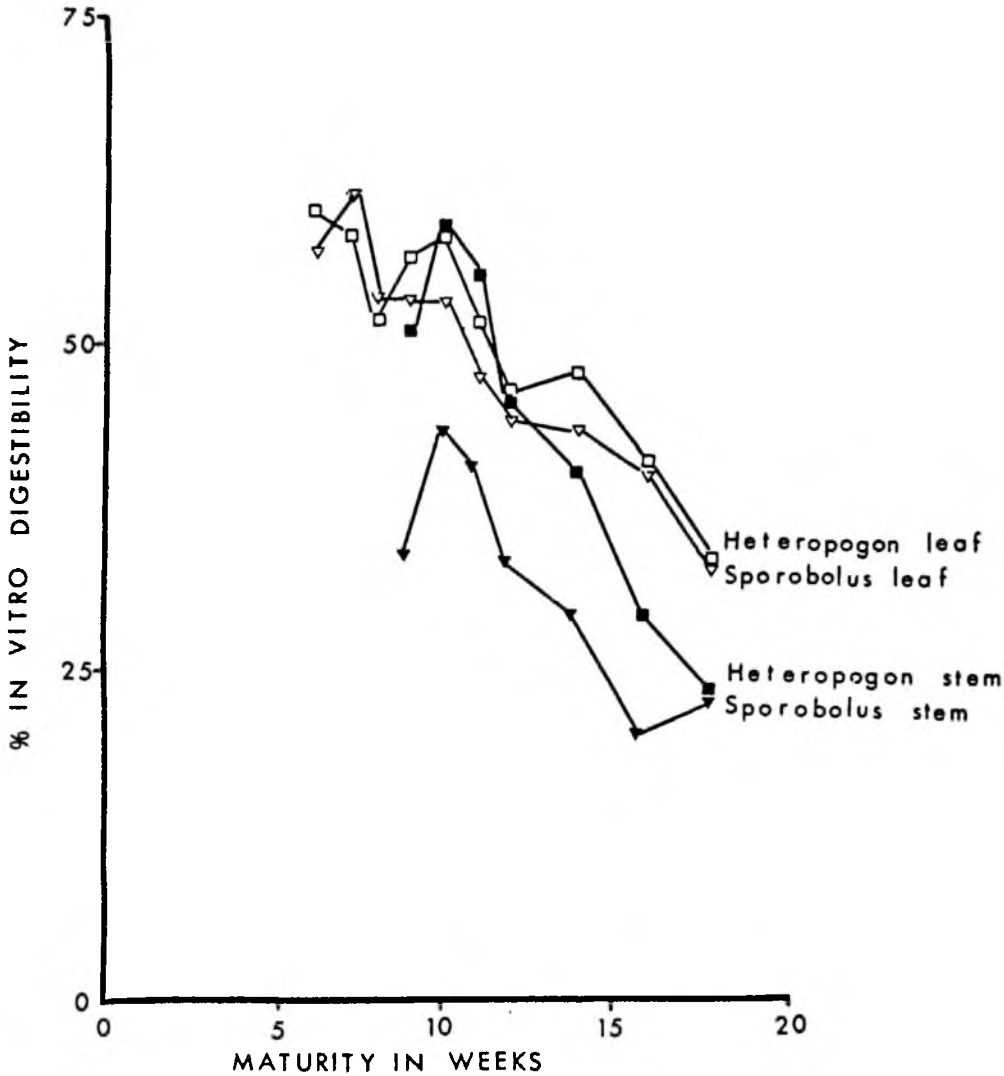

Fig. 2.2. Percent In Vitro dry matter digestibility of leaves and stems of Sporobolus and Heteropogon during the major rainy season of 1975.

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Table 2.3. Percent In Vitro digestible dry matter of whole plants of Sporobolus and Heteropogon during the major rainy seasons of 1974 (upper) and 1975 (lower).

1974	Maturity						
	7+ May 20‡	8 May 27	9 June 3	11 June 17	13 July 1	15 July 15	17 July 29
Sporobolus	$58.9^{a\,o}_{x}$	59.7^{a}_{x}	53.2^{b}_{y}	49.2^{c}_{y}	46.7^{d}_{x}	40.9^{e}_{y}	34.3^{f}_{y}
Heteropogon	61.9^{a}_{x}	59.8^{a}_{x}	56.9^{b}_{x}	53.2^{c}_{x}	43.4^{d}_{x}	44.7^{d}_{x}	37.7^{e}_{x}

1975	Maturity						
	9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Sporobolus	$51.6^{a\,o}_{y}$	51.8^{a}_{y}	46.8^{ab}_{y}	43.7^{bc}_{x}	41.2^{cd}_{y}	37.8^{d}_{x}	29.8^{e}_{x}
Heteropogon	56.5^{ab}_{x}	57.9^{a}_{x}	53.2^{b}_{x}	46.5^{c}_{x}	45.3^{c}_{x}	38.7^{d}_{x}	27.2^{e}_{x}

+ Weeks from pretreatment: April 1, 1974; April 9, 1975.
‡ Harvest date during the major rainy season.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e; between species - x,y.

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decline began. Such initial rise has been ascribed to rapid growth by Drapala, Raymond and Crampton (1947) and Haggar and Ahmed (1970). In the present study, however, while the initial increase in IVD fell within the period of "grand growth", the decline started before the rapid growth phase was over. The decline in IVD with herbage maturity has been attributed to increasing lignification by Moore and Mott (1973) and Crampton and Maynard (1938), to an increase in silica by Van Soest and Jones (1968), and to a rise in hemicellulose content by Danley and Vetter (1973). Owing to inadequacy of samples, these cell wall components were not studied.

In 1974, the relations between percent IVD and maturity was quadratic in the leaves of *Sporobolus* (Table 2.4) but linear in stems and whole plants. However in the leaves, stems and whole plants of *Heteropogon*, IVD was linearly related to maturity. In 1975, the regressions were linear in both plant parts as well as whole plants of both species (Table 2.4). With *Heteropogon* in both years stem IVD tended to decline faster than leaf IVD whereas in *Sporobolus* such differences were not evident (Table 2.4, Figs. 2.1 and 2.2). *Heteropogon* stems appeared to fall in IVD more rapidly than those of *Sporobolus* in both years. With leaves, however, the converse was true. On the other hand, differences in whole plant IVD of the two species did not show any consistent trend in the two years (Table 2.3). In 1974, the IVD of *Sporobolus* whole plant appeared to decline at a similar rate to that of *Heteropogon* whole plant, whereas in 1975 the rates of decline tended to be lower in *Sporobolus* than *Heteropogon*.

The pretreatment of slashing, grazing and burning did not appear to have any consistent effect on N content (Appendices XXV, XXVI,

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Table 2.4. Regressions of percent In Vitro digestibility on maturity in _Sporobolus_ and _Heteropogon_ during the major rainy seasons of 1974 and 1975.

	1974	r^2	1975	r^2
Sporobolus				
Whole plant	$Y = 76.91 - 2.44x$	0.85**	$Y = 73.63 - 2.32x$	0.57**
Leaf IVD	$Y = 49.83 + 2.57x - 0.20x^2$	0.78**	$Y = 73.09 - 2.13x$	0.59**
Stem IVD	$Y = 70.13 - 2.14x$	0.60**	$Y = 61.66 - 2.29x$	0.39**
Heteropogon				
Whole plant	$Y = 78.63 - 2.34$	0.83**	$Y = 87.81 - 3.22x$	0.82**
Leaf IVD	$Y = 65.98 - 1.23x$	0.51**	$Y = 73.22 - 2.00x$	0.65**
Stem IVD	$Y = 83.42 - 2.83x$	0.87**	$Y = 90.68 - 3.63x$	0.52**

** Significant ($P < 0.01$).
x Weeks.
Y In Vitro dry matter digestibility.

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XXVII, XXVIII, XXIX, XXX, XXXI and XXXII). Thus, this study did not confirm the view that burning herbage increases nitrogen content (Plowes 1957, Mes 1958, Smith 1960). Similarly, species differences in N content were not consistent.

Percent N generally fell as the plants matured (Figs. 2.3 and 2.4, Tables 2.5 and 2.6, Appendices XXVIII and XXXIX) in the leaf, stem and whole plant of both species, thus agreeing with reports by Brockington (1961), Lansbury et al. (1965), and Sen and Mabey (1965). Linear relations were found between percent N content and maturity in the leaves and stems of both species in 1974. On the other hand, in 1975, quadratic and cubic regressions were given by stem N of Sporobolus and Heteropogon respectively, while their leaf N contents had linear relations with maturity (Table 2.6). In both species leaf N, like the IVD, tended to fall more rapidly than stem N in both years. Furthermore, N levels in the leaves of both Sporobolus and Heteropogon were higher than in the stem (Figs. 2.3 and 2.4, Appendices XXVIII and XXIX) as was the case in IVD's. Thus, percent IVD and percent N of the two species seemed to be associated. The correlation coefficient of IVD on N in this study was 0.61 and was highly significant ($P < 0.01$). This association between IVD and N agrees with findings by Sullivan (1969), Maynard and Loosli (1969), Leng (1973) and Ventura et al. (1975) who explained the association between IVD and N by nitrogen being a necessity for proper rumen microbial fermentation. However, this contrasts with the results of Sullivan (1964) and Oh, Baumgardt and Scholl (1966) who had low correlation coefficients of 0.24 and 0.37 respectively. The inconsistency in the relations between IVD and N probably arises from the different behaviour of the

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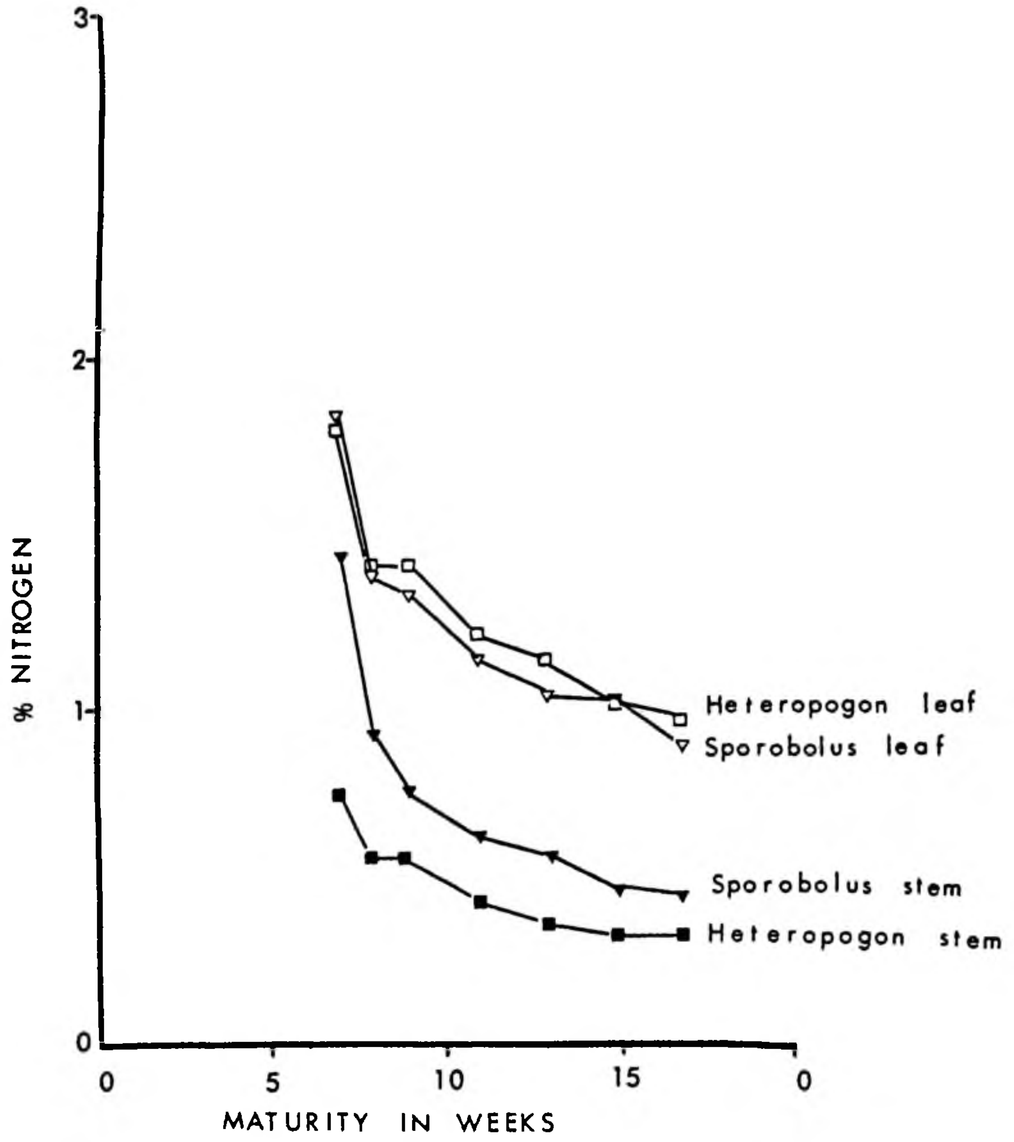

Fig. 2.4. Percent nitrogen content of leaves and stems of Sporobolus and Heteropogon during the major rainy season of 1975.

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Table 2.5. Percent nitrogen in whole plants of Sporobolus and Heteropogon during the major rainy seasons of 1974 (upper) and 1975 (lower).

1974	Maturity						
	7^{+} May 20‡	8 May 27	9 June 3	11 June 17	13 July 1	15 July 15	17 July 29
Sporobolus	1.87^{a}_{x}	1.65^{b}_{x}	1.26^{c}_{y}	1.19^{cd}_{x}	1.10^{d}_{x}	0.82^{e}_{x}	0.85^{e}_{x}
Heteropogon	1.84^{a}_{x}	1.35^{b}_{y}	1.42^{b}_{x}	1.13^{c}_{x}	1.00^{d}_{x}	0.78^{e}_{x}	0.72^{e}_{x}

1975#	Maturity						
	9^{+} June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Sporobolus	1.78^{a}_{x}	1.25^{b}_{x}	1.20^{b}_{x}	1.01^{c}_{x}	0.93^{cd}_{x}	0.92^{cd}_{y}	0.80^{d}_{x}
Heteropogon	1.73^{a}_{x}	1.27^{b}_{x}	1.20^{b}_{x}	0.92^{c}_{x}	0.80^{d}_{x}	0.71^{de}_{x}	0.64^{e}_{y}

+ Weeks from pretreatment: April 1, 1974; April 9, 1975.
‡ Harvest date during the major rainy season.
# Average of two pretreatments: slashed and grazed.
o Data followed by the same letter are not different ($P > 0.05$): rows – a,b,c,d,e; columns within rows – x,y.

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Table 2.6. Regressions of percent nitrogen on maturity in <u>Sporobolus</u> and <u>Heteropogon</u> during the major rainy seasons of 1974 and 1975.

	1974	r^2	1975	r^2
<u>Sporobolus</u>				
Whole plant N	Y = 2.36 – 0.097x	0.67**	Y = 2.20 – 0.08x	0.52**
Leaf N	Y = 2.49 – 0.097x	0.71**	Y = 2.56 – 0.102x	0.54**
Stem N	Y = 1.78 – 0.082x	0.71**	$Y = 5.26 - 0.620x + 0.020x^2$	0.74**
<u>Heteropogon</u>				
Whole plant N	Y = 2.42 – 0.107x	0.80**	Y = 2.41 – 0.11x	0.71**
Leaf N	Y = 2.27 – 0.076x	0.70**	Y = 2.56 – 0.097x	0.67**
Stem N	Y = 0.99 – 0.035x	0.51**	$Y = 9.34 - 1.837x + 1.246x^2 - 2.798x^3$	0.84**

** Significant ($P < 0.01$).
x Weeks.
Y Percent nitrogen.

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two parameters in the plant. In this study for instance, N declined more rapidly in the leaf than in the stem whereas IVD fell faster in the stem than in the leaf. Furthermore, while IVD levels tended to be higher in Heteropogon than Sporobolus, the latter had higher nitrogen content.

As regards the nitrogen and digestible dry matter production of the natural grassland sward and herbage intake by ruminants in the grassland, more information is required on the quality of the other species in the community (e.g. gamba and guinea grasses), during the major rainy season, and on the quality of the component species during the regrowth period, to help determine when these natural grassland swards should be grazed. Certain general inferences may however be drawn from the data on the two dominant species in these communities.

From the viewpoint of dietary nitrogen for ruminants, both Sporobolus and Heteropogon were too low in nitrogen content to meet the requirements for high levels of animal production, such as the 2.5% suggested by Sullivan (1969). These grasses contained enough nitrogen to support moderate levels of livestock production at the early stages of growth but the yield of the sward was low at these stages. On the other hand as the yield rose, nitrogen fell, and if the 0.8 nitrogen suggested by Fianu, Attakrah and Koram (1972) as the minimum for maintenance requirements in yearling wethers be accepted, then whole plant Sporobolus would barely continue to meet this minimum requirement until 17 weeks of maturity and Heteropogon would only do so until week 13.

To meet the needs of the rapidly developing livestock industry in Ghana therefore, introduced species may be examined. Where natural grassland is the only forage, supplementation with nitrogenous concen-

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trates such as urea may be necessitated. Overseeding with legumes would also furnish an alternative method of meeting the dietary nitrogen requirements of ruminants in the Accra Plains.

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Summary

The pretreatments: slashing, grazing and burning did not differ consistently in their effects on leaf production, nitrogen content or In Vitro dry matter digestibility. However, burning, being relatively inexpensive, would seem preferable to slashing as a tool for removing mature growth from small holdings. Long term effects on the sward and safety precautions would, however, have to be considered before vegetation is burned.

Sporobolus produced more leaf dry matter than *Heteropogon* until weeks 5 to 6 when this trend was reversed. Leaf production rose with maturity up to 554 - 878 kg/ha in *Sporobolus* and 1315 - 1360 kg/ha in *Heteropogon* at 9-11 weeks of maturity. *Sporobolus* appeared to have a higher proportion of leaves than *Heteropogon* especially at later stages of growth.

The leaves of both species were more digestible and contained higher levels of nitrogen than the stems. Although nitrogen content of whole plants showed no consistent differences between the two species, *Heteropogon* was more digestible than *Sporobolus*.

Quality declined with maturity in both species. The rate of decline tended to be higher in *Heteropogon* than in *Sporobolus* and the latter would probably continue to meet the maintenance nitrogen requirements of the grazing ruminant until week 17 whereas *Heteropogon* would only do so until week 13.

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PAPER 3: DRY MATTER ACCUMULATION IN GIANT STAR, BUFFEL AND PANGOLA GRASSES IN THE ACCRA PLAINS

Abstract

In two separate trials, giant star (Cynodon plectostachyus (K. Schum.) Pilger, buffel (Cenchrus ciliaris L. cv. Biloela and pangola (Digitaria decumbens Stent.) grasses were harvested at ten maturity dates during (a) the minor rainy season of 1974, and (b) the major rainy season of 1975. To determine the amount of aftermath herbage for use in the ensuing dry period, one-third of each plot was harvested at end of rainy season (December 31, 1974 or August 12, 1975), another third at mid-dry season (March 4, 1975 or August 26, 1975), and the last third at end-dry season (May 5, 1975 or September 9, 1975).

During early growth, pangola was sensitive to moisture stress and failed to grow during the minor rainy season trial. Buffel grass on the other hand, being drought tolerant, grew under the light showers. It flowered from week 3 in both seasons while giant star flowered only during the minor rainy season trial, at week 6, and pangola flowered in week 6 during the major rainy season. In all three grasses growth continued after flowering. In buffel, senescent leaves tended to remain on the plant whereas in the stoloniferous grasses, they were stripped off by rainfall.

During the minor rainy season, September 16 - December 31, 1974, giant star and buffel produced similar dry matter yields (maxima of 4715 and 5707 kg/ha respectively at week 13). In the major rainy season (April 29 - August 12), however, buffel was superior to the prostrate

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grasses which did not differ consistently. Yields rose to 5296, 6212 and 4566 kg/ha in giant star, buffel and pangola grasses respectively at week 9 and levelled off.

Herbage regrowth from the minor rainy season harvests to the end of the rainy season, was highest after the harvests of October 8 and 15: 2384 - 2812 kg/ha in giant star and 4560 kg/ha in buffel. For mid-dry season, the highest regrowth herbage was obtained after harvests of October 22-29 in giant star (3037 - 3789 kg/ha) and October 8-29 in buffel (3400 - 4550 kg/ha). At the end of the dry season, the regrowth herbage yields from all rainy season harvest dates were the same in both species: 1976 - 3756 kg/ha in giant star and 2890 - 5207 kg/ha in buffel.

In the major rainy season trial the highest recovery yields at the end of the rainy season (August 12) were 4110 kg/ha for giant star after May 20 harvest, 5951 - 6508 kg/ha for buffel and 4998 - 5456 kg/ha after May 20-27 harvests. At mid-dry season (August 26) giant star had accumulated regrowth of 4600 - 5106 kg/ha after May 20 - June 3 harvests; buffel had 5791 kg/ha after the May 20 harvest and pangola had 4554 - 5602 kg/ha after the harvests of May 20-27. At end-dry season (September 9) the maximum recovery yields were 6379 kg after May 20 for giant star, while for buffel and pangola it occurred between May 20 and June 10: 4572 - 5646 kg/ha for buffel and 4588 - 5626 for pangola.

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Introduction

Herbage on the natural grasslands in the Accra Plains has been reported to deteriorate rapidly in both quality and dry matter production in the dry season (Lansbury 1960). This deterioration is responsible for retardation in the growth of grazing livestock (Rose Innes 1961). Several grass introductions have been made since the 1920's in attempts to solve this problem. Among these are: pangola (*Digitaria decumbens* Stent.); giant star grass (*Cynodon plectostachyus* (K. Schumach) Pilger) and buffel (*Cenchrus ciliaris* L. syn. *Pennisetum ciliare* L.); these were judged to be promising on the basis of their ease of propagation, and vigorous growth (Evans 1961, Thompson 1961, Rose Innes 1961, Asare 1972).

Several studies have been conducted on these grasses in East Africa (French 1957, Cassady 1973, Taerum 1970a,b,c), in Rhodesia (Brockington 1961), in the Caribbean (Nestel and Creek 1962, Vicente-Chandler *et al*. 1964, Sallette 1965), in Australia (Humphreys 1969), and in the forest zone of Ghana (Asare 1970). However little information is available to describe their dry matter accumulation during growth and development. Furthermore, little is known about their productivity in the Accra Plains.

This study was conducted to appraise these three species for dry matter accumulation during growth in the major and minor rainy seasons and to assess the regrowth yields of herbage for use in the ensuing dry season after cutting in the rainy season.

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Literature Review

Pangola grass is a sod forming stoloniferous perennial adapted to the humid tropics and subtropics over a wide range of soils (Hosaka and Goodell 1954, Nestel and Creek 1962, Sallette 1965, Vicente-Chandler 1975). Because of its creeping habit, pangola is more suited to grazing than cutting (Nestel and Creek 1962) and Vicente-Chandler et al. (1964) advise that it should be grazed with rest periods of 20 to 30 days, while Brown et al. (1966b) recommend 30 to 40 days for proper regrowth in the rainy season, and 60 days in the dry season. Pangola responds to nitrogen fertilization, and in Puerto Rico, Vicente-Chandler et al. (1964) obtained dry matter increases from 13,440 kg/ha at zero N to 30,240 kg/ha at 448 kg/ha N and Sallette (1965) and Plucknett (1970) obtained increased response to higher N level than those of Vicente-Chandler et al. (1964).

Giant star grass is a perennial occurring naturally in association with buffel grass, guinea grass (Panicum maximum Jacq.) and Brachiaria brizantha (Hochst) Stapf. in East Africa (Edwards 1956, Rattray 1960). Ahlgren et al. (1959), Ruthenberg (1974) and Chedda (1971) recommend it as suited to West Africa. At Avetonou in Togo, giant star grass under fertilization yielded 50 tonnes/ha fresh herbage per year (Ruthenberg 1974). Caro-Costas et al. (1973) and Vicente-Chandler (1975) considered giant star superior to pangola as it is leafier, higher in N and produces more dry matter per hectare.

Buffel grass (Cenchrus ciliaris L. synonym Pennisetum ciliare L.) is a tufted, and often weakly rhizomatous, perennial that occurs in arid areas under as little as 300 mm rainfall per year. Though

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susceptible to fungal attack in humid environments, Asare (1972) found that this grass produces well in the West African forest zone if the soil is well drained. He obtained 26.1 tonnes/ha and 11.9 tonnes/ha dry matter in the first and second years of establishment, with 67 kg N, 90 kg P and 45 kg K per hectare while at Bouake, Ivory Coast, Ruthenberg (1974) reported 14.2 tonnes/ha.

Materials and Methods

Two trials each containing the three species were established at the University of Ghana Research Farm, Legon, in March to June 1974. A split plot design with four replicates was used, the species forming the main plots 5 x 20 m in size, and ten harvesting dates were randomly assigned to the subplots. These subplots were further randomly divided into three sub-subplots for harvesting at the end of the rainy season, mid-dry season and at the end of the dry season. The first tiral commenced at the start of the rainy season (October 8 - December 31) 1974, and continued into the ensuing dry period through May 5. The second trial commenced during the major rainy season of 1975 (May 20 - August 12) and continued into the following dry period - through September 9.

Pangola grass and giant star grass were established from cuttings planted at 15 x 15 cm. The cuttings were obtained from the Agricultural Research Station (ARS), Legon. Buffel grass cv. Biloela was established using seed obtained from Australia*. The seed was

* By courtesy of the Director of the Veterinary Services, Accra.

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planted in 15 cm rows, 5 cm apart. Only giant star and buffel grass were harvested from the first trial due to poor growth of pangola during the minor rainy season. At establishment 50 kg N, 40 kg P and 80 kg K per hectare were broadcast over the trial. Following full ground cover an additional 50 kg N/ha was broadcast over each trial. On September 17, 1974 the growth in the first trial was removed by means of machettes to a stubble height of about 5 cms. Harvesting began at week three and continued at weekly intervals for 10 weeks. The three regrowth cuts were harvested on December 31 (end of minor rainy season), March 4, 1975 (mid-dry season) and May 5, 1975 (end of the dry season). All plots were harvested by means of a Jari mower with a 92 cm sickle bar attachment. After weighing, two samples of herbage were taken from the harvested material. The first was dried at 80°C for 48 hours and used for dry matter determination and the second stored in a freezer at -4°C and later separated into leaf and stem.

On April 29, 1975, the treatments on the second trial commenced. The growth was slashed with machettes and harvesting commenced on May 20 (3 weeks following slashing) and continued through to August 12, 1975. Three regrowth cuts were taken on August 12, August 26 and September 9, 1975.

The minor rainy season and major rainy season data were both analyzed as a split plot design with species as main plots and maturity dates as subplots. Dry season harvest data were also analyzed as a split plot experiment with species as the main plots and regrowth dates as subplots but data from each rainy season maturity date were treated separately.

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Results and Discussion

During the minor rainy season, rainfall was light, scarcely more than 20 mm falling in any one week. In the subsequent dry period, however, although there was no rain in the first five weeks, it rained more intensively from February 25 to May 6 than during the minor rainy season. Rainfall during the major rainy season was more intensive than in the minor rainy season while the short dry period of August 13 - September 9 was quite dry (Appendices LXI and LXII).

Dry matter accumulation of the grasses during the minor rainy season and the major rainy season trials are shown in Fig. 3.1, and Appendices XXXIII, XXXIV, and XXV. During the minor rainy season of 1974, both giant star and buffel grasses grew rapidly from 1686 and 1633 kg/ha respectively at week 3, to 4079 and 4665 kg/ha respectively at week 6. Thereafter, growth slowed down and reached a peak of 4715 kg in week 13 for giant star grass and 5707 kg/ha in week 13 for buffel. Giant star then declined to 4467 kg/ha and 5360 kg/ha in week 5. This difference between the two species appeared to be due to the loss of senescent leaves in giant star under the pounding action of the showers of November 18 (week 8); on the other hand, in buffel grass the senescent leaves tended to stay on the plant. The development of new shoots tended to compensate for the loss of senescent leaves in giant star.

The level of dry matter production observed in this study was below that reported by Asare (1972), Caro Costas et al. (1965, 1973) and Vicente-Chandler (1975) for these species. However, the levels are of the same magnitude as those reported by Ruthenberg (1974) in the Ivory Coast and Togo. The superior yields reported by the former

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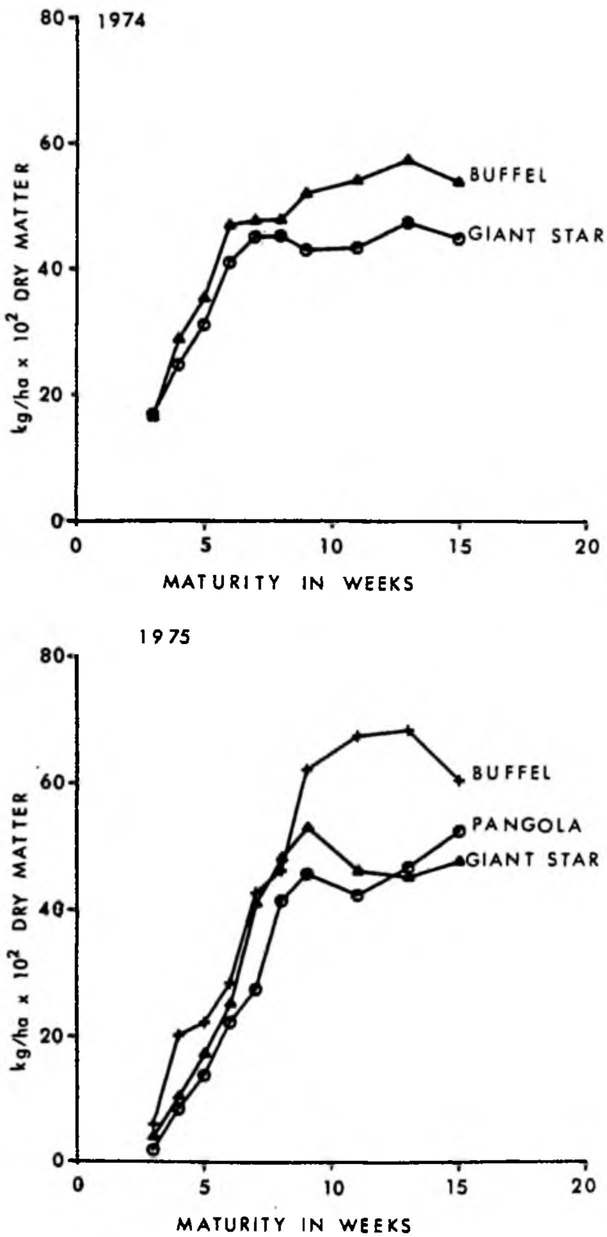

Fig. 3.1. Accumulation of dry matter in giant star, buffel and pangola grasses during the minor rainy season 1974 and the major rainy season 1975.

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authors were obtained under higher rainfall conditions than that which occurred during this trial or those reviewed by Ruthenberg (1974). Buffel grass was headed by week 3 although the flowers had not opened, while giant star began flowering during week 4. In both species dry matter accumulation continued after heading which agrees with the findings of Brockington (1961) in Rhodesia. Seed setting and shattering continued throughout the season and this together with leaf senescence and the development of new shoots during the light showers of November to early December (Fig. 3.1) may have contributed to the small fluctuations in yields.

Although there appeared to be a trend for buffel to produce more dry matter than giant star grass during the light rainfall period of November and December, the differences were not significant ($P > 0.05$). The tendency of buffel to utilize marginal rainfall more efficiently than other grasses tends to confirm the observations of Rattray (1960), Fitzgerald (1955), Humphrey (1969), Pereira and Beckley (1953) and Edwards (1956). During the last fortnight, the yield of both species was reduced by 300 kg each, from week 13 to 15 weeks of maturity (December 17 to 31). This was primarily due to leaf senescence in giant star, while in buffel grass seed shattering was increased by the dry weather and this may have been a factor in reducing yield. Such observations were made on buffel by Brockington (1961) and Cassady (1973). A further factor that may have contributed to this reduction in yield in both species may have been translocation of organic matter to roots (Norman 1963, Taerum 1970a,b,c).

During the major rainy season 1975 trial the accumulation of dry matter of the three species tended to follow a pattern similar to

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the 1974 minor rainy season. However, while buffel grass flowered from week 3, pangola from week 5, giant star grass did not flower during the major rainy season. Dry matter accumulation continued in pangola grass and buffel grass after heading and because of the ability of buffel grass to retain the senescent foliage, it continued to accumulate dry matter, rapidly at first, then more slowly from week 9 to week 13. Pangola and giant star grasses also grew rapidly from week 3 to weeks 8 and 9 respectively. Thereafter the yield of giant star fluctuated; pangola also seemed to fluctuate (Fig. 3.1) but the changes were not significant (Appendic XXXIII). This pattern was apparently determined by the balance between the shedding of senescent leaves and development of new ones. From week 11 (July 15), the shattering of seed tended to reduce buffel yield but this was compensated for by the new flush of leaves induced by the rainfall of July 8 to 22. As leaf development slowed down and seed shattering continued, buffel yields declined after week 13 (July 29). In the stoloniferous grasses on the other hand, the net formation of new foliage from week 11 tended to raise dry matter yields. In pangola grass, the proliferation of a new crop of inflorescence from week 11 enhanced the increase in dry matter accumulation. In all three species, however, the changes in dry matter yield after week 11 were not significant ($P > 0.05$).

The major rainy season of 1975 yields of the stoloniferous grasses were below those reported in giant star by Arias (1965) over a 45 day period (900 kg/ha at 10 days to 3000 kg/ha at 40 days). However Virquez (1965) in Brazil obtained similar dry matter yields to those obtained in pangola in this study. In our study, buffel tended to outyield the other two grasses particularly at the later stages of

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development during the major rainy season. This finding thus agrees with Asare (1974) who reported that buffel was superior to giant star and other grasses in the humid zone of Ghana.

Herbage regrowth from the minor rainy season 1974 and major rainy season 1975 harvests until the end of the rainy season, middle of the ensuing dry season and the end of the dry season, are shown in Tables 3.1 and 3.2 and Appendices XXXVI and XXXVII.

In 1974, although buffel grass generally appeared to produce higher yields than giant star grass at all harvest dates, differences were not consistent (Table 3.1 and Appendices XXXVI and XXXVII), buffel being significantly superior ($P < 0.05$) only in regrowths after the harvests of October 8, 15 and 22 and November 19 at each of the harvests at the end of the rainy season, mid-dry season and the end of the dry season. In both years all grasses tended to grow during the dry period. Within regrowth harvest dates, generally the amount of herbage accumulated during the dry period increased with the lengthening of the recovery period (Tables 3.1 and 3.2).

At the end of the minor rainy season of 1974 (December 31) recovery yield of giant star was highest for the rainy season harvest of October 8 and 15 (2812 and 2384 kg/ha respectively). The low rainfall immediately before and after the October 22 harvest (Fig. 3.1) would appear to be a factor for the decreased recovery from the October 22 harvest. In buffel on the other hand, recovery from the minor rainy season to the end of the rainy season was greatest for the first rainy season harvest of October 8 (4560 kg/ha). Buffel was not affected by the dry period before and after October 22.

Table 3.1. Regrowth yields from giant star and buffel grasses during the dry period (December 1974 to April 1975).

(kg/ha dry matter)

Harvest date in rainy season		End rainy season (December 31, 1974)		Mid dry season (March 4, 1975)		End dry season (May 6, 1975)	
		Giant star	Buffel	Giant star	Buffel	Giant star	Buffel
October 8	3^{+}	$2812^{a\,o}_{y}$	$4560^{a\,o}_{x}$	$2733^{bcd\,o}_{x}$	$3610^{b\,o}_{x}$	$2970^{abc\,o}_{y}$	$5207^{a\,o}_{x}$
15	4	2384^{ab}_{y}	3927^{b}_{x}	2891^{bc}_{x}	3400^{bc}_{x}	3075^{abc}_{y}	4614^{ab}_{x}
22	5	1922^{bc}_{y}	3567^{bc}_{x}	3789^{a}_{x}	4550^{a}_{x}	3756^{a}_{x}	3787^{bcd}_{x}
29	6	2262^{abc}_{x}	2971^{cd}_{x}	3037^{b}_{x}	3588^{b}_{x}	3320^{ab}_{x}	3627^{bcd}_{x}
November 5	7	1702^{c}_{x}	2481^{de}_{x}	2731^{bcd}_{x}	2691^{d}_{x}	3122^{abc}_{x}	3858^{bcd}_{x}
12	8	1677^{c}_{x}	2506^{de}_{x}	2242^{cde}_{y}	3480^{b}_{x}	3402^{ab}_{x}	3579^{bcd}_{x}
19	9	909^{d}_{y}	2233^{e}_{x}	2052^{def}_{y}	3230^{bcd}_{x}	2843^{abc}_{x}	2890^{d}_{y}
December 3	11	593^{d}_{x}	1926^{e}_{x}	1661^{efg}_{y}	2722^{cd}_{x}	2002^{c}_{y}	3942^{bcd}_{x}
17	13	--	826f	1415^{fg}_{y}	2031^{e}_{x}	1976^{c}_{y}	4096^{bc}_{x}
31	15	--	--	1136^{g}_{x}	1918^{e}_{x}	2387^{bc}_{x}	3202^{cd}_{x}

\+ Weeks of maturity from beginning of trial to the harvest date during the rainy season.

o Data followed by the same letter are not different ($P > 0.05$): columns - a,b,c,d,e,f,g; rows within regrowth harvests - x,y.

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Table 3.2. Regrowth yields from giant star, buffel and pangola grasses during the dry period (August – September) 1975.

(Kg/ha dry matter)

Harvest date during rainy season		End rainy season August 12, 1975			Mid dry season August 26, 1975			End dry season September 9, 1975		
		Giant star	Buffel	Pangola	Giant star	Buffel	Pangola	Giant star	Buffel	Pangola
May 20	4+	4110^{a}_{x} o	6508^{a}_{x}	5456^{a}_{x}	5106^{a}_{x}	5791^{a}_{x}	5602^{a}_{x}	6379^{a}_{x}	5646^{a}_{x}	4907^{b}_{x}
27	5	3511^{a}_{x}	5951^{a}_{x}	4998^{a}_{x}	4910^{a}_{x}	4867^{b}_{x}	4554^{b}_{x}	5449^{b}_{x}	5342^{a}_{x}	5626^{a}_{x}
June 3	6	2543^{b}_{x}	3344^{b}_{x}	2348^{b}_{x}	4600^{a}_{x}	4184^{c}_{x}	3141^{c}_{y}	4565^{c}_{x}	5091^{ab}_{x}	4588^{b}_{x}
10	7	1997^{bc}_{x}	3155^{bc}_{x}	2197^{b}_{y}	1924^{b}_{y}	2897^{d}_{x}	2783^{cd}_{x}	3492^{d}_{y}	4572^{b}_{x}	4879^{b}_{x}
17	8	1891^{c}_{x}	2220^{de}_{x}	1765^{b}_{x}	1471^{bc}_{x}	2377^{de}_{x}	2249^{d}_{x}	2166^{e}_{x}	2349^{c}_{x}	2267^{c}_{x}
24	9	1168^{d}_{y}	2668^{cd}_{x}	1040^{c}_{y}	1424^{bcd}_{y}	2811^{d}_{x}	1595^{e}_{y}	1747^{e}_{x}	2042^{c}_{x}	1610^{d}_{x}
July 1	10	991^{d}_{y}	1947^{e}_{x}	794^{c}_{y}	1178^{cde}_{y}	2786^{d}_{x}	1001^{f}_{y}	1915^{e}_{x}	2174^{c}_{x}	938^{e}_{y}
15	11	627^{d}_{y}	993^{f}_{x}	570^{cd}_{y}	864^{def}_{y}	1904^{e}_{x}	759^{f}_{y}	958^{f}_{x}	1099^{d}_{x}	699^{e}_{x}
29	13	--	--	45d	694^{ef}_{x}	662^{f}_{x}	601^{fg}_{x}	693^{f}_{x}	755^{de}_{x}	675^{e}_{x}
August 12	15	--	--	--	573^{f}_{x}	338^{f}_{x}	75^{g}_{y}	561^{f}_{x}	350^{e}_{xy}	75^{f}_{y}

\+ Weeks of maturity from beginning of trial to the harvest date during the rainy season.

o Data followed by the same letter are not different ($P > 0.05$): columns – a,b,c,d,e,f,g; rows within regrowth harvests – x,y,z.

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At the mid-dry season harvest (March 4), giant star grass had reached maximum recovery yields after the harvest of October 22 (3789 kg/ha). This contrasts with recovery to the end of the rainy season and may have been due to the rainfall of February 4 - March 4 stimulating new growth (Fig. 3.1 and Table 3.1). Buffel grass also made its maximum recovery after the October 22 harvest (4550 kg/ha) but the loss in dry matter following October 8 and 15 harvests may have been due more to seed shedding than leaf losses.

By the end of the dry period giant star recovery from harvests of October 22 was the highest (3756 kg/ha) while in buffel recovery fro m October 8 was the highest (5207 kg/ha).

In 1975, buffel grass again tended to produce more regrowth herbage at each of the recovery harvest dates than giant star and pangola grasses (Table 3.2 and Appendices XXXVI and XXXVII). Across the three recovery harvest dates (end of rainy season, mid-dry season and end-dry season) there generally was an increase in herbage recovery in all grasses, although buffel grass fluctuated - probably because of its shedding of seed. Within the regrowth period until August 12 (end of the rainy season) recovery from harvests of May 20 and 27 were the highest yields in all three species. At the mid-dry period harvest of August 26, on the other hand, while giant star made its maximum yields from recovery after rainy season harvests of May 20 to June 3, buffel and pangola made their greatest recovery after May 20. At the end of the dry period (September 9) giant star yielded its highest herbage recovery from the May 20 harvest (6379 kg/ha) while in buffel grass the highest recovery yields were from May 20 to June 3 (5646 kg/ha - 5091 kg/ha) and in pangola grass, the highest recovery yield was 5626 kg/ha

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from May 27.

To obtain the greatest amount of herbage recovery for use in the (August - September) dry period therefore, the major rainy season harvest may be taken in late May in all species. Harvesting in early mid-October would give the maximum recovery herbage growth in both giant star and buffel for use at the end of December, while by harvesting at mid- to late-October, both species would produce their highest recovery yields for use in early March. Giant star may be harvested from October to mid-November to produce the maximum regrowth for use in early May, but buffel would yield its highest recovery for early May when it is cut in early to mid-October. However, harvesting in early October during the minor rainy season or in May to early June during the major rainy season would give poor rainy season yields. The total seasonal yields would therefore need to be considered.

Seasonal total herbage yields obtained from the rainy season and dry season cuts are given in Tables 3.3 and 3.4. In 1974, giant star maximum totals came from the harvests of October 29 (shortly before the rains) and their aftermaths, while buffel being less susceptible to drought, gave its maximum herbage totals for each season from the harvests between October 15 and December 17. On the other hand, timing of major rainy season harvests (1975) for maximum total seasonal yields was the same in all three species and fell from May 27 to June 3 and from June 4 to July 15 of 1975.

The overall superiority of buffel to pangola and giant star seems to be partly in its ability to grow under low rainfall as reported by Taerum (1970a,b,c) in East Africa, Humphreys (1969) in Australia, Rattray (1960) in the Sahel, Brown, Layman and Rotar (1966a) in Hawaii,

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Table 3.3. Seasonal total yields from giant star and buffel grasses during 1974.

(Kg/ha dry matter)

	Maturity									
	3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Minor season + end of rainy season:										
Giant star	4498c°	4854bc	5020abc	6341a	6176ab	6169ab	5176abc	4903bc	4715c	4467c
Buffel	6193ab	6800a	7080a	7636a	7218a	7246a	7390a	7297a	6533ab	5360b
Minor season + mid dry season:										
Giant star	4419e	5361de	6887ab	7116ab	7205a	6534abc	6319abcd	5971bcd	6131abcd	5603de
Buffel	5243c	6273bc	8063a	8253a	7428ab	8220a	8387a	8093a	7738a	7278ab
Minor season + end of dry season:										
Giant star	4656c	5545bc	6854ab	7399a	7596a	7894a	7110ab	6312abc	6691ab	6854ab
Buffel	6840c	7487bc	7300c	8292abc	8595abc	8319abc	8047abc	9313ab	9803a	8562abc

\+ Weeks of maturity from major rainy season harvest.
‡ Harvest date during the major rainy season.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e.

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Table 3.4. Seasonal total yields from giant star, buffel and pangola grasses during 1975.

(Kg/ha dry matter)

	Maturity									
	3+	4	5	6	7	8	9	11	13	15
	May 20‡	May 27	June 3	June 10	June 17	June 24	July 1	July 15	July 29	Aug. 12
Major season + end rainy season:										
Giant star	4513cd[o]	4558cd	4266d	4513cd	5985ab	5982ab	6287a	5239bc	4516cd	4759cd
Buffel	7106ab	7972a	5562c	5993bc	6486abc	7283ab	7456ab	7737a	6833abc	6040bc
Pangola	5647ab	5849a	3728e	4419de	4507cde	5182abcd	5360abc	4836bcd	4712cd	5241abcd
Major season + mid dry season:										
Giant star	5509abc	5957abc	6323ab	4440d	5565abc	6238ab	6474a	5476abc	5210cd	5332bcd
Buffel	6389bc	6888bcd	6402bcd	5735cd	6643bcd	7426ab	7867ab	8648a	7505ab	6378bc
Pangola	5793a	5405ab	4521b	5005ab	4991ab	5737a	5567a	5025ab	5269ab	5418ab
Major season + end dry season:										
Giant star	6782ab	6496abc	6288abcd	6008bcde	6260abcde	6561abc	7211a	5570cde	5209e	5320de
Buffel	6244d	7363abcd	7309abcd	7410abcd	6615bcd	6657bcd	8386a	7843ab	7598abc	6390cd
Pangola	5098c	6477ab	5968abc	7001a	5009c	5752bc	5504bc	4965c	5343bc	5418bc

\+ Weeks of maturity at minor season harvest.

‡ Harvest date during minor or major rainy season.

o Data followed by the same letter are not different ($P > 0.05$): rows – a,b,c,d,e.

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Pereira and Beckley (1953) in Southern Africa, Edwards (1956) in Kenya and Mufti and Kaul (1972) in Iraq. Giant star also seemed to be drought tolerant, although not as good as buffel grass. Pangola was very sensitive to drought especially at the very early stages. In all the three grasses, fluctuations occurred in dry matter accumulation during maturation both during the rainy season and in the dry season recovery, probably reflecting the balance between the formation and shedding of leaves and seeds. Buffel showed more fluctuations particularly during the recovery periods apparently because of its ability to utilize light rainfall for growth and reproduction.

It would therefore appear that pangola grass on account of its sensitivity to drought, especially during its early developmental stages, should not be grown in the drier parts of the Accra Plains. However, it may be suitable for the wetter areas to the north of the plains. Giant star grass and buffel grass, on the other hand, would probably be suitable for the drier as well as the more humid parts of the Accra Plains. The stage to harvest these grasses would appear to depend on the season of the first growth harvest as well as the date the aftermath is required in the ensuing dry season. During the minor rainy season, giant star grass would be best harvested at 6 weeks for maximum combination of the minor rainy season yield and regrowth to the beginning of the dry season. If the aftermath is to be harvested at the middle of the long dry season, then the minor rainy season harvest should be taken at 7 weeks. Similarly the harvest date would be 8 weeks where the aftermath is required at the end of the dry season. During the major rainy season, however, the best stage to harvest giant star would appear to be 9 weeks, regardless of the date at which the aftermath is

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required during the ensuing short dry period. Buffel grass would seem to be best harvested at 6, 9 or 13 weeks during the minor rainy season if the aftermath is required for the beginning of the subsequent dry season, the middle of the dry season or at the end of the dry season respectively. The harvest dates during the major rainy season could be 11 weeks whether the aftermath is harvested at the beginning or middle of the ensuing short dry period; if the regrowth is required for the end of the dry period, then the major rainy season harvest would be at 9 weeks. For pangola grass, the corresponding stages of growth for major rainy season harvest are 4, 3, and 6 weeks.

In addition to the total herbage yields considered above, the quality of herbage during growth and development in both the rainy season and the aftermath should be taken into account to ensure that optimal nutrient levels are harvested.

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Summary

Giant star, buffel and pangola grew rapidly for the first 6 to 8 weeks and then slowed down their rates of growth. Buffel commenced flowering by the third week in both years and had set seed by the sixth week. Giant star flowered at week 6 in 1974 but did not flower in 1975. Pangola began flowering from week 6 during the major rainy season 1975 but made little growth after slashing at the beginning of the minor rainy season 1974. In all three grasses, growth continued after flowering.

Buffel grass was outstanding in its ability to accumulate dry matter even with light showers. Much of this dry matter appeared to be in the seed and the yield was reduced when the seeds were shed. Unlike leaves of the prostrate giant star and pangola, senescent leaves of buffel were resistant to decay and were not easily stripped off by rainfall.

Aftermath yields did not follow a consistent trend in buffel grass but in pangola and giant star, there was an increase in dry matter yield during the dry period. Fluctuations were attributable to leaf losses, seed shedding and growth and because buffel produced seed copiously, it fluctuated markedly.

The most drought sensitive of the three species - pangola - made its highest total seasonal yield of herbage when it was cut shortly before the heavy rains of the major rainy season. The drought-hardy buffel and giant star grasses, on the other hand, made their highest totals after harvesting late in the major rainy season. During the minor rainy season, however, maximum total production of

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herbage in giant star grass was derived from harvests at the middle of the minor rainy season and their aftermaths, while buffel gave its highest seasonal total herbage dry matter yields from harvests of weeks 4 to 13.

It would appear that pangola should not be grown in the drier parts of the Accra Plains but buffel and giant star are suitable for these areas.

To obtain maximum seasonal totals of herbage yield, giant star grass may be harvested in the minor rainy season at 6, 7 or 8 weeks maturity if the aftermath is required at the beginning, the middle or the end of the subsequent dry season. The corresponding growth stages for harvesting buffel, during the minor rainy season, are 6, 9 and 13 weeks.

During the major rainy season giant star may be harvested at 9 weeks regardless of the aftermath harvest date. Buffel, on the other hand, may be cut at 11 weeks of growth if the aftermath is required at the beginning or the middle of the short dry period; if the aftermath is required at the end of the dry period, then the major rainy season harvest should be at 9 weeks of growth.

These indications would need to be modified as information becomes available on the quality of herbage during growth in the rainy season as well as the quality of regrowth herbabe during the subsequent period.

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PAPER 4: EFFECT OF MATURITY ON QUALITY OF GIANT STAR, BUFFEL AND PANGOLA IN THE ACCRA PLAINS

Abstract

Giant star (Cynodon plectostachyus (K. Schum) Pilger and buffel (Cenchrus ciliaris L.), cv. Biloela, were harvested at ten dates during the minor rainy season (September 16 - December 31, 1974). During the major rainy season (April 29 - August 12, 1975), pangola grass (Digitaria decumbens Stent) was added to the experiment.

Leaf dry matter production increased to a plateau at weeks 8-9: 2112 and 2104 kg/ha in giant star and buffel respectively in 1974 and 3153, 3212 and 2374 kg/ha in giant star, buffel and pangola grasses respectively in 1975. Giant star and buffel were not different but both were superior to pangola in leaf dry matter production. Leaf proportions were higher in buffel at the early stages but at mature stages, buffel was stemmier. Leaf proportions were higher in the major rainy season than in the minor rainy season.

Whole plant IVD and N were similar in giant star and buffel during the minor rainy season (60.6 - 61.0% at week 3 and 40.8 - 41.7% at week 15). In the major rainy season, however, whole plant IVD was higher in buffel (70.3 - 38.6%) than pangola (64.7 - 46.2%) and giant star (57.7 - 36.2%).

IVD of leaves was higher than stem: the disparity being wider in buffel than in the creeping grasses; buffel leaves were the most digestible (70.4 - 71.2% at 3 weeks to 53.7 - 60.7% at 15 weeks), while the stems had the lowest IVD values (48.6 - 61.3% at 3 weeks to 26.3 -

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30.3% at 15 weeks).

Whole plant N differed among species only in weeks 3-5 during the major rainy season: pangola and buffel were similar (2.62 - 2.12%) but were superior to giant star (1.54 - 1.43%). During both seasons, leaf N was higher than stem N in all grasses.

The N content of whole plants would be below maintenance requirements after week 7 in the minor rainy season 1974 and week 11 in the major rainy season 1975. However, maximum digestible dry matter and nitrogen yields were obtained in weeks 6-7 in the minor rainy season and weeks 7 to 15 in the major rainy season.

IVD was highly correlated with N in leaves, stems and whole plants of all species (r = 0.714 - 0.989) except in giant star stems (r = 0.024).

Introduction

Giant star (Cynodon plectostachyus (K. Schum.) Pilger), buffel (Cenchrus ciliaris L.) and pangola (Digitaria decumbens Stent.) are three of the grasses reported by Rose Innes (1966) and Asare (1972) as suited to Ghanaian conditions to help solve the poor supply and low quality of natural grassland fodder. Asare (1974) studied the nitrogen content and In Vitro digestibility (IVD) of buffel grass grown in mixtures with other grasses and legumes and found that, harvested at six-week intervals throughout the major and minor rainy seasons, the IVD of buffel averaged 49.0 and 43.9% in the first and second years respectively, while corresponding nitrogen content was 1.91 and 1.68% respectively.

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The changes in quality during growth and development of these or other grasses have not been studied in Ghana.

In this study, the changes in leafiness, IVD and nitrogen content of these three grasses during growth in the minor rainy season of 1974 and the major rainy season of 1975 were investigated.

Literature Review

Nutrients are mostly located in the leaves of forages (Sullivan 1969, Bailey 1973). Funes and Yepes (1974) and Chenost (1975) attributed much of the reduction in nutrient value of pangola and other grasses as they matured, to the decline in percent leafiness and corresponding increase in stem tissue. Thus several studies employ percent leafiness as an index of quality. In buffel grass Taerum (1970a,b,c) reported a decline in leafiness from 55.6 to 44.8% in the first two and a half weeks in East Africa. Vicente-Chandler *et al*. (1959a,b) reported little change in percent leaf in pangola grass during maturity in contrast with the bunch type grasses - *Pennisetum purpureum* Schumach. (elephant grass) and *Panicum maximum* Jacq. (guinea grass). However, Minson, Raymond and Harris (1960) and Mowat *et al*. (1965) showed that stem tissue, at early stages of development, may be more digestible than leaf tissue. Furthermore Minson, Raymond and Harris (1960) reported that percent leafiness was higher in cocksfoot than in ryegrass yet digestibility was lower in the former. Thus the importance of percent leafiness *per se* as an index of quality was weakened. Nonetheless, Minson and Laredo (1972) showed that voluntary intake was highly correlated with percent

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leafiness among panicums of similar growth form.

That herbage digestibility declines as the plant matures is widely documented (Minson and McLeod 1970, Mba, Oke and Oyenuga 1973, Olubajo and Van Soest 1974, Falvey 1977). In pangola grass, Johnson and Pezo (1975) in Peru, reported 81% IVD at 2 weeks declining to 66% at 16 weeks, while in Florida, Ventura et al. (1975) reported 68.4% In Vitro organic matter digestibility at 2 weeks, falling to 54.5% at 12 weeks. In a second trial Ventura et al. (ibid) reported 90.2% at 4 weeks and 39.8% at 10 weeks. In giant star grass, on the other hand, Olubajo and Van Soest (1974) reported 47, 47 and 37% IVD at 6, 8 and 10 weeks respectively in Nigeria. Coward-Lord, Arroyo-Aguilu and Garcia Molinari (1974) reported that in Puerto Rico, buffel grass IVD fell from 69.1% at 30 days to 40.3% at 180 days.

Nitrogen content has been reported by Minson (1973) and Barton et al. (1976) to be a more important index of quality in tropical grasses than in temperate ones. Thus total nitrogen (N) is a widely used parameter in studies on quality of tropical forages, and is generally reported as crude protein (N x 6.25) according to the Weende system of proximate analysis (Church 1972). However, Ferguson (1969) has reported that the conversion factor of 6.25 is too high for forages.

In giant star grass, French (1939) obtained 2.51% N at one month, 1.6 - 1.8% for the next three months and 1.15% at 6 months. Similar data have been furnished by Virquez (1965) on pangola and star grass in Brazil. It is apparent from the data of Vicente-Chandler et al. (1959a,b) in Puerto Rico, Norman (1963) in Northern Australia, and Arias and Butterworth (1965) in Brazil, that although leaf N content is higher than stem N, their rates of decline with plant maturity are the

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same. Thus, Vicente-Chandler et al. (1959a,b) reported 0.11% decline per week in the levels of guinea, pangola and elephant grasses while in the stem, they had 0.103% per week. Arias and Butterworth (1965) reported the faster rates of decline of N in elephant grass: 0.223 and 0.231% per week. Brockington (1961) in Rhodesia, reported nitrogen content of buffel grass decreased from 1.76% to 0.64% in the first 4 weeks and to 0.48 - 0.64% by the end of 12 weeks. Similar studies have been reported by Taerum (1970a,b,c) in buffel in Kenya. French (1939) in Tanzania reported that giant star grass had 2.51% N at one month and 1.15% at 6 months; while in Brazil, Virquez (1965) reported 3.33% at 10 days, declining to 1.05% at 40 days and in pangola grass he had 2.47% and 1.28% at 10 and 40 days respectively. Similar reports have been made by Vicente-Chandler et al. (1964) in Puerto Rico, Ventura et al. (1975) and Johnson and Pezo (1975) on pangola grass.

Materials and Methods

In March-June 1974, giant star, buffel and pangola grasses were established in each of two separate trials at the University of Ghana Research Farm, Legon. The first trial commenced during the minor rainy season of 1974 and the second during the major rainy season of 1975. Each trial was established in a four replicate, split plot design with the three species as the main plots and ten harvesting dates as subplots. The subplots were harvested at 3, 4, 5, 6, 7, 8, 9, 11, 13 and 15 weeks. Pangola and giant star were established by sprigging at 15 x 15 cms while buffel grass was seeded at 5 cms in rows 15 cms apart.

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Fertilizer was applied at the rate of 50 kg N, 50 kg P and 80 kg N/ha, broadcast at 6 weeks.

The 1974 trial was slashed on September 17. As pangola did not make much growth thereafter, only giant star and buffel were harvested, starting at three weeks of growth. The second trial was slashed on April 29, 1975 and harvesting began on May 20.

At each harvest, a sample of herbage was taken by randomly picking out material along the length of the plot after it was cut with a Jari mower. The sample was separated into leaves and stems, weighed fresh and dried in a forced draught oven at 80°C for 48 hours to determine leaf/stem proportions of each species. The dried leaf and stem samples were ground in a Wiley mill (1 mm screen). These were analyzed in the Crop Science Department, University of Guelph for In Vitro dry matter digestibility (IVD) using a modified Tilley and Terry method (Mowat et al. 1965) and for total N using a Technicon autoanalyzer.

The data were analyzed as a split plot design with species as the main plots and plant part in the subplots for each harvest date; for the effect of maturity on plant part, species were in the main plots and dates in the subplots for each plant part separately. Differences were tested by Duncan's Multiple Range Test (Steele and Torrie 1960). Regressions of IVD and N on maturity stages were calculated and the lowest order equations of best fit were taken at the 5% level.

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Results and Discussion

Leaf production at the ten harvest dates in the minor rainy season of 1974 and the major rainy season of 1975 is shown in Tables 4.1 and 4.2 and the analyses of variance in Appendix XXXIX. During the minor rainy season of 1974, giant star grass tended to produce more leaf dry matter than buffel, whereas in the major rainy season of 1975, buffel generally produced more than giant star. Pangola gave the lowest leaf yield of the three species, except for the final harvest date.

Leaf production during the minor rainy season of 1974 increased rapidly in both giant star and buffel up to the 4th week (1462 and 1488 kg/ha in giant star and buffel respectively). Giant star started flowering during week 4 and continued to flower and set seed throughout the growth period. Seed production was poor, however. Similarly, buffel grass began flowering by week 3, although the flowers had not opened. Seed development had commenced by week 5 and by week 8, the large quantities of seed coupled with the dry weather appeared to depress leaf yield (1564 kg/ha). The showers of November 19 (week 9) may have induced a flush of foliage (2104 kg/ha). Thereafter dry weather appeared to have retarded leaf development. Thus senescence tended to cause a steady but slight and nonsignificant drop until week 15 (1849 kg/ha) in buffel.

The 1975 data (Table 4.2) show similar features. Giant star did not flower during this trial. Leaf production rose gently until week 8 (3153 kg/ha) but from week 11, leaf yield dropped slightly to 2375 kg/ha by week 15, apparently because of leaf senescence. Buffel trends were similar to 1974: flowering by week 3 and seed filling to

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Table 4.1. Yield of leaves of giant star and buffel grasses during the minor rainy season of 1974.

(Kg/ha dry matter)

Maturity in weeks	Giant star	Buffel
3+	920 $^{b}_{x}$ o	849 $^{b}_{y}$
4	1462 $^{ab}_{x}$	1488 $^{ab}_{x}$
5	1518 $^{ab}_{y}$	1844 $^{a}_{x}$
6	1958 $^{ab}_{x}$	1731 $^{a}_{y}$
7	1986 $^{ab}_{x}$	1781 $^{a}_{y}$
8	1756 $^{ab}_{x}$	1564 $^{ab}_{y}$
9	2112 $^{a}_{x}$	2104 $^{a}_{x}$
11	2077 $^{a}_{x}$	2073 $^{a}_{x}$
13	2744 $^{a}_{x}$	2009 $^{a}_{y}$
15	2162 $^{a}_{x}$	1849 $^{a}_{y}$

+ Weeks from beginning of trial, September 16, 1974.
o Data followed by the same letter are not different ($P > 0.05$): columns - a,b; rows - x,y.

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Table 4.2. Yield of leaves of giant star, buffel and pangola grasses during the major rainy season of 1975.

(Kg/ha dry matter)

Maturity in weeks	Giant star	Buffel	Pangola
3^{+}	307^{d}_{y}	542^{c}_{x}	143^{c}_{z}
4	799^{cd}_{y}	1651^{bc}_{x}	681^{bc}_{z}
5	1285^{c}_{y}	1442^{bc}_{x}	1129^{b}_{z}
6	1653^{bc}_{x}	1388^{bc}_{y}	1540^{b}_{x}
7	2555^{ab}_{x}	2201^{ab}_{y}	1593^{b}_{z}
8	3153^{a}_{x}	2252^{ab}_{y}	2374^{a}_{y}
9	3098^{a}_{y}	3212^{a}_{x}	2333^{a}_{z}
11	2596^{ab}_{y}	2826^{a}_{x}	2109^{a}_{z}
13	2348^{ab}_{y}	2979^{a}_{x}	2194^{a}_{z}
15	2375^{ab}_{y}	2174^{ab}_{z}	2537^{a}_{x}

+ Weeks from beginning of trial, April 29, 1975.

o Data followed by the same letter are not different ($P > 0.05$): columns - a,b,c,d; rows - x,y,z.

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week 6 at the expense of the leaves. The continuing rainfall sustained buffel leaf development so its leaf yield rose to 3212 kg/ha by week 9. Seed filling and the shedding of senescent leaves under declining rainfall apparently resulted in a drop in leaf yield by week 15 (2174 kg/ha). Pangola grass on the other hand started flowering in week 5 in 1975. However, as the rain continued, more stolons were proliferated and new foliage developed reaching a plateau by week 8 (2374 kg/ha). Thereafter there was a lull in rainfall, slowing down leaf development until August 5 - 12 when about 10 mm of rain fell and leaf yield tended to increase. Thus shifts between leaf development and flower formation and the influence of rainfall on them, seem to explain the pattern of leaf dry matter accumulation among the three species.

Since the diet of the grazing ruminant consists largely of leaves (Zemmelink, Haggar and Davies 1972), leaf production may be considered a basis for determining stage of maturity at which herbage may be grazed. It would appear then that during the minor rainy season, giant star could be grazed from week 9 and buffel from week 5, as these are the dates of highest leaf production. In the major rainy season giant star, buffel and pangola may be grazed at 8-9, 9-13 and 8-15 weeks respectively. The yield of digestible nutrients as well as regrowth potential would, however, need to be considered for the precise date to be determined.

During the major rainy season, the grasses had higher leaf proportions in their dry matter yield (36.0 to 90.6%) than they had in the minor rainy season (33.0 to 59.2%). Buffel grass and giant star grass were similar in leaf proportions at the early stages of growth during the minor rainy season but buffel tended to become stemmier than

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giant star as it matured. During the major rainy season, buffel had higher leaf proportions at the early stages (90.6%) than giant star (76.2%) and pangola (75.1%); but buffel declined more rapidly in leaf proportions than the stoloniferous grasses. These differences in leaf proportions may be related to the growth habits of the two types of grasses; being erect, buffel developed higher proportions of stem tissue to maintain its upright habit in contrast with the prostrate grasses. These findings agree with those of Vicente-Chandler et al. (1959a,b), Brockington (1961) and Taerum (1970a,b,c).

Generally IVD of leaves and whole plants decreased as the grasses matured (Figs. 4.1 and 4.2, Tables 4.3 and 4.4, Appendices XL, XLI, XLII, XLIII, XLIV and XLV). These data conform to those reported for temperate and tropical grasses by Minson and McLeod (1970) and for giant star grass by Mba, Oke and Oyenuga (1973). They however are in contrast with those reported by Butterworth and Butterworth (1965) and Grieve and Osbourn (1965) who found an increased digestibility as pangola matured. The stems of buffel increased in IVD only in week 4 of the major rainy season of 1975 (Appendix XLV). This increase, however, agrees with the findings of Haggar and Ahmed (1970, 1971) who reported that IVD increased in growing stems in Andropogon gayanus Kunth. The decrease in IVD as the grasses matured was more pronounced than the differences among species at the same stage of maturity as reported by Blaser, Skrdla and Taylor (1952) and Oyenuga (1957).

The regressions of IVD on maturity are given in Table 4.4. During the minor rainy season of 1974, giant star gave linear relations in both its leaves and its stems but in buffel grass, the relationship was quadratic in the leaves and linear in the stems. During the major

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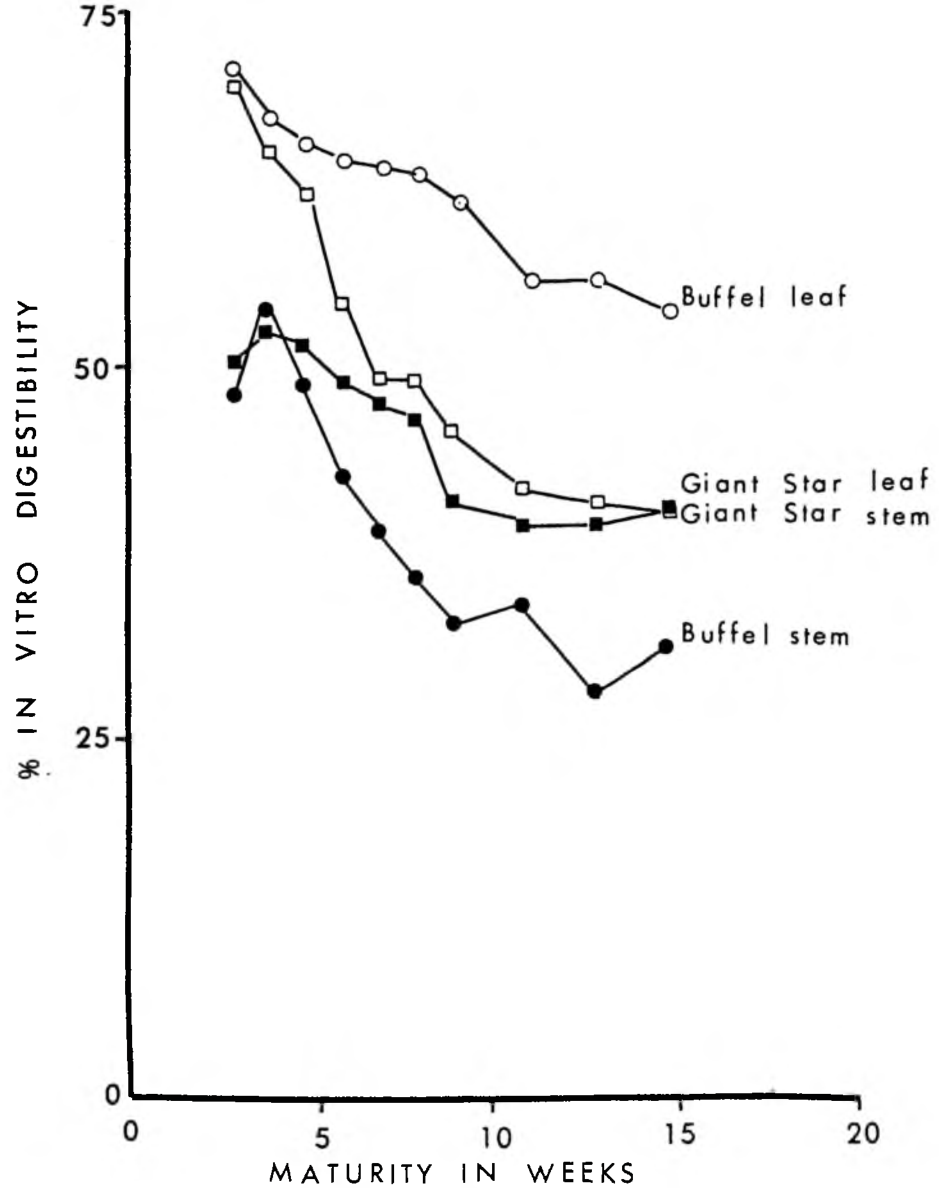

Fig. 4.1. In Vitro dry matter digestibility of leaves and stems of buffel and giant star grasses during the minor rainy season of 1974.

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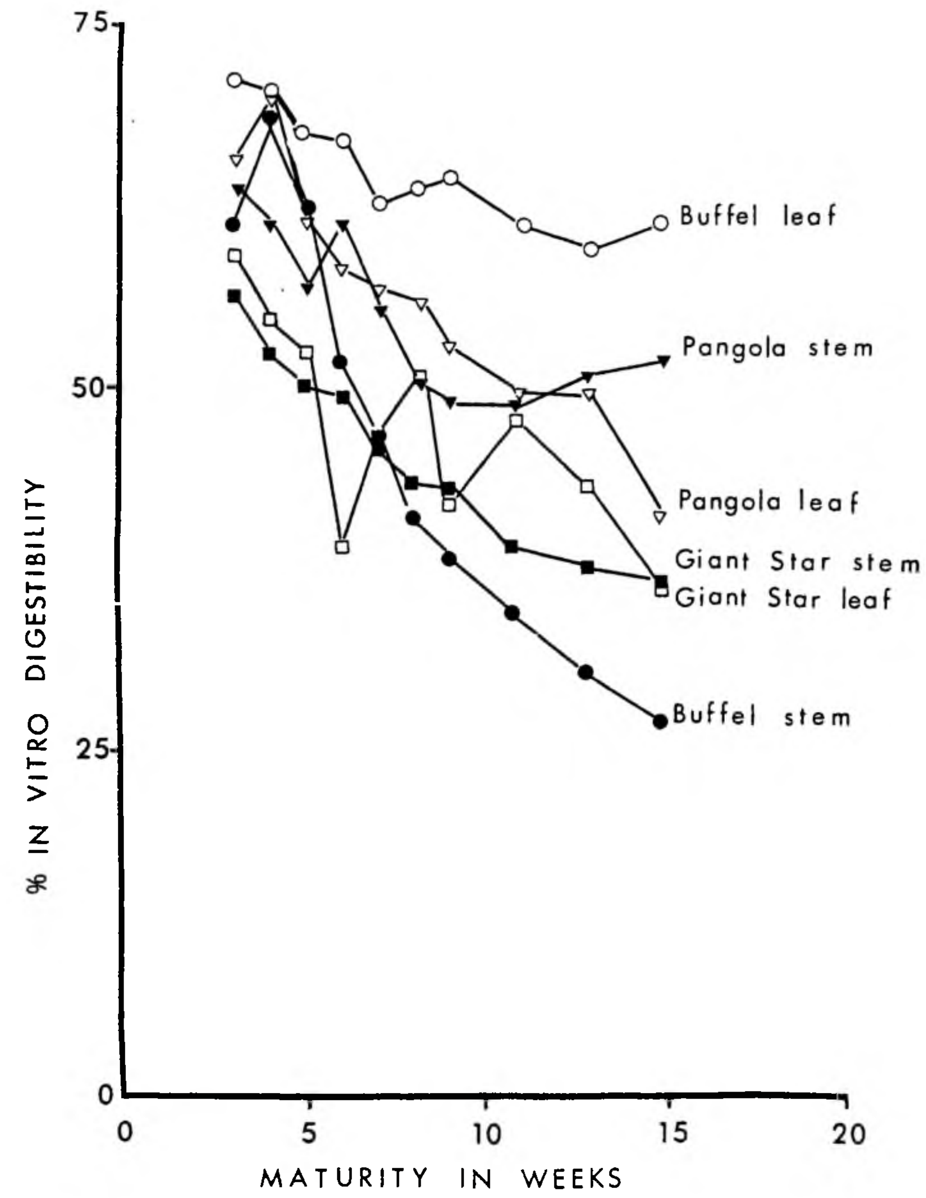

Fig. 4.2. In Vitro dry matter digestibility of leaves and stems of giant star, buffel and pangola grasses during the major rainy season of 1975.

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Table 4.3. Percent In Vitro dry matter digestibility of whole plants of giant star and buffel during the minor rainy season of 1974 (upper) and of giant star, buffel and pangola grasses during the major rainy season of 1975 (lower).

1974 - Minor rainy season

	Maturity									
	3^{+} Oct. $8^{\ddagger}$	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Giant star	$61.0^{a\,o}_{x}$	59.3^{b}_{x}	57.1^{b}_{x}	51.6^{c}_{x}	48.3^{c}_{x}	47.7^{c}_{x}	43.3^{d}_{x}	40.5^{d}_{x}	40.3^{d}_{x}	40.8^{d}_{x}
Buffel	60.6^{ab}_{x}	62.0^{a}_{x}	57.0^{b}_{x}	53.1^{b}_{x}	50.0^{c}_{x}	46.9^{cd}_{x}	47.8^{cde}_{x}	43.8^{de}_{x}	44.6^{de}_{x}	41.7^{e}_{x}

1975 - Major rainy season

	Maturity									
	3^{+} May $20^{\ddagger}$	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Giant star	57.7^{a}_{z}	53.8^{ab}_{y}	51.6^{abc}_{z}	42.3^{def}_{y}	46.5^{cde}_{x}	47.2^{bcd}_{x}	41.8^{def}_{y}	43.7^{de}_{x}	40.0^{ef}_{y}	36.2^{f}_{y}
Buffel	70.3^{a}_{x}	69.9^{a}_{x}	65.5^{a}_{x}	59.2^{b}_{x}	53.9^{bc}_{x}	51.3^{cd}_{x}	51.1^{cd}_{x}	46.2^{de}_{x}	42.6^{ef}_{y}	38.6^{f}_{y}
Pangola	64.7^{ab}_{y}	67.7^{a}_{x}	60.5^{bc}_{y}	55.6^{cd}_{x}	54.5^{cde}_{x}	52.9^{def}_{x}	50.3^{def}_{x}	48.7^{ef}_{x}	49.8^{def}_{x}	46.2^{f}_{x}

\+ Weeks from beginning of trial: September 16, 1974; April 29, 1975.
‡ Harvest date during the minor rainy season of 1974 or major rainy season of 1975.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e; columns within years - x,y,z.

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Table 4.4. Regressions of percent In Vitro dry matter digestibility on maturity of giant star and buffel grasses during the minor rainy season of 1974 and of giant star, buffel and pangola grasses during the major rainy season of 1975.

	1974 Minor rainy season	r^2	1975 Major rainy season	r^2
<u>Giant star</u>				
Whole plant	$Y = 75.9 - 5.09x^2 + 0.18x$	0.92**	$Y = 59.1 - 1.58x$	0.65**
Leaves	$Y = 73.2 - 1.34x$	0.81**	$Y = 57.5 - 1.33x$	0.41**
Stems	$Y = 55.7 - 2.04x$	0.69**	$Y = 58.7 - 1.69x$	0.87**
<u>Buffel</u>				
Whole plant	$Y = 64.3 - 1.64x$	0.68**	$Y = 77.2 - 2.75x$	0.90**
Leaves	$Y = 90.0 - 7.35x + 0.27x^2$	0.94**	$Y = 72.1 - 0.03x$	0.60**
Stems	$Y = 55.8 - 1.21x$	0.74**	$Y = 74.4 - 3.53x$	0.84**
<u>Pangola</u>				
Whole plant			$Y = 68.4 - 1.64x$	0.67**
Leaves			$Y = 72.4 - 2.06x$	0.82**
Stems			$Y = 63.4 - 1.10x$	0.42**

** Significant ($P < 0.01$).
x Weeks.
Y Percent In Vitro dry matter digestibility.

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rainy season of 1975, however, IVD was linearly related to maturity in both leaves and stems of giant star, buffel and pangola grasses (Table 4.4). The regressions in the two years were therefore not consistent.

The rates of decline in IVD in giant star tended to be higher in the leaves than in the stems during the minor rainy season (Fig. 4.1 and Table 4.4). In buffel grass, the stems tended to deteriorate faster in IVD than the leaves in both seasons. In pangola grass, leaf IVD declined faster than stem IVD during the major rainy season. The rates of decline were about 0.21 - 0.31 percentage points per day which are lower than 0.5 points per day reported by Reid (1959) in temperate grasses.

Whole plants of giant star and buffel did not differ in IVD during the minor rainy season (Table 4.3, Appendix XVIV). This appeared to be due to the fact that the leaves of buffel were more digestible than giant star leaves from weeks 6 to 15, whereas the stems of giant star were superior to buffel stems during this period (Fig. 4.1, Appendix XLIV). During the major rainy season of 1975, pangola whole plants were similar to buffel whole plants in IVD and both were superior to giant star whole plants (Table 4.3, Appendix XLV). The leaves of buffel were however superior to pangola, which was also higher in IVD than giant star (Fig. 4.2, Appendix XLV). In the stems on the other hand, buffel tended to be more digestible than the other two grasses at weeks 4 and 5. However, buffel stem IVD fell rapidly (Fig. 4.2). From week 6, it was below pangola and after week 9 below giant star.

Leaf IVD was higher than stem IVD in all species in both years (Figs. 4.1 and 4.2, Appendices XLIII, XLIV and XLV). This agrees with reports by Mowat et al. (1965), Sullivan (1969), Raymond (1969), Minson and McLeod (1970), Bailey (1973) and Moore and Mott (1973). This is

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in contrast with Minson (1973) who reported higher stem digestibility than leaves in guinea grass (Panicum maximum Jacq.). The differences in leaf IVD and stem IVD were most striking in buffel grass both in the minor and the major rainy seasons, in contrast with the prostrate pangola and giant star, especially at the mature stages. This difference may be related to the amount of stem lignification that is required to support the erect buffel grass. This aspect of the differences among the three grasses merits investigation.

There was progressive decline in the nitrogen levels in whole plants, leaves and stems of all three grasses as they matured (Figs. 4.3 and 4.4, Tables 4.5 and 4.6, Appendices XLVI, XLVIII, L and LI). This agrees with reports by Paterson (1933), French (1942), Oyenuga (1957), Arias and Butterworth (1965) and Virquez (1965). The rates of decline of N are given in the regressions in Table 4.6. The nitrogen levels in the leaves generally fell faster than in the stems of all the three grasses in both years. This disagrees with Vicente-Chandler et al. (1959a,b) who reported similar rates of decline in both leaves and stems of pangola, signal, elephant and guinea grasses.

Nitrogen had a quadratic relationship with maturity in the leaves of giant star grass and both leaves and stems of buffel grass in 1974. Giant star stems, on the other hand, gave a linear regression. The relations were linear in the leaves and the stems of all the three grasses in 1975 (Table 4.6).

The whole plants of giant star and buffel did not differ in nitrogen levels during the minor rainy season of 1974 except in week 3 when buffel was higher (Table 4.5, Appendices XLVII, XLVIII, L and LI). In weeks 3 to 5 of the major rainy season of 1975, however, buffel and

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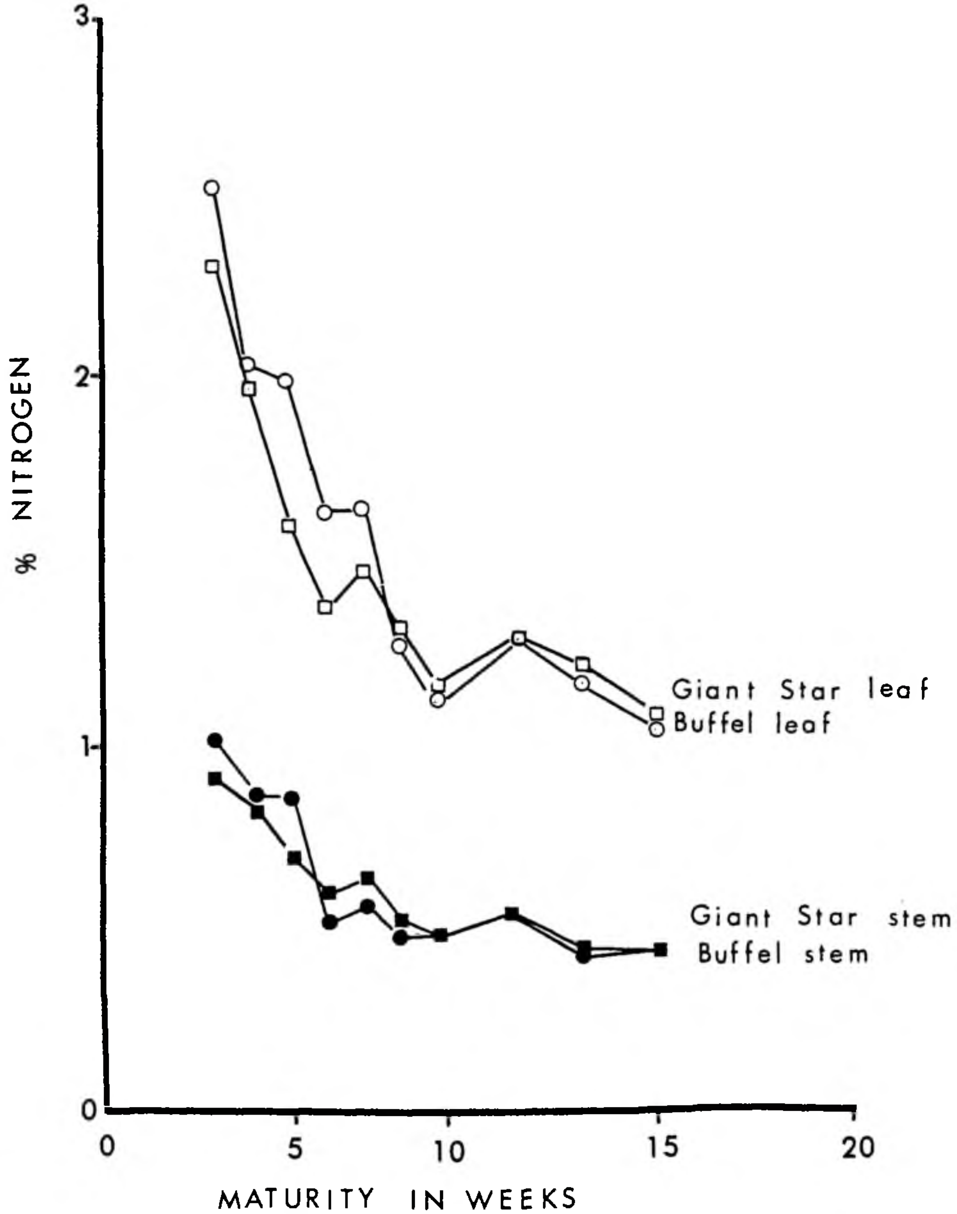

Fig. 4.3. Percent nitrogen content of leaves and stems of giant star and buffel grasses during the minor rainy season of 1974.

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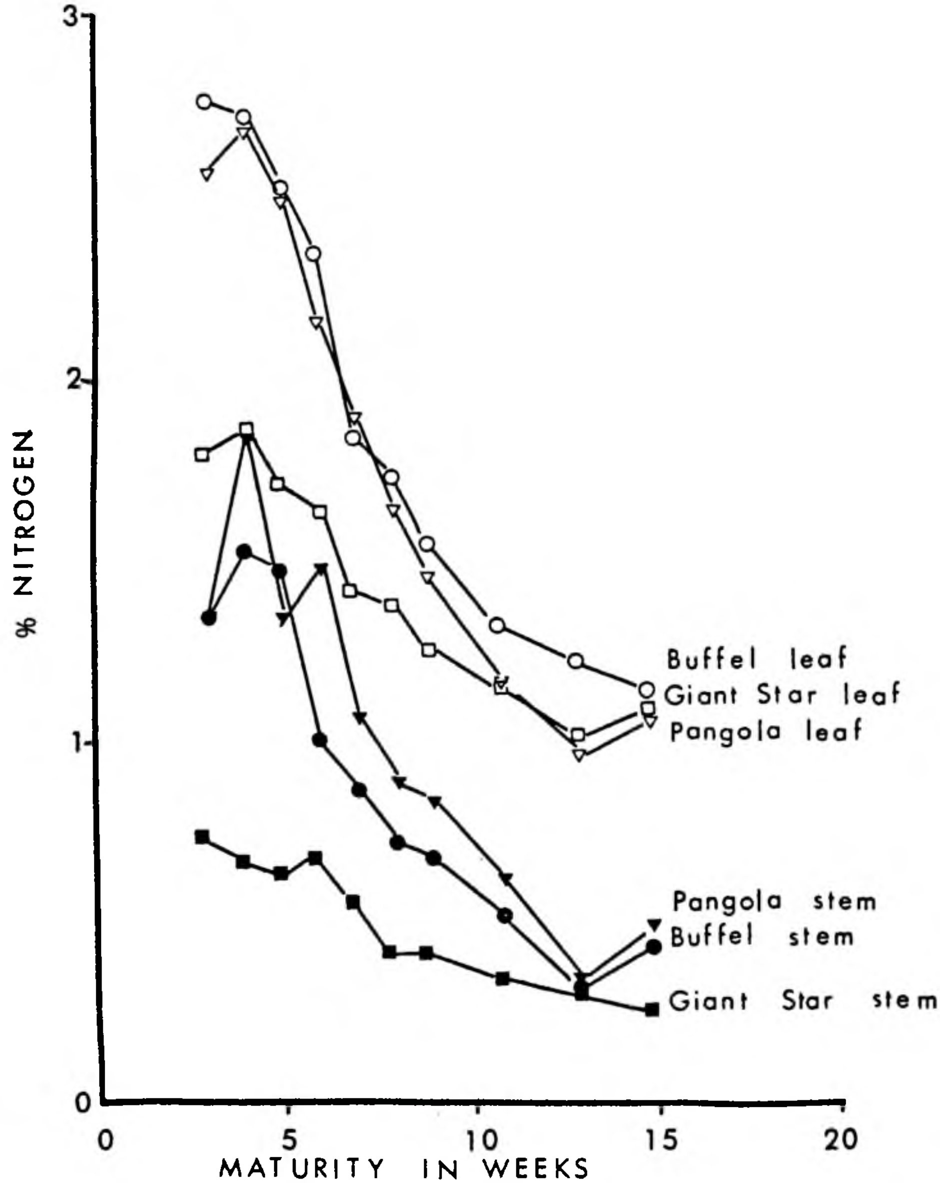

Fig. 4.4. Percent nitrogen content of leaves and stems of giant star, buffel and pangola grasses during the major rainy season of 1975.

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Table 4.5. Percent nitrogen of whole plants of giant star and buffel during the minor rainy season of 1974 (upper) and of giant star, buffel and pangola during the major rainy season of 1975 (lower).

1974 - Minor rainy season

	Maturity									
	3[+] Oct. 8[‡]	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Giant star	1.47$^{a}_{s}$	1.30$^{ab}_{r}$	1.18$^{abc}_{r}$	0.90$^{c}_{r}$	0.96$^{c}_{r}$	0.81$^{cd}_{r}$	0.63$^{d}_{r}$	0.83$^{cd}_{r}$	0.73$^{d}_{r}$	0.66$^{d}_{r}$
Buffel	1.61$^{a}_{r}$	1.44$^{ab}_{r}$	1.30$^{bc}_{r}$	1.00$^{c}_{r}$	0.98$^{c}_{r}$	0.78$^{c}_{r}$	0.80$^{c}_{r}$	0.91$^{c}_{r}$	0.92$^{c}_{r}$	0.77$^{c}_{r}$

1975 - Major rainy season

	Maturity									
	3[+] May 20[‡]	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Giant star	1.54$^{a}_{s}$	1.57$^{a}_{s}$	1.43$^{a}_{s}$	1.29$^{ab}_{r}$	1.13$^{b}_{r}$	1.05$^{bc}_{r}$	0.90$^{bcd}_{r}$	0.80$^{bcd}_{r}$	0.69$^{cd}_{r}$	0.67$^{d}_{r}$
Buffel	2.62$^{a}_{r}$	2.46$^{a}_{r}$	2.12$^{b}_{r}$	1.62$^{c}_{r}$	1.30$^{d}_{r}$	1.16$^{de}_{r}$	1.07$^{de}_{r}$	0.85$^{ef}_{r}$	0.67$^{f}_{r}$	0.67$^{f}_{r}$
Pangola	2.25$^{a}_{r}$	2.49$^{a}_{r}$	2.26$^{a}_{r}$	1.87$^{b}_{r}$	1.51$^{c}_{r}$	1.31$^{d}_{r}$	1.15$^{de}_{r}$	0.89$^{ef}_{r}$	0.64$^{f}_{r}$	0.76$^{f}_{r}$

\+ Weeks from beginning of trial, September 16, 1974 and April 29, 1975.
‡ Harvest date during the minor rainy season of 1974 or major rainy season of 1975.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e,f; columns within years - r,s.

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Table 4.6. Regression of percent nitrogen on maturity of giant star and buffel grasses during the minor rainy season of 1974 and of giant star, buffel and pangola grasses during the major rainy season of 1975.

	1974 Minor rainy season	r^2	1975 Major rainy season	r^2
Giant star				
Whole plant	$Y = 2.33 - 0.287x + 0.012x^2$	0.76**	$Y = 1.78 - 0.083x$	0.86**
Leaves	$Y = 3.02 - 0.320x + 0.013x^2$	0.64**	$Y = 2.02 - 0.074x$	0.79**
Stems	$Y = 0.90 - 0.035x$	0.47**	$Y = 0.84 - 0.041x$	0.78**
Buffel				
Whole plant	$Y = 2.67 - 0.337x + 0.015x^2$	0.74**	$Y = 4.06 - 0.508x + 0.019x^2$	0.95**
Leaves	$Y = 2.46 - 0.390x + 0.016x^2$	0.84**	$Y = 3.12 - 0.152x$	0.85**
Stems	$Y = 1.42 - 0.170x + 0.008x^2$	0.47**	$Y = 1.66 - 0.098x$	0.73**
Pangola				
Whole plant			$Y = 2.82 - 0.162x$	0.77**
Leaves			$Y = 3.06 - 0.157x$	0.80**
Stems			$Y = 1.92 - 0.111x$	0.60**

** Significant ($P < 0.01$).
x Weeks.
Y Percent nitrogen.

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pangola were similar in their whole plant nitrogen content but were superior to whole plant giant star grass. The former declined very rapidly and after week 6, the three grasses were not different in the nitrogen content of their whole plants.

Leaf and stem nitrogen levels were similar in giant star and buffel in 1974 but in 1975, buffel and pangola were superior to giant star grass in both leaf and stem nitrogen from weeks 3 to 7. Thereafter, the three grasses were not different in the nitrogen content of leaves and stems (Figs. 4.3 and 4.4, Appendices L and LI).

Leaves had higher levels of nitrogen than stems in all the three grasses at all stages of maturity (Figs. 4.3 and 4.4, Appendix XLIX) in agreement with reports by Vicente-Chandler et al. (1964) on pangola, guinea and elephant grasses.

Because nitrogen influences the extent to which rumen microbes can ferment forages (Sullivan 1969, Church 1972), high correlations were obtained between IVD and N of leaf and stem fractions of all grasses in both years (Table 4.7) except in giant star stems in 1975. Perhaps this anomaly in giant star stems could be linked with its low nitrogen content, 0.76% at week 3 and 0.28% at week 15 compared with 1.35% to 0.43 - 0.49% in the other two grasses. The high correlation agrees with the report by Barton et al. (1976). Thomas and McLaren (1971) on the other hand, reported low correlations between IVD and N in pangola.

Minson (1967) reported that N limits digestibility only when it is deficient in the diet. He suggested 1.44% as the minimum limit as this was the lowest level required for positive N balance in the ruminant. From work on nitrogen supplementation to tropical ruminants however, it would appear that tropical ruminants may adapt to declining

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Table 4.7. Correlation coefficients between In Vitro dry matter digestibility and nitrogen in leaves and stems of giant star and buffel grasses during the minor rainy season of 1974 and of giant star, buffel and pangola grasses during the major rainy season of 1975.

		1974	1975
Giant star	Leaves	0.92**	C.02
	Stems	0.86**	0.99**
Buffel	Leaves	0.71*	0.96**
	Stems	0.79**	0.98**
Pangola	Leaves		0.94**
	Stems		0.85**

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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nitrogen levels to as low as 0.8% if the rate of decline in nitrogen is gradual enough for the rumen microbes to adapt in kinds and numbers (Topps and Elliott 1965 in Rhodesia, Alhassan 1970 at Kumasi, Ghana, Attakrah 1971, B.Sc. Dissertation, Faculty of Agriculture, Legon, Ghana, Tuah and Tetteh 1972, Kumasi, Ghana). On this basis, nitrogen levels from giant star, buffel and pangola grasses in this study would be inadequate for maintenance after week 7 in the minor rainy season of 1974 and week 11 in the major rainy season of 1975.

The yields of digestible dry matter in the three grasses are shown in Table 4.8 and Appendices LII, LIII, LIV and LV. Digestible dry matter accumulated in the whole plants of all species with advancing maturity to a plateau at weeks 6 and 7 in the minor rainy season of 1974 and weeks 7 to 9 in the major rainy season of 1975. The plateau was reached 1 to 2 weeks earlier in the prostrate grasses than in buffel grass in 1975 (Table 4.8, Appendices LII, LIV and LV).

No species differences were discerned in whole plant digestible dry matter production in 1974 although buffel tended to yield more digestible foliage during the season than giant star grass (Table 4.8, Appendix LIV). During the major rainy season of 1975, on the other hand, buffel produced more digestible dry matter in the whole plants, leaves and stems than the prostrate grasses which did not differ from each other (Table 4.8, Appendix LV). Although there were occasional exceptions to this trend, this tendency agrees with the report by Falvey (1977) that buffel produced more digestible dry matter than pangola grass in Australia.

The leaves tended to contribute more than the stems to whole plant digestible dry matter during the minor rainy season of 1974 but

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Table 4.8. Yield of In Vitro digestible dry matter of whole plants of giant star and buffel grasses during the minor rainy season of 1974 (upper) and of giant star, buffel and pangola grasses during the major rainy season of 1975 (lower).

(Kg/ha dry matter)

1974 - Minor rainy season

	Maturity									
	3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Giant star	$1032^{c\,o}_{x}$	1490^{bc}_{x}	1763^{ab}_{x}	2125^{a}_{x}	2162^{a}_{x}	2046^{ab}_{x}	1868^{ab}_{x}	1756^{ab}_{x}	1928^{ab}_{x}	1825^{ab}_{x}
Buffel	978^{c}_{x}	1741^{b}_{x}	2024^{ab}_{x}	2366^{a}_{x}	2274^{ab}_{x}	2140^{ab}_{x}	2287^{ab}_{x}	2274^{ab}_{x}	2149^{ab}_{x}	2051^{ab}_{x}

1975 - Major rainy season

	Maturity									
	3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Giant star	$233^{c\,o}_{xy}$	564^{bc}_{y}	899^{b}_{y}	1064^{b}_{z}	1890^{a}_{y}	2270^{a}_{x}	2212^{a}_{y}	2016^{a}_{y}	1807^{a}_{z}	1720^{a}_{y}
Buffel	420^{c}_{x}	1411^{c}_{x}	1453^{c}_{x}	1681^{c}_{x}	2304^{b}_{x}	2369^{b}_{x}	3183^{a}_{x}	3045^{a}_{x}	2919^{a}_{x}	2337^{b}_{x}
Pangola	134^{e}_{y}	577^{de}_{y}	834^{cd}_{y}	1300^{bc}_{y}	1524^{b}_{x}	2190^{a}_{x}	2299^{a}_{y}	2064^{a}_{y}	2327^{a}_{y}	2420^{a}_{x}

+ Weeks from beginning of trial, September 16, 1974 and April 29, 1975.
‡ Harvest date during the minor rainy season 1974 or the major rainy season of 1975.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e; columns within years - x,y,z.

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in the major rainy season of 1975, this superiority of leaf contribution to the digestible dry matter harvest was more striking (Appendices LIII, LIV and LV). The digestible dry matter yields obtained by Vicente-Chandler et al. (1964) under humid and high fertilizer conditions in Puerto Rico, were higher than those found in this study.

Assuming leaf digestible dry matter production as the basis for grazing the sward and whole plant digestible dry matter yield for harvesting stored feed, it would seem that during the minor rainy season giant star should be grazed in weeks 6-7 and buffel in week 6 for maximum digestible dry matter yield; during the major rainy season giant star could be harvested at 7-15 weeks, buffel at 9-15 weeks and pangola at 8-15 weeks.

The yields of nitrogen from the three grasses are shown in Table 4.9 and Appendices LII, LVI, LVII and LVIII. The yield of total nitrogen of the whole plants, leaves and stems of the three grasses appeared to increase to a peak and then fall in both years. In the minor rainy season, giant star reached a peak in whole plant nitrogen (45.3 kg/ha) at week 7, while in buffel it occurred at 5 weeks (51.1 kg/ha). In the leaves, giant star accumulated its maximum levels in weeks 4, 7 and 13, while buffel leaves reached their peak at week 5; in the stem the peaks were obtained in weeks 7-8 (14.8 - 15.7% kg/ha) in giant star and week 11 in buffel grass. In the major rainy season, the whole plants reached their maximum nitrogen yield in weeks 7-9 in giant star, week 9 in buffel and weeks 8-9 for pangola grass, while the leaves reached their maximum nitrogen yields in weeks 8-9 (Table 4.9, Appendices LVII and LVIII).

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Table 4.9. Yield of nitrogen of whole plants of giant star and buffel grasses during the minor rainy season of 1974 (upper) and of giant star, buffel and pangola grasses during the major rainy season of 1975 (lower).

(Kg/ha dry matter)

1974 - Minor rainy season	Maturity									
	3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Giant star	28.4^{g}_{q}	37.3^{d}_{q}	35.5^{e}_{q}	39.9^{c}_{q}	45.3^{a}_{q}	38.3^{cd}_{q}	35.0^{e}_{q}	39.1^{cd}_{q}	42.9^{b}_{q}	32.8^{f}_{q}
Buffel	29.3^{g}_{q}	42.4^{cd}_{q}	51.1^{a}_{q}	41.4^{d}_{q}	43.5^{bc}_{q}	34.8^{f}_{q}	37.9^{e}_{q}	44.7^{b}_{q}	40.7^{d}_{q}	35.8^{f}_{q}

1975 - Major rainy season	Maturity									
	3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Giant star	6.2^{e}_{s}	16.5^{d}_{s}	34.4^{bc}_{r}	41.3^{b}_{r}	44.6^{a}_{r}	50.3^{a}_{r}	47.8^{ab}_{r}	37.2^{bc}_{r}	31.1^{c}_{r}	31.9^{c}_{r}
Buffel	15.7^{d}_{q}	49.8^{b}_{q}	47.0^{bc}_{q}	44.8^{c}_{q}	55.3^{b}_{q}	53.4^{b}_{qr}	66.2^{a}_{q}	55.1^{b}_{q}	49.4^{b}_{q}	40.5^{c}_{q}
Pangola	4.3^{f}_{r}	21.3^{e}_{r}	31.2^{c}_{r}	43.1^{b}_{qr}	41.9^{b}_{r}	54.2^{a}_{q}	52.6^{a}_{r}	37.4^{bc}_{r}	29.7^{d}_{r}	39.6^{b}_{q}

\+ Weeks from beginning of trial, September 16, 1974 and April 29, 1975.

‡ Harvest date during the minor rainy season 1974 or the major rainy season 1975.

o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e,f,g; columns within years - q,r,s.

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Although no species differences occurred in nitrogen yields of leaves, stems or whole plants at any harvest date during the minor rainy season of 1974, buffel grass generally yielded more nitrogen in its whole plants, leaves and stems than the stoloniferous grasses during the major rainy season of 1975 (Table 4.9, Appendices LVII and LVIII). The latter trend agrees with Falvey (1977) who reported that buffel outyielded pangola in nitrogen production in North Australia. Vicente-Chandler et al. (1964) on the other hand, found that bunch type grasses yielded similar nitrogen levels to pangola while in other tests (Vicente-Chandler et al. ibid) they reported that pangola was more efficient in recovering fertilizer nitrogen than bunch type grasses. Vicente-Chandler (1975) reported that giant star grass was more efficient than pangola in the yield of nitrogen. This is in contrast with the findings of this study.

For maximum nitrogen yield, giant star would be grazed at week 7 and buffel at week 5, in the minor rainy season, but for mowed stored feed the stages indicated are 5 and 7 weeks for giant star and buffel respectively. During the major rainy season, the maximum nitrogen yields in leaves for grazing were obtained in weeks 8, 9 and 8 for giant star, buffel and pangola respectively; while for mowing the dates for highest yields were 7-8 weeks for giant star, 9-13 weeks for buffel and 8-15 weeks for pangola grass. The harvest dates inferred from leaf production, IVD yields and N yields would need to be combined with their effects on regrowth potential and on longevity of the sward among other factors (e.g., animal management system and economics) to determine the harvesting schedule.

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The leaves contributed more nitrogen than the stems to whole plant nitrogen yield in all the grasses during both seasons, thus confirming the importance of the leaves in the supply of quality feed in grasses as stated by Minson and Laredo (1972) and Bailey (1973).

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Summary

Giant star and buffel gave similar leaf dry matter accumulation during the minor rainy season of 1974 while pangola grass was drought sensitive and failed to grow. During the main rainy season, all the three grasses gave similar leaf dry matter accumulation. Leaf yield was depressed by flowering and seed setting in all species. Senescent leaves of buffel were held on the plant while pangola and giant star dropped their old leaves.

Buffel tended to be leafier than the prostrate giant star and pangola at the early stages but at mature stages it was more stemmy. Leaf proportions appeared to be higher during the major rainy season than in the minor rainy season in all grasses.

Percent IVD and N decreased with maturity in all species. Leaves were higher in N and were more digestible than the stems. Rapid growth seemed to raise stem IVD in buffel grass during the early stages.

Both total nitrogen and digestible dry matter production rose to a peak in 7–8 weeks in giant star and pangola, and 9 weeks in buffel and then tended to fall slightly. Buffel accumulated more digestible dry matter and N than pangola and giant star grasses.

The stages of maturity to harvest the grasses would appear to be 7 and 5 weeks for giant star and buffel during the minor rainy season. In the major rainy season, the harvesting stages would be 8 weeks for giant star and pangola and 9 weeks for buffel.

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GENERAL DISCUSSION

In view of the studies conducted on natural grassland and the three introduced grasses certain observations may be made regarding the comparative usefulness of the two groups of forages in the Accra Plains.

In the natural grassland, Sporobolus began growth and reached its peak production early and then declined. On the other hand, Heteropogon began its period of grand growth later than Sporobolus. The total yield in the natural grassland therefore continued to rise reaching a peak by week 18. The introduced grasses on the other hand, grew more rapidly than the two natural grasses and reached their peak of production by weeks 9 to 13 in the minor rainy season and week 9 in the major rainy season. The introduced grasses appeared to be higher in yield than the natural grassland at the same stages of growth during the rainy season. Recovery rates were of similar magnitude although natural grassland appeared to recover slightly faster than the cultivated grasses. In both types of grassland, a minimum of 9 to 12 weeks recovery period was required to reach maximum recovery yield of dry matter for use in the dry season. Growth occurred in both types of sward during the dry period.

Sporobolus was similar to buffel in earliness to flower: less than four weeks, while Heteropogon was similar to pangola grass and giant star grass in maturing later. However, while Sporobolus declined quickly, buffel sustained its dry matter accumulation over a long period. At the same stages of growth, Sporobolus and Heteropogon had higher leaf proportions in their dry matter yields than the introduced species.

The quality of natural grassland herbage was similar to the introduced grasses at the early stages of growth: IVD was about 60% in

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the whole plant. The erect species, both natural and cultivated, tended to deteriorate in IVD faster than the prostrate cultivated grasses.

The nitrogen content of the natural grassland species appeared to be slightly above the cultivated grasses at the same stages of growth. However by the 15th week the N levels had fallen to about the same in both planted and natural species. It would therefore seem that both natural grassland and cultivated grasses had similar quality characteristics. However, the cultivated species grew faster and produced more fodder at the start of the rainy season. These findings are the reverse of Falvey's (1977) report that natural grassland produced higher yields than pangola, buffel and other introduced grasses in the rainy season although the quality of herbage was inferior to the introduced species. The poorer quality of natural grassland compared with cultivated grassland has also been noted by Reid et al. (1973). On the other hand, recovery yields after the rainy season harvest in the present study were similar in both groups of forages. Falvey (1977) also found that dry matter yields during the dry season were comparable in both native and introduced species. Thus the cultivated grasses could be provided for use early in the season before switching to natural grassland, thereby permitting the cultivated grasses to recover. The natural grassland and cultivated grasses would therefore be used alternately.

The nitrogen content of both the natural grassland and the cultivated grasses fell too low at the mature stages, even for maintenance. To maintain high production at the levels of performance demanded by modern livestock systems, the nitrogen requirements should be about 2.5% (Sullivan 1969). Such levels of nitrogen could only be furnished in the minor rainy season by the leaves of buffel at 3 weeks,

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and in the major rainy season by leaves of buffel and pangola at 3 to 5 weeks or by whole plants of buffel at 3 to 4 weeks, but at these stages, dry matter production was low.

There is little information on the nutrient requirements of tropical ruminants, and although their minimum requirements may be lower than temperate animals as suggested by Topps and Elliott (1965) and Fianu et al. (1972), the levels required for the full expression of their genetic potential production may be of similar magnitude to those of temperate animals with due allowance for ambient temperatures, etc. Thus the nitrogen levels obtained in the forages in this study would probably be inadequate for high animal production if mowed at the suggested 7 to 9 weeks of maturity. To raise the dietary nitrogen levels in the use of these and such mature coarse herbage, various suggestions have been made: irrigation and fertilization of pastures for supplementing natural grazing (Adjei 1972, B.Sc. Dissertation, Faculty of Agriculture, Legon, Ghana), ensilage (Lansbury 1959, Tuah 1971), Hay (Adjei 1972 ibid), supplemental feeding with concentrates (Wharton, Shepard and Buamah 1967, Burton and Asiedu 1972), the use of urea in supplemental feeds (Fianu et al. 1972, Tuah and Adenku-Tetteh 1972), cultivation of shrubby legumes in natural grasslands (Rose Innes 1965), cultivation of grasses mixed with herbaceous legumes (Asare 1974). Other possible ways of solving this nitrogen deficiency problem in feeding low quality herbage include (a) the use of manure treated with sterilants (Smith et al. 1977) or ensiled with herbage (Berger et al. 1977), (b) sodseeding natural grassland with herbaceous legumes. With highly mature grasses, avitaminosis-A and low energy in the herbage could compound the nutrient deficiency. These could be overcome by

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vitamin A supply in the mineral lick and by delignifying the coarse forage by alkali treatment (Oji and Mowat 1977). Delignification could also render more useful the straw of rice, sorghum, maize, etc. as energy supplement to coarse pasture grasses, possibly with urea or manure provided a more readily fermentable energy source such as molasses or cassava chips is added. The diet of cattle grazing in the rangelands of the Accra Plains includes a variable proportion of high quality browse plants which raise the animal's nutrient intake (Rose Innes and Mabey 1964, Fianu 1966, B.Sc. Dissertation, University of Ghana, Legon). Such browse plants as well as other supplements are fed to backyard sheep and goats to upgrade their diet (Fianu et al. 1972).

From the point of view of the yields of digestible nutrients and of nitrogen in herbage dry matter, it would appear that buffel and giant star could provide fodder for use during the minor rainy season. They were similar in digestible dry matter yield and nitrogen yield. For the major rainy season, buffel grass appeared to be the superior species. However buffel being erect in growth habit would lend itself more readily to harvesting by mowing. The stoloniferous grasses, particularly pangola, would be more suited to grazing than mowing by virtue of their prostrate growth habit. This use was suggested by Nestel and Creek (1962) for pangola.

During selective grazing, the ruminants diet is largely foliar (Laredo and Minson 1975, Zemmelink, Haggar and Davies 1972), while herbage harvested by mowing consists indiscriminately of leaves and stems. Thus the stage of herbage maturity for grazing may be based on leaf production, leaf IVD and leaf N, while the stage to mow for stored feed may be determined from total herbage dry matter yield as well as the yields

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of IVD and N of whole plants.

It would appear that during the minor rainy season of 1974 giant star could be grazed at 6 weeks and buffel at 5 weeks, because at these stages the grasses combined high yields of digestible foliage (1071 kg/ha and 1210 kg/ha for giant star and buffel respectively) with high yields of leaf nitrogen (29.6 kg/ha in giant star and 37.5 kg/ha in buffel grass). In both species, some leaf dry matter yield would be sacrificed to obtain the highest levels of nutrient production.

During the major rainy season, the optimum stage for grazing giant star appeared to be week 8, which satisfied the three criteria - maximum leaf dry matter yield (3153 kg/ha), maximum leaf - IVD yield (1561 kg/ha) and maximum leaf - N yield (43.2 kg/ha). In buffel grass, the stage of maturity indicated for grazing during the major rainy season of 1975 was 9 weeks. At that stage, the yields of leaf dry matter, leaf - IVD and leaf - N were 3212, 2046 and 48.8 kg/ha respectively. The grazing date for pangola grass during the major rainy season would also appear to be week 8, for this was the date of the second highest leaf dry matter production (2374 kg/ha), the highest leaf - IVD yield (1318 kg/ha) and the greatest leaf - N yield (38.5 kg/ha) during the season.

At the stages of maturity suggested for each of the three species, percent IVD and N in the leaves were fairly high. During the minor rainy season, nitrogen concentrations in the leaves of giant star and buffel were 1.38% and 2.01% respectively at the recommended grazing stage; the corresponding IVD levels were 54.7 and 65.6%. During the major rainy season, giant star, buffel and pangola grasses had 1.37, 1.52 and 1.62% N respectively in their leaves, while the respective IVD

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levels were 49.5, 63.7 and 55.5%. The low IVD (49.5% - 55.5%) of giant star and pangola during the rainy season may be remedied by supplementation with concentrates.

For mowing during the minor rainy season as stored feed, giant star grass would supply the highest amounts of whole plant digestible nutrients (2162 kg/ha) and nitrogen (43.5 kg/ha) at 7 weeks. These are slightly lower than the levels obtained at 6 weeks, the grazing stage. However, the difference in digestible dry matter was not significant. On the other hand, in buffel grass, the mowing date indicated was the same as the grazing stage of 5 weeks, during the minor rainy season. In the major rainy season, however, both the grazing date and mowing date coincide in all the grasses, i.e., 8 weeks in giant star and pangola and 9 weeks in buffel. For a rule of thumb, therefore, mowing and grazing dates may be the same and the earlier of the two dates would seem preferable, for in utilizing giant star at 7 weeks (mowing date) instead of 6 weeks (grazing date) during the minor rainy season, leaf IVD fell from 54.7 to 49.6% which was significantly different ($P < 0.05$), although percent leaf nitrogen levels were not different. The percent IVD and N in whole plants were also not different at the two dates.

From the totals of seasonal herbage dry matter production harvesting giant star at 6 weeks during the minor rainy season would provide regrowth to result in seasonal total herbage yields of 6341 kg/ha (highest to the end of the rainy season), 7116 kg/ha at mid-dry season (not different from the highest seasonal total of 7205 kg/ha for 7 weeks) and 7399 kg/ha at the end of the dry season (not different from the highest total of 7894 kg/ha at 8 weeks). In buffel grass, too, the

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seasonal sums of the yields at the recommended 5 week harvest stage during the minor rainy season (3513 kg/ha) and the corresponding regrowth until the end of the rainy season (3567 kg/ha), to mid-dry season (4550 kg/ha) and to end dry season (3787 kg/ha) were not different from the highest seasonal total herbage production for these dry season harvest dates (7636 at 6 weeks, 8387 kg/ha at 9 weeks and 9803 kg/ha at 13 weeks respectively). Thus for the optimum combination of regrowth potential and quality, giant star grass may be mowed or grazed at 6 weeks and buffel grass at 5 weeks during the minor rainy season. Similarly during the major rainy season, the regrowth potential and the quality of giant star, buffel and pangola grasses were generally optimal at the suggested dates for mowing or grazing.

In giant star, the total seasonal herbage yields when mowed at 8 weeks during the major season were 5982, 6238 and 6561 kg/ha for end rainy season, mid-dry season and end dry season respectively; buffel gave 7456, 7867 and 8386 kg/ha respectively, while pangola provided 5182, 5737 and 5752 kg/ha respectively. In pangola grass regrowth to end of the dry season at the recommended 8 weeks was 2267 kg/ha which gave a lower seasonal total herbage yield (5752 kg/ha) than harvesting earlier (7001 kg/ha at 6 weeks). Thus about 1250 kg/ha dry matter bulk would be sacrificed for quality. The quality of regrowth herbage would however be needed for a more precise determination of these grazing or mowing dates.

Successive mowing or grazing at these stages could affect their regrowth potential by reducing their root reserves (Fulkerson 1970, Sheard 1973). A rest period would therefore be required periodically. The timing and duration of this rest period requires investigating.

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Pangola grass and giant star grass under grazing would develop long stolons which would be defoliated by the grazing animals. These bare stolons could accumulate and detract from the quality of the pasture by impeding the movement of the grazing animals. To eliminate them, fire may be employed as it has the same effect on yield as slashing, or mowing. A mower would not remove the trailing stolons adequately although it may be safer than fire. However, it is not known how these introduced grasses would withstand burning. Thus, the effect of fire on their regrowth should be explored. As in grazing or mowing for fodder, frequent defoliation by burning may quickly lead to pasture degradation. Thus burning, whether in natural grassland or cultivated pastures, may have to be employed once in one to two years. Some authors have recommended once in three years where herbage is sparse (Edwards 1942). The appropriate burning frequency would have to be determined for the particular pasture.

The timing of the fire is a crucial determinant of its effects on the plant community (Rose Innes 1971). Burning at the beginning of the rainy season after the first showers would minimize the period of exposure of bare soil to erosion and sun scorch as new sprouts could then cover the ground within two to three weeks. This brief exposure of the soil could enhance nitrification (Doyne 1937, Diamond 1937, Daubenmire 1968).

The use of fire to remove rank herbage in large fields would require special precautions to prevent wild fires consuming valuable forage and destroying property. A high capital outlay could be involved in using fire on such large estates, e.g., in tractor drawn water tanks and sprayers or even the use of aircraft to control fires. Fire should therefore only be used after due consideration of such problems.

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GENERAL CONCLUSIONS

1. Pretreatment slashing, grazing and burning did not affect the dry matter yield and quality of natural grassland. Sporobolus dominated the sward for the first 7-9 weeks and Heteropogon took over thereafter.

2. Flowering was early in both the natural grassland sward and the introduced grasses but dry matter accumulation continued after flowering. The introduced grasses grew faster than the natural grassland.

3. Fluctuations in dry matter yield in the prostrate grasses giant star and pangola seemed to be due mainly to loss of senescent leaves but in buffel grass senescent leaves were retained, seed production and shedding being the apparent major cause of fluctuations in dry matter yield in buffel grass.

4. Leaves contained more nitrogen and were more digestible than stems, this difference being most striking in buffel grass. Species differences in nitrogen were not consistent but the natural grassland whole plants appeared to be as digestible as the introduced species at comparable stages of growth. Among the introduced grasses, giant star and buffel grasses had similar digestibilities during the minor rainy season but in the major rainy season, buffel was the most digestible followed by pangola and then giant star grass.

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5. Optimum harvest dates for giant star grass appeared to be 7 weeks during the minor rainy season and 8 weeks in the major rainy season. In buffel grass, it was 5 weeks during the minor rainy season and 9 weeks in the major season, while in pangola grass, the most desirable harvest stage seemed to be 8 weeks during the major rainy season. Pangola would seem to be inappropriate for the drier parts of the Accra Plains as it was drought sensitive particularly at the early stages of growth and grew poorly in the minor rainy season. Buffel was the most hardy and giant star intermediate between the two.

6. Both natural and introduced grasses would need to be supplemented with concentrates or leguminous forage for high levels of animal production.

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LITERATURE CITED

Ahlgren, G.H., A. Adegbola, K. Eweje and A. Salami. 1959. Development of grasslands in the western region of Nigeria. Tech. Report, Min. of Agr. and Natural Resources, W. Nigeria. 133 pp.

Alhassan, W.S. 1970. Review of problems of cattle nutrition in the tropics. Proc. 3rd Anim. Sci. Symp., U.S.T., Kumasi, Ghana.

Anon. 1941. Grassland Research. Trop. Agr. (Trin.) 18: 21-22.

Arias, P.J. 1965. Growth of coastal Bermuda. Int. Grassl. Congr. Proc. 9th (Sao Paulo, Brazil). pp. 457-463.

Arias, P.J. and M. Butterworth. 1965. Growth of elephant grass. Int. Grassl. Congr. Proc. 9th (Sao Paulo, Brazil). pp. 407-411.

Asare, E.O. 1970. Effects of fertilization, height and frequency of cutting on herbage yield and nutritive value of Cenchrus ciliaris (buffel grass) in the forest region of Ghana. Int. Grassl. Congr. Proc. 11th (Surfers Paradise, Australia).

Asare, E.O. 1972. Agronomic studies on buffel grass (Cenchrus ciliaris var. Biloela) in the humid tropics of Ghana. Ph.D. Thesis, Univ. of Wales (Aberyswyth).

Asare, E.O. 1974. Dry matter yield, chemical composition and nutritive value of buffel grass grown alone and in mixture with other tropical grasses and legumes. Int. Grassl. Congr. Proc. 12th (Mowcow, U.S.S.R.). Vol. 3, Part 1, pp. 45-55.

Bailey, R.W. 1973. Structural carbohydrates. Chp. 4 in G.W. Butler and R.W. Bailey (eds.), Chemistry and Biochemistry of Herbage. Vol. 1. Academic Press, N.Y. 639 pp.

Barton, F.E., H.E. Amos, D. Burdick and R.L. Wilson. 1976. Relationship of chemical analysis to in vitro digestibility for selected tropical and temperate grasses. J. Anim. Sci. 43: 504-512.

Berger, J.C.A., J.P. Fontenot, E.T. Kornegay and K.E. Webb. 1977. Ensiled swine manure and grass hay. Am. Soc. Anim. Sci. Meeting 69th (Madison, Wisconsin). (Abstr.).

Birch, H.F. 1960. Soil drying and soil fertility. Trop. Agr. (Trin.) 37: 1-6.

Blair, T.J. 1963. Production from grassland (Ghana). F.A.O. Report to the Ghana Government. 23 pp.

University of Ghana http://ugspace.ug.edu.gh

Blaser, R.E., W.H. Skrdla and T.H. Taylor. 1952. Ecological and physiological factors in compounding forage seed mixtures. Adv. in Agron. 4: 179-219.

Brady, C.J. 1973. Changes accompanying growth and senescence and effect of physiological stress. Chp. 24 in G.W. Butler and R.W. Bailey (eds.), Chemistry and Biochemistry of Herbage. Vol. 2. Academic Press, N.Y. 455 pp.

Brammer, H. 1956. Report on reconnaissance soil survey of the Accra Plains. Dept. of Soil and Land Use Survey. Min. Agr., Accra.

Brammer, H. 1962. Soils. Chp. 6 in B. Wills (ed.), Agriculture and Land Use in Ghana. Oxford University Press, London. 504 pp.

Brammer, H. 1967. Soils of the Accra Plains. Memoir No. 3, Soil Res. Inst., Kumasi, Ghana.

Brand, B. and H. Brammer. 1956. Provisional grassland associations of interior and coastal Savannah zones of Gold Coast. Gold Coast Dept. of Soil and Land Use Survey. Tech. Report No. 21. 17 pp.

Brockington, N.R. 1961. The growth, yield and protein content of 12 cultivated grasses in Northern Rhodesia. Empire J. of Exp. Agr. 29: 196-211.

Brown, T.A., C. Layman and P. Roter. 1966a. Buffel grass. Co-op. Ext. Serv., Univ. of Hawaii. Leaflet 100, Conservation Series. 4 pp.

Brown, T.A., C. Layman and P. Roter. 1966b. Pangola grass. Co-op. Ext. Serv., Univ. of Hawaii. Leaflet 104, Conservation Series. 4 pp.

Burton, G.W. 1976. Breeding to improve quality in tropical grasses. Am. Soc. of Agron. Meeting 68th (Houston, Texas). 105. (Abstr.).

Burton, J.H. and F.H.K. Asiedu. 1972. Growth rates of the West African dwarf goat. Proc. Anim. Sci. Symp. 5th (Kumasi, Ghana). pp. 11-14.

Butterworth, M.H. 1967. The digestibility of tropical grasses. Nutr. Abstr. and Rev. 37: 349-356.

Butterworth, M.H. and J.P. Butterworth. 1965. Some aspects of the utilization of tropical forages. J. Agr. Sci. 65: 389-395.

University of Ghana http://ugspace.ug.edu.gh

Caro-Costas, R., J. Vicente-Chandler and J. Figerella. 1965. Productivity of intensively managed pastures of five grasses on steep slopes in the humid mountains of Puerto Rico. J. Agr., Univ. of Puerto Rico 49: 99-111.

Caro-Costas, R., F. Abruna and J. Vicente-Chandler. 1973. Comparison of heavily fertilized pangola grass and star grass pastures under humid tropical conditions. Agron. J. 65: 132-133.

Cassady, J.T. 1973. The effect of rainfall, soil moisture and harvesting intensity on grass production on two range sites in Kenya. Afr. Agr. and Forest. J. 39: 26-36.

Chenost, M. 1975. Factors affecting the feeding value of pangola grass in a humid tropical zone. Ann. Zoot. 24: 327-349.

Church, D.C. 1972. Digestive Physiology and Nutrition of Ruminants. 3 Vols. Oregon State University Bookstores, Corvallis, Oregon.

Coward-Lord, J., J.A. Arroyo-Aguilu and O. Garcia-Molinari. 1974. Fibrous carbohydrate fractions and In Vitro true and apparent digestibility of 10 tropical forage grasses. J. Agr., Univ. of Puerto Rico 58: 293-304.

Crampton, E.W. and L.A. Maynard. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. J. Nutr. 15: 383-395.

Cross, H.H., L.W. Smith and J.V. DeBarth. 1974. Rates of in vitro forage digestion as influenced by chemical treatment. J. Anim. Sci. 39: 808-810.

Danley, M.M. and R.L. Vetter. 1973. Changes in carbohydrate and nitrogen fractions and digestibility of forages. J. Anim. Sci. 37: 994-999.

Daubenmire, R. 1968. Plant Communities. A textbook of plant synecology. Harper and Row, N.Y. 300 pp.

Diamond, W.E. 1937. Fluctuations in nitrogen content of some Nigerian soils. Part 1: Fluctuations in nitric nitrogen. Emp. J. Exp. Agr. 5: 264-280.

Doyne, H.C. 1937. Green manuring in southern Nigeria. Emp. J. Exp. Agr. 5: 248-253.

Drapala, J.W., L.C. Raymond and E.W. Crampton. 1947. Pasture studies. XXVII. The effects of maturity of the plant and its lignification and subsequent digestibility by animals as indicated by methods of plant histology. Sci. Agr. 27: 36-41.

Duckworth, J. 1946. A statistical comparison of the influence of crude fibre of the digestibility of roughage by Bos indicus and Bos taurus cattle. Trop. Agr. (Trin.) 23: 4-8.

University of Ghana http://ugspace.ug.edu.gh

Edwards, D.C. 1942. Grass burning. Emp. J. Exp. Agr. 10: 219-231.

Edwards, D.C. 1956. The ecological regions of Kenya, their classification in relation to agricultural development. Emp. J. Exp. Agr. 24: 89-108.

Engdahl, G.R. and W.C. Ellis. 1974. Digestibility of grass selections as influenced by maturity. J. Anim. Sci. 38: 214-215.

Evans, D.C.P. 1961. A review of past and present work connected with grassland pasture and fodder problems in Ghana. Grassl. Symp. 1 (Min. of Agric., Accra, Ghana).

Falvey, J.L. 1977. Dry season regrowth of six forage species following wild fire. J. Range Man. 30: 37-38.

Ferguson, K.A. 1969. Pasture chemistry. In Animal Health Production and Pasture. Eds. A.N. Worden, K.C. Sellers and D.E. Tribe. Longmans, London.

Fianu, F.K., M.K. Attakrah and K. Koram. 1972. Some aspects of the dry season nutrition of small ruminants in Ghana. Anim. Sci. Symp. 5th. Univ. of Sci. and Tech., Kumasi, Ghana. pp. 96-103.

Fitzgerald, K. 1955. Buffel grass (Cenchrus ciliaris L.). J. Agr. W. Aust. 4: 83-86.

French, M.H. 1939. Liveweight development of certain shorthorned zebu cattle in Tanganyika territory. Trop. Agr. (Trin.) 16: 51-54.

French, M.H. 1942. The nutritive value of some Tanganyika grasses. Emp. J. Exp. Agr. 9: 23-28.

French, M.H. 1957. Nutritional value of tropical grasses and fodders. Herb. Abstr. 27: 1-7.

Fulkerson, R.S. 1970. Location and fall harvest effects in Ontario on food reserve storage in alfalfa (Medicago sativa L.). Int. Grassl. Congr. 11th. pp. 555-559.

Funes, F. and S. Yepes. 1974. Pasture introductions in Cuba. Int. Grassl. Congr. 12th (Moscow, U.S.S.R.). Vol. III, Part II, pp. 759-773.

Garza, A., J.M. Hertell and G.D. Jolliff. 1976. Seasonal changes in nutritive value of coast cross-1 coastal Bermuda in southern Texas. Am. Soc. of Agron. Meeting 68th (Houston, Texas). p. 197.

Gohl, B. 1975. Tropical feeds. Feeds Information Summaries and Nutritive Values. F.A.O., Rome. 661 pp.

University of Ghana http://ugspace.ug.edu.gh

Gomide, J.A., C.H. Noller, G.O. Mott, J.H. Conrad and D.L. Hill. 1969. Effect of plant age and nitrogen fertilization on chemical composition in vitro cellulose digestibility of tropical grasses. Agron. J. 61: 116-120.

Grieve, C.M. and D.F. Osbourn. 1965. The nutritional value of some tropical grasses. J. Agr. Sci. 65: 411-415.

Haggar, R.J. and M.B. Ahmed. 1970. Seasonal production of Andropogon gayanus. II. Seasonal changes in digestibility and feed intake. J. Agr. Sci. 75: 369-377.

Haggar, R.J. and M.B. Ahmed. 1971. Seasonal production of Andropogon gayanus. III. Changes in crude protein content and in vitro dry matter digestibility of leaf and stem portions. J. Agr. Sci. 77: 47-52.

Hopkins, B. 1963. The role of fire in promoting the sprouting of some Savanna species. J. W. Afr. Sci. Ass. 7: 154-162.

Hosaka, E.Y. and D. Goodall. 1954. Pangola grass in Hawaii. Agric. Ext. Serv., Univ. of Hawaii. Ext. Circ. 342.

Humphreys, L.R. 1969. A Guide to Better Pastures for the Tropics and Subtropics. Wright and Stephenson and Co., Brisbane, Qsld.

Johnson, W.L., J. Guerrero and D. Pezo. 1973. Cell wall constituents and IVD of Napier grass (Pennisetum purpureum). J. Anim. Sci. 37: 1255-1261.

Johnson, W.L. and D. Pezo. 1975. Cell wall fractions and in vitro digestibility of Peruvian feedstuffs. J. Anim. Sci. 41: 185-197.

Juko, C.D. and R.M. Bredon. 1961. The chemical composition of leaves and whole plants as an indicator of the range of available nutrients for selective grazing by cattle. Trop. Agr. (Trin.) 38: 179-188.

Kamstra, L.D., H.L. Moxon and O.G. Bentley. 1958. The effect of stage of maturity and lignification on the digestion of cellulose in forage plants by rumen microorganisms in vitro. J. Anim. Sci. 17: 199-208.

Kamstra, L.D., R.W. Stanley and S.M. Ishizaki. 1966. Seasonal and growth period changes of some nutritive components of Kikuyu grass. J. Range Manage. 19: 288-291.

Kannegieter, A. 1961. Work done on grasses and legumes by the arable crops section of the Kumasi College of Technology. Grassl. Symp. 1st (Min. Agric., Accra, Ghana).

University of Ghana http://ugspace.ug.edu.gh

Kannegieter, A. 1965. Cultivation of grasses and legumes in the forest zone of Ghana. Int. Grassl. Congr. (Sao Paulo, Brazil). pp. 313-318.

Kayongo-Male, H. and J.W. Thomas. 1972. Laboratory evaluation of Puerto Rican grasses. J. Anim. Sci. 35: 231. (Abstr.).

Klock, M.A., S.C. Schanck and J.E. Moore. 1975. Laboratory evaluation of quality in subtropical grasses. III. Genetic variation among digitarias and in vitro digestion and its relationship to plant morphology. Agron. J. 67: 672-675.

Lansbury, T.J. 1959. Composition and digestibility of some conserved fodder crops. Part 2. Silage. Trop. Agr. (Trin.) 36: 299-302.

Lansbury, T.J. 1960. A review of some limiting factors in cattle nutrition in Ghana. Trop. Agr. (Trin.) 37: 185-191.

Lansbury, T.J., R. Rose Innes and G.L. Mabey. 1965. Studies on Ghana grasslands: yields and composition on the Accra Plains. Trop. Agr. (Trin.) 42: 1-18.

Laredo, M.A. and D.J. Minson. 1973. The voluntary intake, digestibility and retention time by sheep of leaf and stem fractions of five grasses. Aust. J. Agr. Res. 24: 875-888.

Laredo, M.A. and D.J. Minson. 1975. Pepsin soluble dry matter of leaf and stem fractions of grasses in relation to voluntary intake by sheep. Aust. J. Exp. Agr. and Anim. Husb. 15: 203-206.

Leng, R.A. 1973. Salient features of the digestion of pastures by ruminous and other herbivores. Chp. 30 in G.W. Butler and R.W. Bailey (eds.), Chemistry and Biochemistry of Herbage. Vol. 3. Academic Press, N.Y. 295 pp.

Loxton, R.F. 1955. The catchment area and environs of the agricultural research station, Nungua. An ecological land use study with the aid of aerial photography including a discussion of technique and procedure. Mimeo. Faculty of Agric., Univ. of Gold Coast. 16 pp.

Maynard, L.A. and J.K. Loosli. 1969. Animal Nutrition. 6th ed. McGraw Hill, N.Y. 613 pp.

Mba, A.U., S.A. Oke and V.A. Oyenuga. 1973. Studies in in vitro and in vivo digestibility and metabolizable energy utilization in the ruminants. Nig. Agr. J. 10: 48-56.

Mes, M.G. 1958. The influence of veld burning or mowing on the water, nitrogen and ash content of grasses. S. Afr. J. Sci. 54: 83-86.

University of Ghana http://ugspace.ug.edu.gh

Miller, T.B. 1960. The effect of feeding high protein and high carotene concentrates to young cattle during the late dry season and early wet season in N. Nigeria. W. Afr. J. Bioch. 4: 29.

Minson, D.J. 1967. Voluntary intake and digestibility of pangola following application of fertilizer N. Brit. J. Nutr. 21: 587-290.

Minson, D.J. 1971. Digestibility and voluntary intake of 6 cultivars of panicum. Aust. J. Exp. Agr. Anim. Husb. 11: 18-25.

Minson, D.J. 1973. Effect of fertilizer nitrogen on digestibility and voluntary intake of Chloris gayana, Digitaria decumbens and Pennisetum clandesinum. Aust. J. Agr. and Anim. Husb. 13: 153-155.

Minson, D.J. and M.A. Laredo. 1972. Influence of leafiness on voluntary intake of tropical grasses by sheep. J. Aust. Inst. Agr. Sci. 38: 303-305.

Minson, D.J. and N.M. McLeod. 1970. The digestibility of temperate and tropical grasses. Int. Grassl. Congr. Proc. 11th (Surfers Paradise, Australia). pp. 719-723.

Minson, D.J., W.F. Raymond and C.E. Harris. 1960. Studies in the digestibility of herbage. 8. The digestibility of S37 cocksfoot, S23 ryegrass and S24 ryegrass. J. Brit. Grassl. Soc. 15: 174-178.

Moore, J.E. and G.O. Mott. 1973. Structural inhibitors of quality in tropical grasses. Chp. 4 in Antiquality Components of Forages. Crop Sci. Soc. of Am. Special Pub. No. 4, A.G. Matches (ed.). pp. 43-87.

Mowat, D.N. 1968. Applications and implications of in vitro digestibility technique to plant breeding. Pages 55-93 in C.M. Harrison (ed.), Forage economics - quality. American Society of Agronomy Special Pub. No. 13.

Mowat, D.N., R.S. Fulkerson, W.E. Tossell and J.E. Winch. 1965. The in vitro dry matter digestibility and protein content of leaf and stem portions of several species and varieties with advancing stages of maturity. Can. J. Pl. Sci. 45: 321-331.

Mufti, A.M.M. and R.N. Kaul. 1972. A preliminary evaluation of some exotic forage species grown in the environs of Judhaliya. First scientific conference, Scientific Research Foundation, General and Agricultural Sciences, Baghdad, Iraq. Ministry of Higher Education and Scientific Research. pp. 243-252.

Nestel, B.L. and M.J. Creek. 1962. Pangola grass. Herb. Abst. 32: 265-271.

University of Ghana http://ugspace.ug.edu.gh

Norman, J.T. 1963. Pattern of dry matter and nutrient content changes in native pastures at Katherine, N.T. Aust. J. Exp. Agr. and Anim. Husb. 3: 119-124.

Oh, Hi Kon, B.R. Baumgardt and J.M. Scholl. 1966. Evaluation of forages in the laboratory. V. Comparison of chemical analyses, solubility tests and in vitro fermentation. J. Dairy Sci. 49: 850-855.

Oji, U.I. and D.N. Mowat. 1977. Nutritive value of storke treated corn stover. Agricultural Institute of Canada Conference, Guelph, Ont., August 14-18, 1977. (Abstr.).

Olubajo, F.O., P.J. Van Soest and V.A. Oyenuga. 1973. Chemical composition of tropical grasses by the detergent methods and their in vitro digestibility. J. Assoc. for Adv. of Agr. Sci. Afr. 2: 135-138.

Olubajo, F.O. and P.J. Van Soest. 1974. Comparison and digestibility of four tropical grasses grown in Nigeria. J. Anim. Sci. 38: 149-153.

Oyenuga, V.A. 1957. The composition and agricultural value of some grass species in Nigeria. Emp. J. Exp. Agr. 25: 237-255.

Paterson, D.O. 1933. Influence of time of cutting on growth, yield and composition of tropical fodder grasses. J. Agr. Sci. 23: 615-641.

Paterson, D.O. 1935. Growth, yield and composition of certain tropical fodders. J. Agr. Sci. 25: 369-397.

Paterson, D.O. 1938. Dried grass concentrate in the tropics. Trop. Agr. (Trin.) 15: 267-270.

Pereira, H.C. and V.R.S. Beckley. 1953. Grass establishment in eroded soil in semi arid African reserve. Emp. J. Exp. Agr. 21: 1-6.

Plowes, D.C.H. 1957. Seasonal variation of crude protein in twenty common veld grasses at Matropos, Southern Rhodesia and related observations. Rhod. Agr. J. 54: 33-55.

Plucknett, D.L. 1970. Productivity of tropical pastures in Hawaii. Int. Grassl. Congr. Proc. 11th (Surfers Paradise, Australia). Paper A38.

Pritchard, G.I., L.P. Folkins and W.J. Pigden. 1963. The In Vitro digestibility of whole grasses and their parts at progressive stages of maturity. Can. J. Plant Sci. 43: 79-87.

Rattray, J.M. 1960. The Grass Cover of Africa. F.A.O., Rome. 168 pp.

Raymond, W.F. 1969. The nutritive value of forage crops. Chp. 1 in Adv. in Agron. 21: 1-81. Academic Press.

Reid, J.T. 1959. Effect of growth stage chemical composition and physical properties upon the nutritive value of forages. J. Dairy Sci. 42: 567-571.

University of Ghana http://ugspace.ug.edu.gh

Reid, J.T., W.K. Kennedy, K.L. Tunk, S.T. Slack, G.W. Trimberger and R.P. Murphy. 1975. Effect of growth, chemical composition and physical properties upon the nutritive value of forages. J. Dairy Sci. 42: 567-572.

Reid, R.L., A.J. Post, F.J. Olsen and J.S. Mugerha. 1973. Studies on the nutritional quality of grasses and legumes in Uganda. Part 1. Application of IVD technique to species and stage of growth effects. Trop. Agr. (Trin.) 50: 1-15.

Reid, R.L., A.J. Post and F.J. Olsen. 1975. Chemical composition and digestibility of tropical forages. J. Anim. Sci. 40: 182-186.

Rose Innes, R. 1961. Sugar in the sky or beef for the butcher. In Grassl. Symp. 1st (Min. of Agr., Accra). 64 pp.

Rose Innes, R. 1962. Grasslands, pastures and fodder production. Chp. in B. Wills (ed.), Agriculture and Land Use in Ghana. Oxford University Press.

Rose Innes, R. 1963. Final Report: Grassland and livestock. In F.A.O., U.N.D.P. Land and water survey in the upper and northern regions of Ghana. Report F.A.O./S.F.: 31/GHA. Vol. IV, Agronomy and Sociology. 223 pp. F.A.O., Rome, 1967.

Rose Innes, R. 1965. Concept of woody pastures in low latitude tropical tree Savanna environments. Int. Grassl. Congr. Proc. 9th (Sao Paulo, Brazil). pp. 1419-1422.

Rose Innes, R. 1966. Agricultural Research Station Kpong. Annual Report, Univ. of Ghana. 38 pp.

Rose Innes, R. 1971. Fire in West African vegetation. Ann. Tall Timbers Fire Ecol. Conf. Proc. pp. 147-173.

Rose Innes, R. and G.L. Mabey. 1964. Studies on browse plants in Ghana. III. Browse/grass ingestion ratios. Emp. J. Exp. Afr. 32: 180-185.

Ruthenberg, H. 1974. Artificial pastures and their utilization in the Southern Guinea Savanna and Deriver Savanna of West Africa. Ms. 98 pp. Stuttgart Hoheinheim.

Sallette, J.E. 1965. Effects of heavy frequent dressings of nitrogen on pangola. Int. Grassl. Congr. Proc. 9th (Sao Paulo, Brazil). pp. 1199-1203.

Salter, P.J. and J.E. Goode. 1967. Crop responses to water at different stages of growth. Commonwealth Agr. Bureau, Bucks, England.

Semple, A.T. 1970. Grassland Improvement. Leonard Hill Books, London. 1st ed. 400 pp.

University of Ghana http://ugspace.ug.edu.gh

Sen, M.K. and G.L. Mabey. 1965. The chemical composition of some indigenous grasses of the coastal savanna zone of Ghana at different stages of growth. Int. Grassl. Congr. Proc. 9th (Sao Paulo, Brazil). pp. 763-771.

Sheard, R.W. 1973. Organic reserves and plant growth. Chp. 25 in G.W. Butler and R.W. Bailey (eds.), Chemistry and Biochemistry of Herbage. Academic Press. 455 pp.

Smith, E.L. 1960. Effects of burning and clipping at various times during the wet season on tropical tall grass range in Northern Australia. J. Range Manage. 13: 197-203.

Smith, O.B., G.K. McLeod, D.N. Mowat and E.T. Moran. 1977. Acid-treated poultry excreta as a nitrogen supplement for feedlot cattle. Agricultural Institute of Canada Conference, Univ. of Guelph. (Abstr.).

Steele, R.G.D. and J.H. Torrie. 1960. Principles and Procedures of Statistics with Special Reference to the Biological Sciences. McGraw-Hill Book Company, Toronto. 481 pp.

Sullivan, J.T. 1959. A rapid method for determination of acid insoluble lignin in forages and its relation to digestibility. J. Anim. Sci. 18: 1292-1298.

Sullivan, J.T. 1964. Chemical composition of forages in relation to digestibility by ruminants. United States Department of Agriculture, Agricultural Research Service Ms. No. 34-62.

Sullivan, J.T. 1969. Chemical composition of forages with reference to the needs of the grazing animal. U.S.D.A., A.R.S. Ms. No. 34-107. July 1969. 113 pp.

Sullivan, J.T. 1973. Drying and storing herbage as hay. Chp. 27 in G.W. Butler and R.W. Bailey (eds.), Chemistry and Biochemistry of Herbage. Vol. 3. Academic Press, N.Y. 295 pp.

Taerum, R. 1970a. Comparative shoot and root growth studies on 6 grasses in Kenya. E. Afr. Agr. Forest J. 36: 94-113.

Taerum, R. 1970b. A study of root and shoot growth on three grass species in Kenya. E. Afr. Agr. Forest J. 36: 155-170.

Taerum, R. 1970c. A note on chemical content of some east African grasses. E. Afr. Agr. Forest J. 36: 171-176.

Taylor, C.J. 1952. The vegetation zones of the Gold Coast. Ms. Government Printer, Accra. 27 pp.

Thomas, O.A. and L.E. McLaren. 1971. Some studies on digestibility of pangola grass in Jamaica. Trop. Agr. (Trin.) 48: 225-235.

University of Ghana http://ugspace.ug.edu.gh

Thompson, H.E. 1961. Grassland problems in the Volta Region. Grassl. Symp. Proc. 1st (Min. of Agr., Accra). 64 pp.

Tilley, J.M.A. and R.A. Terry. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Brit. Grassl. Soc. 18: 104-111.

Topps, J.H. and R.C. Elliott. 1965. Nitrogen metabolism of cattle and sheep in Southern Africa. Outlook on Agr. 4: 310-315.

Tuah, A.K. and Adenku Tetteh. 1972. Effect of feeding urea supplement on performance of confined W.A. dwarf sheep. Proceedings 5th Anim. Sci. Symp., Kumasi, Ghana. June 28-29, 1972.

Tuah, A.K. 1971. The preparation of silage in small sized silos in Ghana. In Some Aspects of Livestock Production in Ghana. A symposium sponsored by the Dept. of Anim. Sci., Legon, 26th March, 1971. p. 68.

Van Biljon, P.L. and P. LeRoux. 1969. The nutritive value of leaf samples of Themeda triandra at different stages of growth. 1. Chemical composition. Agr. Sci. S. Afr. 1: 171-177.

Van Soest, P.J., Arroyo Aguilu and S. Tessema. 1974. Relationship between silica content and IVD of tropical grasses. J. Dairy Sci. 57: 621.

Van Soest, P.J. and L.H.P. Jones. 1968. Effect of silica in forages upon digestibility. J. Dairy Sci. 51: 1644-1646.

Van Soest, P.J. and R.H. Wine. 1967. Use of detergents in the analysis of fibrous feeds. IV. The determination of plant cell wall constituents. J. Assoc. Off. Anal. Chem. 50: 50-53.

Ventura, M., J.E. Moore, O.C. Ruelke and D.E. Frank. 1975. Effect of maturity and protein supplementation on intake and digestibility of pangola digit grass hays. J. Anim. Sci. 40: 769-774.

Vicente-Chandler, J. 1975. Intensive management of pastures and forages in Puerto Rico. In E. Bornemisza and A. Alvarado (eds.), Soil Management in Tropical America. Proc. Seminar at C.I.A.T., Cali, Colombia, 1974. Soil Sci. Dept., North Carolina State Univ., Raleigh.

Vicente-Chandler, J., S. Silva and J. Figarella. 1959a. Effect of nitrogen fertilization and frequency of cutting on the yield and composition of three tropical grasses. Agron. J. 51: 202-206.

Vicente-Chandler, J., S. Silva and J. Figarella. 1959b. Effect of nitrogen fertilization and frequency of cutting on yield of: I. Napier grass; II. Guinea grass; and III. Guinea grass. J. Agr., Univ. of Puerto Rico 43: 215-248.

University of Ghana http://ugspace.ug.edu.gh

Vicente-Chandler, J., C.R. Costas, R.W. Pearson, F. Abruna, J. Figarella and S. Silva. 1964. The intensive management of tropical forages in Puerto Rico. Puerto Rico Agr. Exp. Stat. Bull. 187.

Virquez, G.O. 1965. Growth of star grass and pangola grass. Int. Grassl. Congr. Proc. 9th (Sao Paulo, Brazil). pp. 443-448.

Walker, H.O. 1962. Weather and climate. Chp. 2 in B. Wills (ed.), Agriculture and Land Use in Ghana. O.U.P., London. 504 pp.

Wharton, F.D., J.M. Shepard and F.T. Buamah. 1967. Preliminary studies on supplemental feeding of cattle reared under essentially "local" conditions in Northern Ghana. Ghana J. of Sci. 7: 30-36.

Whyte, R.O., T.R.G. Moir and J.P. Cooper. 1959. Grasses in Agriculture. F.A.O., Rome. 416 pp.

Zemmelink, G., R.J. Haggar and J.H. Davies. 1972. A note on voluntary intake of Andropogon gayanus hay by cattle, as affected by level of feeding. Anim. Prod. 15: 85-88.

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APPENDICES

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Appendix I. Analyses of variance of weekly yields from natural grassland during the major rainy season of 1974.

(Sums of squares x 10^4)

Source	Degrees of freedom	Maturity							
		4+ April 29‡	5 May 6	6 May 13	7 May 20	8 May 27	9 June 3	11 June 17	13 July 1
Replications	3	0.0190	0.0390	0.9294	17.940	16.96	10.50	141.10	50.84
Pretreatment	2	0.0250	0.1139	0.5600	4.998	29.07	18.79	91.90	46.25
Error (A)	6	0.0530	0.1806	2.4070	9.110	19.67	30.30	102.60	125.40
Species	2	0.0475*	0.4328**	2.3260*	12.560**	38.26	231.40**	1358.00**	1911.00**
Species x pretreatment	4	0.0630	0.4420	1.6850	10.320	24.98	138.60	396.00	157.60
Error (B)	18	0.1019	0.4187	5.9760	15.830	102.00	241.80	1856.00	1862.00

\+ Weeks from pretreatment: April 1, 1974.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix II. Analyses of variance of weekly yields from natural grassland during the major rainy season of 1975.

(Sums of squares x 10^4)

Source	Degrees of freedom	Maturity 6+ May 21‡	7 May 28	8 June 4	9 June 11	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	1.023	1.834	3.168	19.09	48.88	114.30	69.81	155.20	279.70	1095.00
Pretreatment	2	3.187	3.626	15.820	25.68	4.50	2.55	12.65	9.01	108.00	62.10
Error (A)	6	2.296	17.450	23.180	55.80	151.90	150.80	306.80	389.20	463.00	676.80
Species	2	5.591*	3.965*	12.320*	232.00**	415.50**	785.30**	1203.00	579.90*	829.50*	2002.00*
SPP x pretreat.	4	10.990	23.700	44.580	122.50	144.00	279.90	323.20	557.50	729.00	840.60
Error (B)	18	15.700	51.410	82.530	109.40	495.00	735.60	1005.00	1199.00	1457.00	3896.00

\+ Weeks from pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix III. Analyses of variance of dry matter of species components of natural grassland during 1974 (upper) and 1975 (lower).

1974 Source	Degrees of freedom	Sums of squares x 10^4		
		Sporobolus	Heteropogon	Others
Replications	3	12.11	217.5	120.00
Pretreatment	2	12.68	233.5	85.07
Error (A)	6	65.13	572.8	349.10
Dates	7	1404.00**	6603.0**	300.90
Date x pretreat.	14	96.53	263.2	230.30
Error (B)	63	437.70	1903.0	934.80

1975 Source	Degrees of freedom	Sums of squares x 10^4		
		Sporobolus	Heteropogon	Others
Replications	3	216.0	1447.00	113.30
Pretreatment	2	923.8*	17.59	214.90
Error (A)	6	325.5	1993.00	117.40
Dates	9	1342.0**	7438.00**	173.80
Date x pretreat.	18	290.4	1084.00	32.07
Error (B)	81	1048.0	4922.00	25.63

* Significant ($P < 0.05$).
** Significant ($P \leq 0.01$).

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Appendix IV. Weekly yield of species components of natural grassland during the major rainy season of 1974.

(Kg/ha dry matter)

Pre-treatment	Species	Maturity 4[+] Apr. 29[‡]	5 May 6	6 May 13	7 May 20	8 May 27	9 June 3	11 June 17	13 July 1
Slashed	Sporobolus	11	59	113	290	336	386	586	1265
	Heteropogon	10	13	90	210	370	1054	2272	2643
	Others[ǂ]	10	4	24	48	155	135	203	162
	Total	31	75	227	548	861	1575	3062	4070
Grazed	Sporobolus	9	26	111	225	285	696	1126	1117
	Heteropogon	6	1	29	71	128	293	1380	1706
	Others[ǂ]	7	19	0	34	20	186	119	531
	Total	21	46	141	330	433	1175	2625	3359
Burned	Sporobolus	19	13	50	122	338	422	760	1255
	Heteropogon	1	10	85	359	572	1047	2134	2118
	Others[ǂ]	0	12	25	101	178	210	894	712
	Total	20	35	160	582	1087	1679	3788	4085
Average	Sporobolus	13^{e}_{x}[o]	32^{e}_{x}	92^{e}_{x}	212^{de}_{x}	320^{cd}_{y}	505^{c}_{xy}	826^{b}_{xy}	1212^{a}_{y}
	Heteropogon	6^{c}_{y}	8^{c}_{y}	68^{c}_{x}	213^{c}_{x}	357^{bc}_{x}	798^{b}_{x}	1928^{a}_{x}	2156^{a}_{x}
	Others[ǂ]	6^{c}_{y}	12^{c}_{y}	17^{c}_{y}	61^{bc}_{y}	117^{abc}_{z}	177^{ab}_{y}	405^{a}_{y}	468^{a}_{z}
	Total	24f	52f	176ef	487de	794d	147bc	3158b	3838a

+ Weeks from pretreatment: April 1, 1974.
‡ Harvest dates during the major rainy season.
ǂ Other species consisting of variable proportions of *Panicum maximum*, *Andropogon gayanus*, *Cenchrus ciliaris*, *Vetiveria fulvibarbis*, *Setaria sphacelata*, *Pennisetum* sp., *Uraria picta*, *Astragalus* sp., *Desmodium triflorum*, *Galactia tenuifolia* and *Rhynchosia minima*.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e,f; columns - x,y,z.

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Appendix V. Weekly yields of species components of natural grassland during the major rainy season of 1975.

(Kg/ha dry matter)

Pre-treatment	Species	Maturity 6+ May 21‡	7 May 28	8 June 4	9 June 11	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Slashed	Sporobolus	262	254	473	655	716	974	1143	1463	1543	1051
	Heteropogon	40	222	328	776	846	1213	1258	1841	2183	1787
	Othersǂ	61	58	89	143	335	391	363	244	153	1382
	Total	363	535	890	1573	1897	2578	2764	3548	3879	4220
Grazed	Sporobolus	170	243	279	996	738	1213	1074	1174	1368	985
	Heteropogon	39	83	143	448	744	1307	1930	1913	1166	3009
	Othersǂ	73	173	143	52	390	104	222	542	570	1427
	Total	282	498	565	1495	1873	2624	3226	3629	3104	5421
Burned	Sporobolus	14	89	84	220	437	449	473	777	736	992
	Heteropogon	59	85	405	832	1934	1947	2413	2311	2472	2969
	Othersǂ	96	235	206	288	67	629	440	1374	1341	1408
	Total	168	408	695	1340	2438	3025	3326	4462	4549	5369
Average	Sporobolus	148^{e}_{x}[o]	196^{e}_{x}	279^{e}_{x}	339^{de}_{xy}	630^{cd}_{xy}	879^{bc}_{xy}	897^{abc}_{xy}	1138^{ab}_{xy}	1216^{a}_{xy}	1009^{ab}_{y}
	Heteropogon	46^{e}_{y}	130^{e}_{y}	292^{e}_{x}	685^{de}_{x}	1175^{cd}_{x}	1489^{bc}_{x}	1867^{b}_{x}	2022^{ab}_{x}	1940^{ab}_{x}	2588^{a}_{x}
	Othersǂ	77^{f}_{y}	155^{e}_{y}	146^{e}_{y}	161^{e}_{y}	264^{d}_{y}	375^{c}_{y}	341^{c}_{y}	720^{b}_{y}	688^{b}_{y}	1406^{a}_{y}
	Total	271f	481f	718f	1469e	2069d	2742c	3105c	3876b	3844b	5003a

\+ Weeks from pretreatment: April 9, 1975.

‡ Harvest date during the major rainy season.

ǂ Other species consisting of variable proportions of Panicum maximum, Andropogon gayanus, Cenchrus ciliaris, Vetiveria fulvibarbis, Setaria sphacelata, Pennisetum pedicellatum, Uraria picta, Astragalus sp., Desmodium triflorum, Galactia tenuifolia and Rhynchosia minima.

o Data followed by the same letter are not different ($P > 0.05$): rows – a,b,c,d,e,f; columns – x,y,z.

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Appendix VI. Analyses of variance of weekly regrowth yields from natural grassland during 1974.

(Sums of squares x 10^4)

Source	Degrees of freedom	Maturity							
		4+ Apr. 29‡	5 May 6	6 May 13	7 May 20	8 May 27	9 June 3	11 June 17	13 July 1
Replications	3	225.6	801.5	297.2	235.0	235.4	335.0	27.4	160.7
Pretreatment	2	15.8	157.9	145.9	162.2	97.7	316.5*	5.0	102.4
Error (A)	6	1034.0	1200.0	281.4	618.3	166.2	180.2	295.1	770.7
Regrowth dates	2	1047.0*	1283.0**	614.9**	1243.0	3683.0**	2249.0**	5595.0**	3477.0**
Dates x pretreat.	4	308.8	151.5	139.4	442.4	123.8	373.4	150.9	326.2
Error (B)	18	1761.0	1884.0	494.3	3620.0	1843.0	1288.0	1211.0	1989.0

\+ Weeks from pretreatment: April 1, 1974.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix VII. Analyses of variance of weekly regrowth yields from natural grassland during 1975.

(Sums of squares x 10^4)

Source	Degrees of freedom	Maturity 6+ May 21‡	7 May 28	8 June 4	9 June 11	10 June 18	11 June 25	12 July 3	14 July 16
Replications	3	242.30	40.98	325.80	268.50	54.67	12.67	44.90	82.16
Pretreatment	2	2.256	0.8297	83.15	119.90	66.48	25.15	71.73	46.83
Error (A)	6	553.70	519.70	686.10	108.50	225.80	209.60	91.15	15.43
Regrowth dates	2	4176.00**	1752.00**	2399.00**	5331.00**	1615.00**	1361.00**	1795.00**	1887.00**
Dates x pretreat.	4	35.39	315.60	55.26	73.43	120.10	38.87	49.88	30.48
Error (B)	18	832.50	1081.00	719.70	77.16	750.90	275.70	177.20	191.20

+ Weeks from pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
* Significant ($P \leq 0.05$).
** Significant ($P \leq 0.01$).

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Appendix VIII. Analyses of variance of regrowth yields during the dry periods of 1974 (upper) and 1975 (lower).

1974 Source	End of rainy season Degrees of freedom	Sums of squares x 10^4	Mid dry season Degrees of freedom	Sums of squares x 10^4	End of dry season Degrees of freedom	Sums of squares x 10^4
Replications	3	143.00	3	81.09	3	1988.00
Pretreatment	2	71.58	2	29.74	2	542.60
Error (A)	6	328.10	6	638.70	6	2185.00
Dates	7	20488.00**	8	28552.00**	9	20335.00**
Dates x pretreat.	14	447.70	16	1004.00	18	1186.00
Error (B)	63	3500.00	72	5506.00	81	7163.00

1975 Source	End of rainy season Degrees of freedom	Sums of squares x 10^4	Mid dry season Degrees of freedom	Sums of squares x 10^4	End of dry season Degrees of freedom	Sums of squares x 10^4
Replications	3	108.50	3	35.82	3	21.65
Pretreatment	2	180.20	2	41.36	2	134.50
Error (A)	6	92.61	6	268.00	6	257.70
Dates	8	17983.00**	8	27397.00**	9	38317.00**
Dates x pretreat.	16	131.80	16	449.70	18	288.70
Error (B)	72	826.00	72	2842.00	81	4225.00

** Significant ($P < 0.01$).

Appendix IX. Yield of regrowth from natural grassland during the dry period of 1974.

Harvest date during major rainy season / Maturity at major rainy season harvest	4[+] Apr. 29[‡]	5 May 6	6 May 13	7 May 20	8 May 27	9 June 3	11 June 17	13 July 1	15 July 15	17 July 29
End of major rainy season (July 29)										
Maturity	13[ǂ]	12	11	10	9	8	6	4	2	0
Slashed	5037	4243	2100	2475	2163	1803	969	566	0	0
Grazed	5546	3964	2272	3082	2078	2233	1060	289	0	0
Burned	5518	3574	2714	3295	2040	2333	738	789	0	0
Mid dry season (Aug. 12)										
Maturity	15[ǂ]	14	13	12	11	10	8	6	4	2
Slashed	6088	5312	1952	3770	4285	3015	1497	1091	745	0
Grazed	6047	5196	2020	3112	4795	2584	1595	2440	601	0
Burned	5296	4981	2487	3188	3887	3038	2080	1638	618	0
End of dry season (Aug. 26)										
Maturity	17[ǂ]	16	15	14	13	12	10	8	6	4
Slashed	4302	4969	1036	3635	3869	3084	4084	2859	1664	1374
Grazed	4299	5793	1850	4458	4377	4412	4007	2927	1430	2204
Burned	4897	4903	1312	4956	4189	4645	3570	3079	1941	1290
Average end rainy season	5367^{a}_{xy} [o]	3927^{a}_{y}	2352^{b}_{x}	2951^{b}_{x}	2093^{b}_{y}	2123^{b}_{y}	923^{c}_{y}	548^{c}_{y}	0	0
Average mid dry season	5796^{a}_{x}	5163^{a}_{x}	2153^{d}_{x}	3357^{bc}_{x}	4322^{c}_{x}	2894^{d}_{y}	1724^{d}_{y}	1723^{d}_{xy}	654d	0
Average end dry season	4499^{a}_{y}	5221^{a}_{x}	1399^{c}_{y}	4350^{a}_{x}	4145^{a}_{x}	4047^{a}_{x}	3875^{b}_{x}	2955^{b}_{x}	1678c	1723c

\+ Weeks from pretreatment: April 1, 1974.

‡ Harvest date during the major rainy season.

ǂ Weeks from major rainy season harvest to recovery harvest.

o Data followed by the same letter are not different ($P > 0.05$): columns - a,b,c,d; rows - x,y,z.

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Appendix X. Yield of regrowth from natural grassland during the dry period of 1975.

Harvest date during rainy season / Maturity at rainy season harvest	6+ May 21‡	7 May 28	8 June 4	9 June 11	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
End of major rainy season (Aug. 13)										
Maturity	12‡	11	10	9	8	7	6	4	2	0
Slashed	3465	3206	2870	1907	1221	740	567	290	120	0
Grazed	3449	3297	3122	2128	1166	796	550	301	98	0
Burned	3554	3869	3301	2643	1411	1151	608	373	166	0
Mid dry season (Aug. 27)										
Maturity	14‡	13	12	11	10	9	8	6	4	2
Slashed	4949	5057	4018	2789	2161	1890	938	704	696	0
Grazed	5045	5016	3808	2910	2326	1757	880	851	632	0
Burned	5256	4168	4014	3348	3015	1865	1115	879	737	0
End of dry season (Sept. 10)										
Maturity	16‡	15	14	13	12	11	10	8	6	4
Slashed	6164	4973	5010	5026	2942	2207	2213	1782	1279	527
Grazed	6207	5025	4804	5238	2780	2516	1874	1986	1181	548
Burned	5949	5216	5457	5066	2736	2430	2611	2359	1567	995
Average end rainy season	3489^{a}_{z} [o]	3456^{a}_{y}	3098^{a}_{z}	2226^{b}_{y}	1266^{c}_{y}	895^{c}_{z}	575^{d}_{y}	321^{d}_{z}	128^{d}_{z}	0
Average mid dry season	5083^{a}_{y}	4747^{a}_{x}	3947^{b}_{y}	3016^{c}_{y}	2501^{c}_{x}	1837^{d}_{y}	978^{e}_{y}	811^{e}_{y}	690^{c}_{y}	0
Average end dry season	6107^{a}_{x}	5071^{b}_{x}	5090^{b}_{x}	5110^{b}_{x}	2819^{c}_{x}	2384^{c}_{x}	2233^{cd}_{x}	2042^{cd}_{x}	1342^{de}_{x}	690^{e}

+ Weeks from pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
‡ Weeks from major rainy season harvest to recovery harvest.
o Data followed by the same letter are not different (P > 0.05): columns – a,b,c,d,e; rows – x,y,z.

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Appendix XI. Analyses of variance of seasonal total yield from natural grassland during 1974.

Source	Degrees of freedom	Sums of squares ($x 10^4$)		
		End of rains	Mid dry season	End dry season
Replications	3	179.5	680.1	3330.0
Pretreatment	2	425.6	121.5	505.2
Error (A)	6	525.8	1124.0	3287.1
Dates	7	6675.4**	1067.3**	22890.1**
Date x pretreat.	14	712.1	1234.9	1121.9
Error (B)	63	4974.2	7002.2	8326.9

** Significant ($P < 0.01$).

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Appendix XII. Analyses of variance of seasonal total yield from natural grassland during 1975.

Source	Degrees of freedom	Sums of squares (x 10^4)		
		End of rains	Mid dry season	End dry season
Replications	3	525.2	400.9	121.7
Pretreatment	2	800.7	470.2	737.1
Error (A)	6	764.2	492.3	1169.6
Dates	9	213.9*	1565.3	3052.2**
Date x pretreat.	18	578.8	1354.1	1245.7
Error (B)	81	394.7	6445.7	7520.6

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XIII. Analyses of variance of weekly yields of leaves of <u>Sporobolus</u> and <u>Heteropogon</u> during the major rainy seasons of 1974 (upper) and 1975 (lower).

(Sums of squares x 10^4)

1974

Source	Degrees of freedom	Maturity 4+ Apr. 29‡	5 May 6	6 May 13	7 May 20	8 May 27	9 June 3	11 June 14	13 July 1
Replications	3	0.0046	0.0527	0.5746	9.4890	11.340	13.74	58.910	19.320
Pretreatment	2	0.0097	0.3415*	0.3731	6.0040	24.840	23.86	2.843	35.530
Error (A)	6	0.0119	0.1310	1.8006	8.0125	18.120	32.18	137.000	133.500
Species	1	0.0312*	0.2992*	0.1033	0.5611	9.277	51.90	302.700	159.000
SPP x Pretreat.	2	0.0187	0.1377	1.3470	6.1450**	19.080	81.17	109.700	1.564
Error (B)	9	0.0354	0.1084	3.9012	2.0870	51.790	97.44	312.700	538.600

1975

Source	Degrees of freedom	Maturity 6+ May 21‡	7 May 28	8 June 4	9 June 11	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	0.351	3.168	6.75	23.43	75.01	10.93	9.43	25.24	84.67	150.10
Pretreatment	2	4.863	10.890*	30.97	32.17	8.08	31.30	72.73	122.40	148.80	133.70
Error (A)	6	5.132	3.135	12.12	88.69	123.80	110.90	152.90	161.60	102.90	392.00
Species	1	3.240*	1.862	.82	2.57	76.00	71.20	87.72	3.77	2.88	158.40
SPP x Pretreat.	2	3.724*	3.639	6.87	68.86**	53.64	94.41	80.36	25.86	79.09	72.16
Error (B)	9	2.847	9.462	10.33	24.92	145.50	215.90	284.60	251.90	394.50	284.00

+ Weeks from pretreatment: April 1, 1974, April 9, 1975.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XIV. Analyses of variance of yield of leaves of *Sporobolus* and *Heteropogon* during the major rainy seasons of 1974 (upper) and 1975 (lower).

1974 Source	Degrees of freedom	Sums of squares x 10^4 *Sporobolus*	*Heteropogon*
Replications	3	5.458	88.27
Pretreatment	2	4.315	114.40
Error (A)	6	50.160	273.10
Dates	7	725.600**	2594.00**
Date x pretreat.	14	69.940	124.30
Error (B)	63	282.600	751.20

1975 Source	Degrees of freedom	Sums of squares x 10^4 *Sporobolus*	*Heteropogon*
Replications	3	170.70	394.0000
Pretreatment	2	61.72	0.2959
Error (A)	6	241.40	593.3000
Dates	9	858.70**	1821.0000**
Date x pretreat.	18	193.80	273.3000
Error (B)	81	729.40	1136.0000

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XV. Analyses of variance of weekly percent In Vitro dry matter digestibility of leaves (upper) and stems (lower) of Sporobolus and Heteropogon during the major rainy season of 1974.

(Sums of squares)

Leaves

Source	Degrees of freedom	Maturity 4+ Apr. 29‡	5 May 6	6 May 13	7 May 20	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	46.74	34.92	98.73	87.84	40.10	64.05	128.70	78.28	96.97	136.80
Pretreatment	2	22.11	66.57	1.44	28.73	61.92*	47.30	17.89	54.25	42.02	4.28
Error (A)	6	98.87	13.36	32.36	67.49	26.14	48.81	52.88	111.30	51.20	66.53
Species	1	31.05*	33.61	12.61	33.84	9.88	23.60	53.70**	21.09	241.30**	180.40**
SPP x pretreat.	2	103.00**	29.05	33.44	9.27	44.21*	58.90	0.23	28.87	23.12	11.50
Error (B)	9	44.57	11.90	64.12	76.39	24.35	75.96	39.52	167.20	62.79	151.70

Stems

Source	Degrees of freedom	Maturity 7+ May 20‡	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	97.26	111.70	121.60	46.82	111.30	120.20	317.70
Pretreatment	2	164.60**	190.60**	285.30*	136.80*	40.79	2.44	79.91
Error (A)	6	43.57	34.81	102.20	36.48	28.45	38.65	219.90
Species	1	552.00**	32.43	897.90**	236.90**	43.47*	35.28*	26.25
SPP x pretreat.	2	94.65	72.78	57.78	44.08	29.21	46.59	47.32
Error (B)	9	130.90	75.93	23.62	32.83	64.07	53.53	129.10

\+ Weeks from pretreatment date: April 1, 1974.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XVI. Analyses of variance of weekly percent In Vitro dry matter digestibility of leaves (upper) and stems (lower) of Sporobolus and Heteropogon during the major rainy season of 1975.

(Sums of squares)

Leaves

Source	Degrees of freedom	Maturity									
		6+ May 21‡	7 May 28	8 June 4	9 June 11	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	75.87	36.31	20.58	125.00	19.66	198.60	300.70	11.91	83.50	221.20
Pretreatment	2	250.50**	64.81	168.90*	179.20*	65.66	7.76	83.99	28.66	121.70	177.40
Error (A)	6	51.27	50.24	82.92	68.31	53.46	236.20	254.70	120.30	158.60	358.30
Species	1	17.17	35.04*	19.82	49.88	67.33	135.80**	11.48	117.00	10.53	19.08
SPP x pretreat.	2	161.50	44.74*	175.60**	13.06	43.88	31.51	287.70	20.73	32.30	162.60
Error (B)	9	170.70	32.11	71.86	99.03	158.90	213.90	897.90	298.40	395.00	621.00

Stems

Source	Degrees of freedom	Maturity						
		9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	91.40	54.97	15.14	149.60	98.73	8.63	35.66
Pretreatment	2	1371.00**	21.39	46.81	192.80	133.00	140.53	288.70
Error (A)	6	77.83	421.60	177.40	187.50	193.90	186.40	567.00
Species	1	1549.00**	1332.00**	1350.00**	840.11**	735.90**	1114.00**	2.60
SPP x pretreat.	2	622.20	472.50	124.50	28.33	336.40*	130.00	162.50
Error (B)	9	643.00	737.00	164.30	328.50	272.90	868.70	208.40

\+ Weeks after pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XVII. Analyses of variance of percent In Vitro dry matter digestibility of leaves (upper) and stems (lower) of Sporobolus and Heteropogon during the major rainy season of 1974.

Leaves

Source	Degrees of freedom	Sums of squares	
		Sporobolus	Heteropogon
Replications	3	184.60**	165.90*
Pretreatments	2	81.59*	34.22
Error (A)	6	33.78	51.72
Dates	9	7729.00**	4697.00**
Date x pretreat.	18	315.10*	257.20
Error (B)	81	710.40	954.00

Stems

Source	Degrees of freedom	Sums of squares	
		Sporobolus	Heteropogon
Replications	3	315.00	328.2
Pretreatments	2	244.70*	569.8**
Error (A)	6	91.20*	122.2
Dates	6	4743.00**	8621.0**
Date x pretreat.	12	111.70	358.5**
Error (B)	54	666.80	414.6

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XVIII. Analyses of variance of percent In Vitro dry matter digestibility of leaves (upper) and stems (lower) of Sporobolus and Heteropogon during the major rainy season of 1975.

Leaves

Source	Degrees of freedom	Sums of squares Sporobolus	Sums of squares Heteropogon
Replications	3	183.00	69.04
Pretreatments	2	52.24	194.00
Error (A)	6	335.70	120.90
Dates	9	8759.00**	7663.00**
Date x pretreat.	18	1424.00*	452.10
Error (B)	81	3044.00	1733.00

Stems

Source	Degrees of freedom	Sums of squares Sporobolus	Sums of squares Heteropogon
Replications	3	25.41	230.0
Pretreatment	2	28.13	190.0
Error (A)	6	100.00	518.0
Dates	6	5225.00**	11,112.0*
Date x pretreat.	12	1298.00**	1840.0**
Error (B)	54	2408.00	3351.0

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XIX. Analyses of variance of percent In Vitro dry matter digestibility of whole plants of Sporobolus and Heteropogon during the major rainy seasons of 1974 (upper) and 1975 (lower).

1974

Source	Degrees of freedom	Sums of squares: Sporobolus	Sums of squares: Heteropogon
Replications	3	183.64	226.76
Pretreatment	2	187.98*	156.03
Error (A)	6	81.52	77.08
Dates	6	6165.30**	5566.36**
Date x pretreat.	12	75.48	75.74
Error (B)	54	337.06	539.78

1975

Source	Degrees of freedom	Sums of squares: Sporobolus	Sums of squares: Heteropogon
Replications	3	47.17	36.28
Pretreatment	2	55.82	124.15
Error (A)	6	325.79	105.73
Dates	6	4379.60**	8496.50**
Date x pretreat.	12	452.89	182.80
Error (B)	54	2962.75	881.01

* Significant ($P \leq 0.05$).
** Significant ($P \leq 0.01$).

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Appendix XX. Percent In Vitro digestible dry matter of leaves, stems and whole plants of _Sporobolus_ and _Heteropogon_ during the major rainy season of 1974.

	Maturity									
	4+ Apr. 29‡	5 May 6	6 May 13	7 May 20	8 May 27	9 June 3	11 June 17	13 July 1	15 July 15	17 July 29
#_Sporobolus_										
Leaves	57.7^{bc}_{t} [o]	52.7^{d}_{t}	59.9^{ab}_{t}	59.7^{ab}_{t}	61.5^{a}_{t}	54.5^{c}_{t}	49.6^{de}_{u}	48.4^{e}_{u}	43.3^{f}_{u}	34.6^{g}_{u}
Stem	‡+--	--	--	55.3^{a}_{w}	53.5^{a}_{v}	48.5^{b}_{w}	48.7^{b}_{w}	42.3^{c}_{v}	38.0^{d}_{w}	33.3^{e}_{v}
Whole	‡+--	--	--	58.9^{a}_{x}	59.7^{a}_{x}	53.2^{b}_{y}	49.2^{c}_{y}	46.7^{d}_{x}	40.9^{e}_{y}	34.3^{f}_{y}
#_Heteropogon_										
Leaves	55.4^{c}_{u} [o]	55.1^{c}_{t}	61.3^{a}_{t}	62.0^{a}_{t}	60.2^{ab}_{t}	56.5^{bc}_{t}	52.6^{cd}_{t}	50.3^{d}_{u}	49.7^{d}_{t}	40.1^{e}_{t}
Stem	‡+--	--	--	64.9^{a}_{v}	55.8^{b}_{v}	60.7^{c}_{v}	55.0^{c}_{v}	45.0^{d}_{v}	40.5^{e}_{v}	35.4^{f}_{v}
Whole	‡+--	--	--	61.9^{a}_{x}	59.8^{a}_{x}	56.9^{b}_{x}	53.2^{c}_{x}	43.4^{d}_{x}	44.7^{d}_{x}	37.7^{e}_{x}

\+ Weeks from pretreatment: April 1, 1974.
‡ Harvest date during the major rainy season.
‡+ Not determined.
o Data followed by the same letter are not different ($P > 0.05$): within rows – a,b,c,d,e,fg; between species: within leaves – t,u; within stems – v,w; within whole plants – x,y.

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Appendix XXI. Percent In Vitro digestible dry matter of leaves, stems and whole plants of Sporobolus and Heteropogon during the major rainy season of 1975.

	Maturity									
	6+ May 21‡	7 May 28	8 June 4	9 June 11	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
#Sporobolus										
Leaves	$58.6^{ab\,o}_{t}$	61.9^{a}_{t}	53.9^{bc}_{t}	53.9^{bc}_{t}	54.1^{abc}_{t}	47.6^{cd}_{u}	45.7^{d}_{t}	44.1^{d}_{t}	41.0^{d}_{t}	33.5^{e}_{t}
Stems	‡+—	—	—	34.7^{bc}_{w}	43.6^{a}_{w}	40.8^{ab}_{w}	33.7^{bc}_{w}	29.1^{c}_{w}	20.8^{d}_{w}	22.5^{d}_{v}
Whole	‡+—	—	—	51.6^{a}_{y}	51.8^{a}_{y}	46.8^{ab}_{y}	43.7^{bc}_{x}	41.2^{cd}_{y}	37.8^{d}_{x}	29.8^{e}_{x}
#Heteropogon										
Leaves	$60.3^{a\,o}_{t}$	59.4^{a}_{u}	52.1^{bc}_{t}	56.7^{ab}_{t}	57.5^{ab}_{t}	52.4^{bc}_{t}	47.0^{c}_{t}	48.5^{c}_{t}	42.4^{d}_{t}	33.5^{e}_{t}
Stems	‡+—	—	—	50.8^{bc}_{v}	58.5^{a}_{v}	55.8^{ab}_{v}	45.5^{cd}_{v}	40.2^{de}_{v}	34.5^{e}_{v}	22.5^{f}_{v}
Whole	‡+—	—	—	56.5^{ab}_{x}	57.9^{a}_{x}	53.2^{b}_{x}	46.5^{c}_{x}	45.3^{c}_{x}	38.7^{d}_{x}	27.2^{e}_{x}

\+ Weeks from pretreatment: April 9, 1975.

‡ Harvest date during the major rainy season.

‡+ Not determined.

o Data followed by the same letter are not different ($P > 0.05$): within rows - a,b,c,d,e,f; between species: within leaves - t,u; within stems - v,w; within whole plants - x,y.

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Appendix XXII. Analyses of variance of percent In Vitro dry matter digestibility (leaves vs. stems) in Sporobolus (upper) and Heteropogon (lower) during the major rainy season of 1974.

(Sums of squares)

Sporobolus

Source	Degrees of freedom	Maturity 7+ May 20‡	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	3.81	77.75	82.38	70.55	87.76	184.30	273.00
Pretreatment	2	38.52	101.40*	158.20**	54.72**	17.16	59.63	87.36
Error (A)	6	41.61	27.78	48.99	13.20	68.88	40.73	149.00
Leaves vs. stems	1	114.00**	380.80**	214.80**	4.86	225.70**	167.50**	10.93
L-S x pretreat.	2	3.66	2.67	.5908	7.57	16.69	5.30	40.09
Error (B)	9	95.36	51.86	86.43	53.00	65.67	28.81	219.20

Heteropogon

Source	Degrees of freedom	Maturity 7+ May 20‡	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	117.70	65.87	114.70	89.01	77.39	55.00	236.70
Pretreatment	2	122.90	225.30**	187.60*	89.85	115.10	40.24	11.56
Error (A)	6	146.80	55.46	72.52	80.35	200.30	65.81	50.00
Leaves vs. stems	1	49.02	114.00**	109.20**	34.32**	169.60**	507.80**	134.90**
L-S x pretreat.	2	132.10*	40.14*	102.90**	46.88**	4.21	9.01	4.00
Error (B)	9	98.24	34.36	31.22	31.06	60.70	48.59	94.00

\+ Weeks from pretreatment: April 1, 1974.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXIII. Analyses of variance on percent In Vitro dry matter digestibility (leaves vs. stems) in <u>Sporobolus</u> (upper) and <u>Heteropogon</u> (lower) during the major rainy season of 1975.

(Sums of squares)

<u>Sporobolus</u>

Source	Degrees of freedom	Maturity 9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	19.18	76.63	199.10	427.30	54.07	95.22	57.06
Pretreatment	2	163.80	164.60	113.60	231.60	178.10	175.60	5.89
Error (A)	6	193.60	125.60	255.80	450.80	280.60	270.50	563.70
Leaf vs. stem	1	2214.00**	669.90**	277.40*	856.80*	1350.00**	2444.00**	439.40**
L-S x pretreat.	2	36.90	266.40	33.95	284.20	279.90	85.86	5.06
Error (B)	9	449.40	290.90	277.70	883.10	374.40	373.40	193.30

<u>Heteropogon</u>

Source	Degrees of freedom	Maturity 9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	98.22	67.92	27.51	137.60	37.64	127.80	218.30
Pretreatment	2	1287.00**	57.39	46.03	18.61	58.86	67.51	121.60
Error (A)	6	177.40	311.00	119.00	172.60	172.60	254.30	578.10
Leaf vs. stem	1	217.80**	5.80	71.07	13.50	417.50**	372.90*	726.00**
L-S x pretreat.	2	698.20**	115.10	17.06	58.44*	1.97**	95.56	658.30*
Error (B)	9	166.70	573.50	126.50	47.55	76.94	579.50	401.10

\+ Weeks from pretreatment: April 9, 1975.
‡ Harvest date
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXIV. Analyses of variance for weekly percent In Vitro dry matter digestibility in whole plants of Sporobolus and Heteropogon during the major rainy seasons of 1974 (upper) and 1975 (lower).

(Sums of squares)

1974 Source	Degrees of freedom	Maturity 7+ May 20‡	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	68.80	51.44	75.04	98.17	83.79	93.69	130.60
Pretreatment	2	42.19	83.24**	85.79	45.00	53.96	19.17	7.16
Error (A)	6	68.90	16.30	49.48	35.12	68.06	41.43	48.42
Species	1	55.28	0.17	82.68**	96.12**	16.81	85.07**	66.97*
SPP x pretreat.	2	11.43	48.31	56.93	2.11	15.79	17.48	9.93
Error (B)	9	95.34	41.67	51.40	25.54	128.30	58.96	64.06

1975 Source	Degrees of freedom	Maturity 9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	115.70	23.34	126.60	297.50	5.03	51.31	130.90
Pretreatment	2	138.60*	43.29	17.20	74.52	1.70	63.67	26.65
Error (A)	6	79.20	34.13	228.70	174.70	110.70	122.80	317.50
Species	1	139.80*	224.00**	312.20**	48.28	101.80*	5.12	42.35
SPP x pretreat.	2	9.45	11.66	70.72	169.10	35.31	67.27	36.31
Error (B)	9	147.60	104.50	129.40	578.60	186.00	262.40	238.60

+ Weeks from pretreatment: April 1, 1974, April 9, 1975.
‡ Harvest date during the major rainy season.
* Significant ($P \leq 0.05$).
** Significant ($P \leq 0.01$).

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Appendix XXV. Analyses of variance of weekly percent nitrogen of leaves (upper) and stems (lower) of Sporobolus and Heteropogon during the major rainy season of 1974.

(Sums of squares)

Leaves Source	Degrees of freedom	Maturity 7+ May 20‡	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	0.0163	0.2376	0.3004	0.0790	0.1477	0.0413	0.0146
Pretreatment	2	0.2288	0.2666	0.2032	0.0061	0.1290	0.0335	0.1163
Error (A)	6	0.3289	0.2728	0.1599	0.2960	0.0875	0.0979	0.0767
Species	1	0.0150	0.5281**	0.1536	0.0247	0.0171	0.1751**	0.0610**
SPP x pretreat.	2	0.0802	0.1256*	0.1047	0.0076	0.0044	0.0129	0.0119
Error (B)	9	0.0768	0.1506	0.3034	0.1165	0.0325	0.0665	0.0218

Stems Source	Degrees of freedom	Maturity 7+ May 20‡	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	0.0501	0.0997	0.1698	0.0120	0.0837	0.0177	0.0276
Pretreatment	2	0.2228**	0.1444	0.0503	0.0223	0.0488	0.0253	0.0097
Error (A)	6	0.0459	0.1324	0.2340	0.1670	0.0593	0.0240	0.0270
Species	1	1.6590**	1.4702**	0.0794**	0.8932**	0.2542**	0.0280**	0.0012
SPP x pretreat.	2	0.0484*	0.1043**	0.0663*	0.0097	0.0052	0.0144**	0.0176*
Error (B)	9	0.0717	0.0690	0.1728	0.0260	0.0146	0.0150	0.0426

\+ Weeks from pretreatment: April 1, 1974.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXVI. Analyses of variance of weekly percent nitrogen of leaves (upper) and stems (lower) of *Sporobolus* and *Heteropogon* during the major rainy season of 1975.

(Sums of squares)

Leaves

Source	Degrees of freedom	Maturity 9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	0.3024	0.1277	0.2540	0.1829	0.0382	0.0466	0.0049
Pretreatment	1	0.0827	0.0256	0.0600**	0.0380	0.0156	0.0077	0.0100
Error (A)	3	0.1381	0.0198	0.0095	0.0310	0.0118	0.0870	0.0244
Species	1	0.0011	0.0600	0.0144	0.0042	0.0756*	0.0039	0.0342*
SPP x pretreat.	1	0.0248	0.1225*	0.0002	0.0484*	0.0306	0.0077	0.0182*
Error (B)	6	0.4447	0.0822	0.1308	0.0339	0.0521	0.0715	0.0176

Stems

Source	Degrees of freedom	Maturity 9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	0.2902	0.0245	0.0616	0.0105	0.0221	0.0152	0.0099
Pretreatment	1	0.0729	0.0218	0.0248	0.0176	0.0031	0.0014	0.0072
Error (A)	3	0.1729	0.0398	0.0098	0.0061	0.0125	0.0118	0.0390
Species	1	1.5500**	0.3752**	0.2328**	0.1871**	0.1702**	0.0333**	0.0600
SPP x pretreat.	1	0.0040	0.0495**	0.0086	0.0060	0.0011	0.0028	0.0169
Error (B)	6	0.5246	0.0159	0.0151	0.0077	0.0266	0.0069	0.1329

\+ Weeks from pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXVII. Analyses of variance of percent nitrogen in leaves, stems and whole plant of Sporobolus and Heteropogon during the major rainy seasons of 1974 (upper) and 1975 (lower).

1974

Source	Degrees of freedom	Sums of squares					
		Sporobolus			Heteropogon		
		Leaf	Stem	Whole	Leaf	Stem	Whole
Replications	3	0.1376	0.0347	0.1541	0.2350	0.0909	0.4080
Pretreatments	2	0.0887	0.1287	0.2251	0.0965	0.0040	0.1247*
Error (A)	6	0.4035	0.1083	0.4237	0.1476	0.0443	0.0837
Dates	6	10.8400**	7.9400**	11.0450**	6.6480**	1.5330**	12.5930**
Date x pretreat.	12	0.9491	0.3419	1.1592	0.2909	0.2943*	0.3013
Error (B)	54	1.3150	0.7677	1.2832	0.7482	0.4423	0.7330

1975

Source	Degrees of freedom	Sums of squares					
		Sporobolus			Heteropogon		
		Leaf	Stem	Whole	Leaf	Stem	Whole
Replications	3	0.6812	0.0945	0.5959	0.1891	0.0915	0.1824
Pretreatment	1	0.2379	0.0106	0.1029	0.0412	0.0463	0.0818
Error (A)	3	0.0920	0.0660	0.0897	0.0831	0.1840	0.0778
Dates	6	5.0282**	5.8150**	5.1112**	4.1190**	6.9570**	7.1293
Date x pretreat.	6	0.0858	0.2017	0.1075	0.2455*	0,2007	0.3205
Error (B)	36	0.8537	1.1910	1.1377	0.7115	0.2930	0.4272

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXVIII. Percent nitrogen in leaves, stems and whole plant of <u>Sporobolus</u> and <u>Heteropogon</u> during the major rainy season of 1974.

	Maturity						
	7[+] May 20[‡]	8 May 27	9 June 3	11 June 17	13 July 1	15 July 15	17 July 29
<u>Sporobolus</u>							
Leaves	2.00^{a}_{t}[o]	1.78^{b}_{t}	1.39^{c}_{t}	1.32^{cd}_{t}	1.25^{d}_{t}	0.99^{e}_{u}	0.95^{e}_{u}
Stems	1.34^{a}_{v}	1.18^{b}_{v}	0.80^{d}_{v}	0.93^{c}_{v}	0.69^{e}_{v}	0.49^{f}_{v}	0.47^{f}_{v}
Whole plant	1.87^{a}_{x}	1.65^{b}_{x}	1.26^{c}_{y}	1.19^{cd}_{x}	1.10^{d}_{x}	0.82^{e}_{x}	0.85^{e}_{x}
<u>Heteropogon</u>							
Leaves	1.95^{a}_{t}	1.49^{bc}_{u}	1.55^{b}_{t}	1.40^{c}_{t}	1.30^{d}_{t}	1.16^{e}_{t}	1.00^{f}_{t}
Stems	0.82^{a}_{w}	0.68^{b}_{w}	0.68^{b}_{w}	0.55^{c}_{w}	0.48^{cd}_{w}	0.42^{d}_{w}	0.48^{cd}_{v}
Whole plant	1.84^{a}_{x}	1.35^{b}_{y}	1.42^{b}_{x}	1.13^{c}_{x}	1.00^{d}_{x}	0.78^{e}_{x}	0.72^{e}_{x}

+ Weeks from pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
o Data followed by the same letter are not different ($P > 0.05$): rows – a,b,c,d,e,f; between species: within leaves – t,u; within stems – v,w; within whole plants – x,y.

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Appendix XXIX. Percent nitrogen in leaves, stems and whole plants of Sporobolus and Heteropogon during the major rainy season of 1975.#

	Maturity						
	9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Sporobolus							
Leaves	1.84^{a}_{t} [o]	1.37^{b}_{t}	1.31^{b}_{t}	1.12^{c}_{t}	1.02^{cd}_{u}	1.01^{cd}_{t}	0.88^{d}_{t}
Stems	1.43^{a}_{v}	0.92^{b}_{v}	0.77^{bc}_{v}	0.61^{cd}_{v}	0.57^{d}_{v}	0.45^{d}_{v}	0.44^{d}_{v}
Whole plant	1.78^{a}_{x}	1.25^{b}_{x}	1.20^{b}_{x}	1.01^{c}_{x}	0.93^{cd}_{x}	0.92^{cd}_{y}	0.80^{d}_{x}
Heteropogon							
Leaves	1.80^{a}_{t}	1.39^{b}_{t}	1.40^{b}_{t}	1.20^{c}_{t}	1.13^{cd}_{t}	1.00^{de}_{t}	0.95^{e}_{u}
Stems	0.74^{a}_{w}	0.57^{b}_{w}	0.57^{b}_{w}	0.41^{c}_{w}	0.37^{c}_{w}	0.35^{c}_{w}	0.34^{c}_{v}
Whole plant	1.73^{a}_{x}	1.27^{b}_{x}	1.20^{b}_{x}	0.92^{c}_{x}	0.80^{d}_{x}	0.71^{de}_{x}	0.64^{e}_{y}

+ Weeks from pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
# Average of 2 pretreatments: slashed and grazed.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e; between species: within leaves - t,u; within stems - v,w; within whole plants - x,y.

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Appendix XXX. Analyses of variance of percent nitrogen of leaves vs. stems in Sporobolus (upper) and Heteropogon (lower) during the major rainy season of 1974.

(Sums of squares)

Sporobolus

Source	Degrees of freedom	Maturity 7[+] May 20[‡]	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	0.0645	0.2857	0.1541	0.0729	0.1226	0.0121	0.0156
Pretreatment	2	0.2784	0.5489	0.3328*	0.0089	0.0991	0.0268	0.0277
Error (A)	6	0.2738	0.4129	0.1603	0.3234	0.0769	0.0984	0.0503
Leaves vs. stems	1	2.5091**	2.2510**	2.0827**	0.9600**	0.8816**	1.5150**	1.0584**
L-S x pretreat.	2	0.0059	0.0275	0.0369	0.0095	0.0104	0.0016	0.0120*
Error (B)	9	0.1230	0.0924	0.2422	0.0585	0.0226	0.0395	0.0210

Heteropogon

Source	Degrees of freedom	Maturity 7[+] May 20[‡]	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	0.0104	0.0761	0.3236	0.0278	0.1057	0.0570	0.0241
Pretreatment	2	0.1296*	0.0240	0.0388	0.0174	0.0731	0.0530	0.0899
Error (A)	6	0.0654	0.0573	0.2943	0.1719	0.0545	0.0223	0.0328
Leaves vs. stems	1	7.5600**	3.9450**	4.4807**	4.3350**	4.0262**	3.3000**	1.7174**
L-S x pretreat.	2	0.1662**	0.0405**	0.0162	0.0099	0.0048	0.0046	0.0257
Error (B)	9	0.0526	0.0376	0.1659	0.0398	0.0429	0.0329	0.0665

\+ Weeks from pretreatment: April 1, 1974.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXXI. Analyses of variance of percent nitrogen of leaves vs. stems in <u>Sporobolus</u> (upper) and <u>Heteropogon</u> (lower) during the major rainy season of 1975.

(Sums of squares)

<u>Sporobolus</u>

Source	Degrees of freedom	Maturity 9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	1.0837	0.1318	0.2279	0.0839	0.0721	0.0488	0.0483
Pretreatment	1	0.0064	0.1936*	0.0218	0.0977*	0.0306	0.0120	0.0010
Error (A)	3	0.6298	0.0256	0.0220	0.0109	0.0375	0.0491	0.0399
Leaves vs. stems	1	0.6889**	0.7056**	1.2155**	1.0353**	0.7921**	1.2660**	0.7744**
L-S x pretreat.	1	0.0441	0.0049	0.0068	0.0105	0.0156*	0.0020	0.0506
Error (B)	6	0.0968	0.0597	0.0848	0.0551	0.0140	0.0448	0.0806

<u>Heteropogon</u>

Source	Degrees of freedom	Maturity 9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	0.0201	0.0359	0.0967	0.0512	0.0084	0.0166	0.0202
Pretreatment	1	0.0095**	0.0176	0.0650	0.0002	0.0011	0.0064	0.0020
Error (A)	3	0.0010	0.0397	0.0340	0.0280	0.0145	0.0828	0.0092
Leaves vs. stems	1	4.4420**	2.8820**	2.9070**	2.2952**	2.4885**	1.8769**	1.7161**
L-S x pretreat.	1	0.1207**	0.0033	0.0020	0.0016	0.0003	0.0090	0.0016
Error (B)	6	0.0416	0.0172	0.0148	0.0437	0.0168	0.0269	0.0300

+ Weeks from pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXXII. Analyses of variance of weekly percent nitrogen of whole plants of <u>Sporobolus</u> and <u>Heteropogon</u> during the major rainy seasons of 1974 (upper) and 1975 (lower).

(Sums of squares)

1974

Source	Degrees of freedom	Maturity 7+ May 20‡	8 May 27	9 June 3	11 June 14	13 July 1	15 July 15	17 July 29
Replications	3	0.0103	0.2687	0.4011	0.0375	0.2192	0.0213	0.0605
Pretreatment	2	0.4010	0.0361	0.3609	0.0189	0.0886	0.0165	0.0923
Error (A)	6	0.2853	0.3185	0.2250	0.2884	0.0585	0.0731	0.0376
Species	1	0.0054	0.2541*	0.1454*	0.0252	0.0572	0.0109	0.0973
SPP x pretreat.	2	0.0017*	0.1100	0.1243	0.0014	0.0451	0.0086	0.0175
Error (B)	9	0.0017	0.2311	0.1413	0.0789	0.0617	0.0541	0.0104

1975

Source	Degrees of freedom	Maturity 9+ June 11‡	10 June 18	11 June 25	12 July 3	14 July 16	16 July 28	18 Aug. 13
Replications	3	0.6189	0.0815	0.3540	0.0781	0.0371	0.0743	0.0098
Pretreatment	1	0.1892	0.1278*	0.0105	0.0163	0.0136	0.0072	0.0049
Error (A)	3	0.4172	0.0176	0.0379	0.0100	0.0067	0.1253	0.0193
Species	1	0.0072	0.0011	0.0005	0.0371	0.0495	0.1849*	0.1122**
SPP x pretreat.	1	0.1406	0.0028	0.0068	0.0495*	0.0126	0.0009	0.0272*
Error (B)	6	0.2346	0.0643	0.0646	0.0481	0.0777	0.1119	0.0217

+ Weeks after pretreatment: April 9, 1975.
‡ Harvest date during the major rainy season.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXXIII. Analyses of variance of weekly yields from giant star, buffel and pangola grasses during the minor rainy season of 1974 (upper) and the major rainy season of 1975 (lower).

(Sums of squares x 10^4)

1974-Minor rainy season

Source	Degrees of freedom	Maturity 3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Replications	3	10.83	11.72	53.96	33.26	43.34	76.92	346.10	125.60	56.81	39.62
Species	1	0.56	32.52	34.36	68.68	13.89	12.35	158.20	225.10	196.90	159.60
Error	3	42.61	11.49	10.79	419.20	258.00	90.09	114.80	149.90	603.20	458.00

1975-Major rainy season

Source	Degrees of freedom	Maturity 3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Replications	3	0.35	14.89	20.92	87.96	123.60	73.83	87.26	201.60	98.49	386.80
Species	2	33.18**	314.20*	142.20	75.81	557.50*	95.20	544.20*	1471.00**	1343.00	334.90
Error	6	3.86	42.26	87.39	103.20	221.70	248.20	254.30	112.90	238.30	321.00

\+ Weeks from beginning of trial.
‡ Harvest date during minor rainy season of 1974 and major rainy season of 1975.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXXIV. Analyses of variance of yields from giant star, buffel and pangola grasses during the minor rainy season of 1974 and the major rainy season of 1975.

Source	Minor rainy season of 1974		Major rainy season of 1975	
	Degrees of freedom	Sum of squares x 10^4	Degrees of freedom	Sum of squares x 10^4
Replications	3	380.30	3	301.90
Species	1	649.60	2	3126.00**
Error (A)	3	443.30	6	374.80
Dates	9	9637.00**	9	39062.00**
Date x species	9	252.60	18	1785.00
Error (B)	54	2132.00	81	2055.00

* Significant ($P \leq 0.05$).
** Significant ($P \leq 0.01$).

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Appendix XXXV. Accumulation of dry matter of giant star, buffel and pangola grasses during the minor rainy season of 1974 (upper) and the major rainy season of 1975 (lower).

1974	Maturity									
	3[+] Oct. 8[‡]	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Giant star	1686^{d}_{x}[o]	2470^{dc}_{x}	3098^{bc}_{x}	4079^{bc}_{x}	4474^{b}_{x}	4492^{b}_{x}	4267^{b}_{x}	4310^{b}_{x}	4715^{a}_{x}	4467^{b}_{x}
Buffel	1633^{d}_{x}	2873^{cd}_{x}	3513^{bc}_{x}	4665^{b}_{x}	4737^{b}_{x}	4740^{b}_{x}	5157^{b}_{x}	5371^{a}_{x}	5707^{a}_{x}	5360^{a}_{x}

1975	Maturity									
	3[+] May 20[‡]	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Giant star	403^{e}_{x}	1047^{cd}_{y}	1723^{cd}_{x}	2516^{c}_{x}	4094^{b}_{x}	4814^{b}_{x}	5296^{a}_{y}	4612^{b}_{y}	4516^{b}_{x}	4759^{b}_{x}
Buffel	598^{d}_{x}	2021^{c}_{x}	2218^{c}_{x}	2838^{c}_{x}	4266^{b}_{x}	4615^{b}_{x}	6212^{a}_{x}	6744^{a}_{x}	6833^{a}_{x}	6040^{a}_{x}
Pangola	191^{e}_{y}	851^{cd}_{y}	1380^{dc}_{x}	2222^{bc}_{x}	2742^{b}_{y}	4142^{a}_{x}	4566^{a}_{y}	4266^{a}_{y}	4668^{a}_{x}	5241^{a}_{x}

\+ Weeks from beginning of trial: September 16, 1974; April 29, 1975.

‡ Harvest date during minor rainy season of 1974 or major rainy season of 1975.

o Date followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e; columns within years - x,y.

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Appendix XXXVI. Analyses of variance of regrowth yields from giant star, buffel and pangola grasses during the dry periods of December 1974 – May 1975 (upper) and August – September 1975 (lower).

1974

Source	End rainy season		Mid dry season		End dry season	
	Degrees of freedom	Sums of squares x 10^4	Degrees of freedom	Sums of squares x 10^4	Degrees of freedom	Sums of squares x 10^4
Replications	2	54.16	3	176.40	3	396.70
Species	1	1921.00**	1	1196.00**	1	1981.00**
Error (A)	2	202.30	3	276.90	3	444.70
Harvest dates	8	4853.00**	9	4430.00**	9	1436.00
Date x species	8	201.80	9	300.70	9	1414.00
Error (B)	32	637.20	54	2219.00	54	5601.00

1975

Source	End rainy season		Mid dry season		End dry season	
	Degrees of freedom	Sums of squares x 10^4	Degrees of freedom	Sums of squares x 10^4	Degress of freedom	Sums of squares x 10^4
Replications	3	1101.00	3	51.17	3	263.50
Species	2	2708.00**	2	983.00**	2	199.20
Error (A)	6	1076.00	6	109.60	6	168.80
Harvest dates	7	23127.00**	9	32972.00**	9	45478.00**
Date x species	14	1234.00	18	1621.00	18	1213.00
Error (B)	63	2278.00	81	2466.00	81	2553.00

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXXVII. Analyses of variance of weekly regrowth yields from giant star, buffel and pangola grasses across regrowth dates during 1974 (upper) and 1975 (lower).

(Sums of squares x 10^4)

1974 - Minor rainy season

Source	Degrees of freedom	Maturity 3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 12	8 Nov. 19	9 Dec. 3	11 Dec. 17	13 Dec. 31
Replications	2	29.31	61.28	48.92	88.13	74.55	67.74	192.40	164.70	99.25
Species	1	1570.00*	831.40*	633.60	457.50*	99.83	293.50*	195.60	984.30	478.30
Error (A)	2	25.15	76.64	253.20	28.80	85.87	9.25	242.10	194.10	167.80
Regrowth dates	2	326.50	520.00	646.40*	168.70	801.60*	568.90*	532.80	880.60*	2078.00*
Date x species	2	191.90	84.89	55.66	64.93	131.00	0.58	270.90	426.90	101.80
Error (B)	8	464.50	480.50	368.70	430.30	369.90	498.20	860.60	556.50	130.70

1975 - Major rainy season

Source	Degrees of freedom	Maturity 3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15
Replications	3	111.40	32.79	176.90	276.20	131.70	170.70	56.36	19.47
Species	2	425.90	350.80	442.30	749.90*	134.40	927.20	1209.00	286.20*
Error (A)	6	363.50	284.90	302.90	336.40	266.70	229.50	236.90	79.23
Regrowth dates	2	49.05	363.60	2450.00*	2661.00*	59.52	60.79	142.30	119.90*
Date x species	4	1263.00	906.30	303.20	207.00	109.00	224.80	208.30	109.10
Error (B)	18	1857.00	2227.00	626.70	432.90	344.50	637.90	609.70	105.70

\+ Weeks from beginning of trial.
‡ Harvest date during the minor rainy season of 1974 and the major rainy season of 1975.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XXXVIII. Analyses of variance of seasonal total yields from giant star, buffel and pangola grasses during 1974 (upper) and 1975 (lower).

(Sums of squares x 10^4)

1974 Source	Degrees of freedom	End rainy season December 31, 1974 Giant star	Buffel	Degrees of freedom	Mid dry season February 4, 1975 Giant star	Buffel	Degrees of freedom	End dry season April 6, 1975 Giant star	Buffel
Replications	2	103.1	1075.6	3	624.2	708.0	3	415.72	1864.3
Dates	9	1023.4**	1797.0**	9	2631.5**	3701.7**	9	3437.50**	2914.8**
Error	27	899.7	1054.1	27	1360.0	2166.1	27	3285.90	3746.0

1975 Source	Degrees of freedom	End rainy season August 12, 1975 Giant star	Buffel	Pangola	Mid dry season August 26, 1975 Giant star	Buffel	Pangola	End dry season September 9, 1975 Giant star	Buffel	Pangola
Replications	3	825.70	3216.50	162.90	292.60	659.30	21.30	62.00	520.00	334.50
Dates	9	2044.30**	2860.50**	1570.00**	1355.80**	3980.40**	649.00**	1520.90**	1704.30**	1784.60**
Error	27	745.10	2350.00	741.60	1021.90	2164.50	1241.70	1158.00	1701.50	1817.50

** Significant ($P < 0.01$).

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Appendix XXXIX. Analyses of variance of yield of leaves of giant star and buffel grasses during the minor rainy season of 1974 and of giant star, buffel and pangola during the major rainy season of 1975.

Source	1974 Minor rainy season		1975 Major rainy season	
	Degrees of freedom	Sums of squares $\times 10^4$	Degrees of freedom	Sums of squares $\times 10^4$
Replications	3	2.634	3	2.503
Species	1	66.558*	2	14.868**
Error (A)	3	8.847	6	2.554
Dates	9	7.230**	9	15.492**
Date x species	9	5.592**	18	8.688**
Error (B)	54	5.187	81	1.277

* Significant ($P \angle 0.05$).
** Significant ($P \angle 0.01$).

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Appendix XI. Analyses of variance of percent In Vitro dry matter digestibility of leaves, stems and whole plants of giant star, buffel and pangola grasses during the minor rainy season of 1974 and the major rainy season of 1975.

Source	1974 Minor rainy season				1975 Major rainy season			
	Degrees of freedom	Leaves	Stems	Whole plants	Degrees of freedom	Leaves	Stems	Whole plants
Replications	3	27.90	60.85	3.72	3	96.70	1.59	41.81
Species	1	2060.01**	958.40**	59.28*	2	6337.00**	2161.00**	2106.00**
Error (A)	3	14.38	79.57	7.53	6	94.33	155.80	122.40
Dates	9	4352.00**	3466.00**	452.00**	9	4012.00**	8346.00**	7126.00**
Date x species	9	636.10**	338.30**	7.34*	18	1008.00**	2272.00**	761.50**
Error (B)	54	341.50	534.40	10.38	81	857.90	785.10	744.40

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XLI. Analyses of variance of weekly percent In Vitro dry matter digestibility of leaves, stems and whole plants of giant star, buffel and pangola grasses during the minor rainy season of 1974.

(Sums of squares)

Source	Degrees of freedom	Maturity									
		3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Leaves											
Replications	3	10.97	31.42	17.44	19.18	50.30	4.01	57.64	35.33	5.83	25.48
Species	1	0.85	4.96	22.78	199.00**	444.02**	421.95**	433.65**	38.92**	457.50**	322.58**
Error	3	3.38	6.89	6.91	15.77	4.67	5.76	11.39	16.78	21.51	33.12
Stems											
Replications	3	19.80	2.80	21.63	14.07	10.75	2.92	4.90	187.40	5.37	6.91
Species	1	10.55	1.44	17.11	101.53**	172.05**	252.00**	139.44**	67.28	306.28**	228.98**
Error	3	96.92	42.12	9.96	13.96	4.16	17.25	0.49	192.83	9.27	11.25
Whole plants											
Replications	3	12.11	17.58	4.44	1.35	16.89	5.83	11.71	88.90	15.20	23.90
Species	1	0.36	14.39	0.02	4.99	4.29	1.47	40.41	20.64	37.30	1.45
Error	3	9.13	19.00	2.12	7.16	12.97	1.57	63.83	111.68	34.40	28.98

\+ Weeks from beginning of trial, April 1, 1974.
‡ Harvest date during the minor rainy season of 1974.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XLII. Analyses of variance of weekly percent In Vitro dry matter digestibility of leaves, stems and whole plants of giant star, buffel and pangola grasses during the major rainy season of 1975.

(Sums of squares)

Source	Degrees of freedom	Maturity 3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Leaves											
Replications	3	32.14	19.96	34.12	3.63	125.36	42.07	15.93	8.28	57.89	11.37
Species	2	330.62**	641.51**	481.57**	1713.40**	482.18	346.65**	973.01**	426.30**	571.92**	1378.28**
Error	6	33.36	12.77	16.52	38.67	361.06	54.77	34.48	30.49	27.66	88.45
Stems											
Replications	3	51.17	13.45	14.81	6.96	6.61	13.81	38.96	97.24	8.66	22.03
Species	2	112.36	554.77**	265.85**	257.61**	211.83*	166.03*	224.70*	469.08**	903.84**	1266.33**
Error	6	84.62	19.27	29.04	31.67	103.44	80.37	81.87	106.89	100.87	30.90
Whole plants											
Replications	3	15.70	13.76	27.94	22.94	59.07	26.58	23.36	25.17	24.65	4.56
Species	2	317.84**	607.45**	392.39**	638.52*	159.58	69.80	212.82**	49.35	205.53*	213.90
Error	6	13.74	12.47	12.52	177.99	237.72	58.88	35.98	35.09	73.16	7.38

\+ Weeks from beginning of trial, April 29, 1975.
‡ Harvest date during the major rainy season of 1975.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XLIII. Analyses of variance of weekly percent In Vitro dry matter digestibility (leaves vs. stems) of giant star, buffel and pangola grasses during the minor rainy season of 1974 (upper) and the major rainy season of 1975 (lower).

(Sums of squares)

1974 Source	Degrees of freedom	Maturity 3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Reps	3	3.92	13.80	1.24	4.10	49.90*	4.33	27.86	103.70	7.94	22.99
Species	1	2.72	5.88	0.20	8.12	31.64*	10.89	40.64*	66.42	7.56	4.00
Error (A)	3	58.14	36.14	8.21	15.24	3.61	7.55	7.98	149.30	14.02	40.48
Leaves vs. stems	1	1652.00*	706.20**	753.50**	737.10**	822.30**	951.70**	1121.00**	622.50**	1014.00**	524.40**
L-S x species	1	8.70	0.53	39.69	292.40**	584.40**	663.10**	532.50**	390.10**	756.20**	547.60**
Error (B)	6	69.00	33.30	46.51	43.65	16.39	18.07	38.58	179.40	20.04	13.29

1975 Source	Degrees of freedom	Maturity 3+ May 20‡	4 May 22	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Reps	3	9.14	13.32	40.46	5.03	54.80	51.42	48.89	49.66	15.67	7.46
Species	2	359.80**	1132.00**	729.80**	1229.00**	396.10	187.90*	404.10**	142.90*	392.40**	134.10**
Error (A)	6	17.23	24.54	24.79	64.86	328.70	94.17	52.46	72.37	58.98	47.87
Leaves vs. stems	1	130.70**	90.87**	104.60**	0.15	240.00*	824.80**	563.60**	885.70**	777.50**	680.40**
L-S x species	2	83.17	64.39*	17.58	742.30**	297.90*	324.80**	793.70**	752.40**	1083.00**	67.03
Error (B)	9	174.90	27.58	29.25	11.03	212.90	45.42	69.90	120.90	120.40	91.41

\+ Weeks from beginning of trial, September 16, 1974; April 29, 1975.
‡ Harvest date during minor rainy season 1974 or major rainy season 1975.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XLIV. Percent In Vitro dry matter digestibility of leaves, stems and whole plants of giant star and buffel grasses during the minor rainy season of 1974.

	Maturity									
	3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Leaves										
Giant star	69.8^{a}_{x} o	65.6^{ab}_{x}	62.3^{b}_{x}	54.7^{c}_{y}	49.6^{d}_{y}	49.5^{d}_{y}	46.4^{de}_{y}	42.1^{ef}_{y}	41.8^{ef}_{y}	40.7^{f}_{y}
Buffel	70.4^{a}_{x}	67.2^{ab}_{x}	65.6^{abc}_{x}	64.7^{bc}_{x}	64.5^{bc}_{x}	64.1^{bc}_{x}	61.1^{cd}_{x}	56.1^{de}_{x}	56.9^{de}_{x}	53.4^{e}_{x}
Stems										
Giant star	50.9^{a}_{x}	52.7^{a}_{x}	51.7^{a}_{x}	49.7^{a}_{x}	47.3^{ab}_{x}	47.0^{ab}_{x}	41.2^{bc}_{x}	39.5^{c}_{x}	39.6^{c}_{x}	41.0^{bc}_{y}
Buffel	48.6^{ab}_{x}	53.5^{a}_{x}	48.8^{ab}_{x}	42.5^{b}_{y}	38.1^{cd}_{y}	35.8^{cde}_{y}	32.8^{def}_{y}	33.7^{def}_{x}	27.2^{ef}_{y}	30.3^{f}_{x}
Whole plants										
Giant star	61.0^{a}_{x}	59.3^{b}_{x}	57.1^{b}_{x}	51.6^{c}_{x}	48.3^{c}_{x}	47.7^{c}_{x}	43.3^{d}_{x}	40.5^{d}_{x}	40.3^{d}_{x}	40.8^{d}_{x}
Buffel	60.6^{ab}_{x}	62.0^{a}_{x}	57.0^{b}_{x}	53.1^{b}_{x}	50.0^{c}_{x}	46.9^{cd}_{x}	47.8^{cd}_{x}	43.8^{cde}_{x}	44.6^{de}_{x}	41.7^{e}_{x}

\+ Weeks from beginning of trial, September 16, 1974.
‡ Harvest date during the minor rainy season 1974.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e; columns within plant part: leaves - x,y; stems - q,r.

Appendix XLV. Percent In Vitro dry matter digestibility of leaves, stems and whole plants of giant star, buffel and pangola grasses during the major rainy season of 1975.

	Maturity									
	3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Leaves										
Giant star	$58.4^{a\,o}_{z}$	54.3^{ab}_{y}	52.1^{ab}_{z}	38.3^{cd}_{z}	46.5^{abcd}_{x}	49.5^{abc}_{z}	41.6^{bcd}_{z}	47.7^{abcd}_{y}	42.8^{bcd}_{z}	36.0^{d}_{y}
Buffel	71.2^{a}_{x}	70.1^{a}_{x}	67.5^{a}_{x}	66.9^{a}_{x}	61.9^{a}_{x}	62.7^{a}_{x}	63.7^{a}_{x}	60.9^{a}_{x}	59.6^{a}_{x}	60.7^{a}_{x}
Pangola	65.2^{ab}_{y}	69.5^{a}_{x}	61.4^{abc}_{y}	57.6^{abc}_{y}	56.4^{bc}_{x}	55.5^{bc}_{y}	52.2^{cd}_{y}	49.0^{cd}_{y}	49.0^{cd}_{y}	40.7^{d}_{y}
Stems										
Giant star	56.1^{a}_{q}	52.3^{ab}_{s}	50.3^{ab}_{s}	49.9^{ab}_{r}	45.6^{bc}_{r}	42.7^{cd}_{r}	42.0^{cd}_{r}	38.6^{d}_{r}	37.0^{d}_{r}	36.3^{d}_{r}
Buffel	61.3^{b}_{q}	68.9^{a}_{q}	61.8^{b}_{q}	51.9^{c}_{r}	45.6^{cd}_{r}	40.5^{de}_{r}	37.9^{ef}_{s}	33.8^{fg}_{r}	29.7^{gh}_{s}	26.3^{h}_{s}
Pangola	63.4^{a}_{q}	61.0^{ab}_{r}	56.3^{abc}_{r}	60.6^{ab}_{q}	54.5^{bcd}_{q}	49.3^{d}_{q}	48.4^{d}_{q}	48.7^{d}_{q}	50.6^{cd}_{q}	51.3^{cd}_{q}
Whole plants										
Giant star	57.7^{a}_{v}	53.8^{ab}_{u}	51.6^{abc}_{v}	42.3^{def}_{u}	46.5^{cde}_{t}	47.2^{bcd}_{t}	41.8^{def}_{u}	43.7^{de}_{t}	40.0^{ef}_{u}	36.2^{f}_{u}
Buffel	70.3^{a}_{u}	69.9^{a}_{t}	65.5^{a}_{t}	59.2^{b}_{t}	53.9^{bc}_{t}	51.3^{cd}_{t}	51.1^{cd}_{t}	46.2^{de}_{t}	42.6^{ef}_{u}	38.6^{f}_{u}
Pangola	64.7^{ab}_{t}	67.7^{a}_{t}	60.5^{bc}_{u}	55.6^{cd}_{t}	54.5^{cde}_{t}	52.9^{def}_{t}	50.3^{def}_{t}	48.7^{ef}_{t}	49.8^{def}_{t}	46.2^{f}_{t}

+ Weeks from beginning of trial, April 29, 1975.
‡ Harvest date during the major rainy season 1975.
o Data followed by the same letter are not different ($P > 0.05$); rows - a,b,c,d,e,f,g,h; columns within plant part: leaves - x,y,z; stems - q,r,s; whole plnnt - t,u,v.

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Appendix XLVI. Analyses of variance of percent nitrogen in leaves, stems and whole plants of giant star, buffel and pangola grasses during the minor rainy season of 1974 and the major rainy season of 1975.

(Sums of squares)

Source	1974 Minor rainy season				1975 Major rainy season			
	Degrees of freedom	Leaves	Stems	Whole plants	Degrees of freedom	Leaves	Stems	Whole plants
Replications	3	0.9309	0.0861	0.2868	3	0.1495	0.4674	0.2388
Species	1	0.1361	0.0001	0.2152	2	4.5450**	5.3950**	3.8210*
Error (A)	3	0.2340	0.1100	0.0843	6	1.1890	1.2770	1.1770
Dates	9	13.5170**	2.2840**	5.9240**	9	30.1850**	13.3130**	35.7280**
Date x species	9	0.3380	0.1147	0.0731	18	2.8370*	2.8040**	3.6490**
Error (B)	54	2.3690	1.0680	2.2100	81	2.7660	2.2240	2.1830

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XLVII. Analyses of variance of weekly percent nitrogen content of leaves, stems and whole plants of giant star, buffel and pangola grasses during the minor rainy season of 1974.

(Sums of squares)

Source	Degrees of freedom	Maturity									
		3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Leaves											
Replications	3	0.4829	0.2047	0.0793	0.0465	0.0276	0.1755	0.0945	0.2195	0.4049	0.8085
Species	1	0.0861	0.0112	0.3120	0.0465	0.0084	0.0098	0.0005	0.0003	0.0004	0.0026
Error	3	0.0356	0.5570	0.0724	0.1374	0.0566	0.1307	0.0007	0.0006	0.0013	0.0041
Stems											
Replications	3	0.0483	0.1072	0.0914	0.0334	0.0244	0.0878	0.1185	0.0121	0.0285	0.1749
Species	1	0.0162	0.0018	0.0420	0.0231	0.0231	0.0084	0.0001	0.0001	0.0011	0.0039
Error	3	0.0675	0.2396	0.1256	0.0318	0.0201	0.0520	0.0004		0.0034	0.0071
Whole plants											
Replications	3	0.0658	0.0978	0.0995	0.0305	0.0180	0.2052	0.0434	0.0669	0.1856	0.4475
Species	1	0.0778*	0.0496	0.1143	0.0200	0.0011	0.0010	0.0080	0.0122	0.0669	0.0222
Error	3	0.0206	0.3560	0.1052	0.0812	0.0176	0.0922	0.0215	0.0248	0.0335	0.0243

+ Weeks from beginning of trial, April 1, 1974.
‡ Harvest date during the minor rainy season of 1974.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix XLVIII. Analyses of variance of weekly percent nitrogen content of leaves, stems and whole plants of giant star, buffel and pangola during the major rainy season of 1975.

(Sums of squares)

Source	Degrees of freedom	Maturity									
		3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Leaves											
Replications	3	0.1630	0.0715	0.1123	0.0554	0.1477	0.0908	0.0169	0.0417	0.0319	0.0121
Species	2	2.0713**	1.7877**	1.5921**	1.0863*	0.3225	0.2267	0.1705	0.0546	0.0617	0.0087
Error	6	0.1038	0.2843	0.1509	0.5713	0.2515	0.5091	0.5039	0.5887	0.1465	0.2521
Stems											
Replications	3	0.0459	0.1668	0.0446	0.4194	0.1017	0.0740	0.1279	0.1161	0.0059	0.0723
Species	2	0.9048**	2.9520**	1.5221**	1.3251**	0.5482**	0.4008	0.3310	0.1232	0.0026	0.0894
Error	6	0.1625	0.0827	0.2093	0.5651	0.1004	0.3383	0.4828	0.4726	0.0115	0.3693
Whole plants											
Replications	3	0.0738	0.0730	0.0983	0.1271	0.0915	0.1082	0.0359	0.0650	0.0091	0.0384
Species	2	2.4181**	2.2046**	1.5877**	0.6703	0.2867	0,1331	0.1307	0.0132	0.0058	0.0197
Error	6	0.1143	0.1174	0.1595	0.5067	0.2065	0.5273	0.4825	0.4754	0.0347	0.2558

\+ Weeks from beginning of trial,

‡

* Significant ($P < 0.05$).

** Significant ($P < 0.01$).

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Appendix XLIX. Analyses of variance of weekly percent nitrogen (leaves vs. stems) of giant star, buffel and pangola grasses during the minor rainy season of 1974 (upper) and major rainy season of 1975 (lower).

(Sums of squares)

1974 - Minor rainy season

Source	Degrees of freedom	Maturity 3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Reps	3	0.4139	0.2737	0.1555	0.0653	0.0495	0.2552	0.0681	0.1757	0.3051	0.0962
Species	1	0.0885	0.0110	0.2916	0.0020	0.0018	0.0182	0.0370	0.0808	0.0051	0.0047
Error (A)	3	0.1001	0.7479	0.1898	0.1472	0.0685	0.1709	0.2750	0.2911	0.1687	0.0897
Leaves vs. stems	1	8.7470**	5.4760**	4.3470**	3.2760**	3.5630**	2.5440**	4.2950**	2.6090**	2.3790**	3.3420**
L-S x species	1	0.0138	0.0020	0.0625**	0.0676*	0.0298**	0.0002	0.0157	0.0032	0.0006	0.0112
Error (B)	6	0.1204	0.0869	0.0236	0.0367	0.0109	0,0200	0.0836	0.0290	0.1286	0.1256

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1975 - Major rainy season

Source	Degrees of freedom	Maturity 3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Reps	3	0.1679	0.1935	0.1487	0.3068	0.1819	0.1636	0.0999	0.1207	0.0324	0.0391
Species	2	2.8320	4.5750**	3.1080**	1.9040*	0.7866*	0.5271	0.4028	0.0902	0.0241	0.0368
Error (A)	6	0.2126	0.1802	0.2748	0.0323	0.3171	0.8330	0.9379	1.0250	0.1040	0.7862
Leaves vs. stems	1	8.9060**	6.8800**	6.7950**	5.9000**	4.9960**	4.9699**	3.7520**	3.1030**	2.8630**	1.7550**
L-S x species	2	0.1444*	0.1639	0.0059	0.5067*	0.0842	0.1005**	0.0988*	0.0877*	0.0401	0.0167
Error (B)	9	0.0948	0.2315	0.0938	0.3721	0.1023	0.0155	0.0938	0.0728	0.0594	0,0329

+ Weeks from beginning of trial, September 16, 1974; April 29, 1975.
‡ Harvest date during the minor rainy season of 1974 or the major rainy season of 1975.
* Significant (P ∼ 0.05).
** Significant (P ∼ 0.01).

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Appendix L. Percent nitrogen of leaves, stems and whole plants of giant star and buffel grasses during the minor rainy season of 1974.

	Maturity									
	3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Leaves										
Giant star	2.33^{a}_{x} o	1.98^{ab}_{x}	1.61^{bc}_{x}	1.38^{cd}_{x}	1.49^{cd}_{x}	1.34^{cde}_{x}	1.18^{de}_{x}	1.30^{cde}_{x}	1.23^{cde}_{x}	1.09^{e}_{x}
Buffel	2.53^{a}_{x}	2.05^{b}_{x}	2.01^{b}_{x}	1.54^{c}_{x}	1.56^{c}_{x}	1.27^{c}_{x}	1.12^{c}_{x}	1.30^{c}_{x}	1.20^{c}_{x}	1.08^{c}_{x}
Stems										
Giant star	0.91^{a}_{q}	0.83^{ab}_{q}	0.70^{abc}_{q}	0.61^{abc}_{q}	0.63^{abc}_{q}	0.54^{bc}_{q}	0.47^{c}_{q}	0.54^{bc}_{q}	0.46^{c}_{q}	0.45^{c}_{q}
Buffel	1.00^{a}_{q}	0.86^{a}_{q}	0.84^{a}_{q}	0.50^{b}_{q}	0.53^{b}_{q}	0.47^{b}_{q}	0.47^{b}_{q}	0.54^{b}_{q}	0.45^{b}_{q}	0.45^{b}_{q}
Whole plants										
Giant star	1.47^{a}_{u}	1.30^{ab}_{t}	1.18^{abc}_{t}	0.90^{c}_{t}	0.96^{c}_{t}	0.81^{cd}_{t}	0.63^{d}_{t}	0.83^{cd}_{t}	0.73^{d}_{t}	0.66^{d}_{t}
Buffel	1.61^{a}_{t}	1.44^{ab}_{t}	1.30^{bc}_{t}	1.00^{c}_{t}	0.98^{c}_{t}	0.78^{c}_{t}	0.80^{c}_{t}	0.91^{c}_{t}	0.92^{c}_{t}	0.77^{c}_{t}

\+ Weeks from beginning of trial, September 6, 1974.
‡ Harvest date during the minor rainy season of 1974.
o Data followed by the same letter are not different ($P > 0.05$): rows – a,b,c,d,e; columns within plant part: leaves – x,y; stems – q,r; whole plants – t,u.

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Appendix LI. Percent nitrogen of leaves, stems and whole plants of giant star, buffel and pangola grasses during the major rainy season of 1975.

	Maturity									
	3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
<u>Leaves</u>										
Giant star	1.79^{a}_{y} o	1.86^{a}_{y}	1.70^{a}_{y}	1.61^{a}_{y}	1.41^{a}_{x}	1.37^{a}_{x}	1.24^{a}_{x}	1.15^{a}_{x}	1.02^{a}_{x}	1.06^{a}_{x}
Buffel	2.76^{a}_{x}	2.68^{a}_{x}	2.48^{ab}_{x}	2.32^{abc}_{x}	1.81^{abc}_{x}	1.70^{abc}_{x}	1.52^{abc}_{x}	1.30^{bc}_{x}	1.22^{c}_{x}	1.10^{c}_{x}
Pangola	2.56^{a}_{x}	2.67^{a}_{x}	2.46^{a}_{x}	2.14^{ab}_{xy}	1.85^{ab}_{x}	1.62^{ab}_{x}	1.46^{ab}_{x}	1.16^{b}_{x}	0.95^{b}_{x}	1.04^{b}_{x}
<u>Stems</u>										
Giant star	0.76^{a}_{r}	0.66^{abc}_{r}	0.65^{abc}_{r}	0.68^{ab}_{s}	0.56^{abc}_{s}	0.43^{abc}_{q}	0.43^{abc}_{q}	0.36^{bc}_{q}	0.33^{bc}_{q}	0.28^{c}_{q}
Buffel	1.35^{a}_{q}	1.51^{a}_{qr}	1.44^{a}_{q}	0.95^{b}_{r}	0.75^{bcd}_{r}	0.64^{bcd}_{q}	0.58^{cd}_{q}	0.47^{cd}_{q}	0.34^{d}_{q}	0.43^{cd}_{q}
Pangola	1.35^{bc}_{q}	1.84^{a}_{q}	1.35^{bc}_{q}	1.48^{b}_{q}	1.08^{cd}_{q}	0.88^{d}_{q}	0.83^{d}_{q}	0.61^{e}_{q}	0.36^{e}_{q}	0.49^{e}_{q}
<u>Whole plants</u>										
Giant star	1.54^{a}_{u}	1.57^{a}_{v}	1.43^{a}_{u}	1.29^{ab}_{t}	1.13^{b}_{t}	1.05^{bc}_{t}	0.90^{bcd}_{t}	0.80^{bcd}_{t}	0.69^{cd}_{t}	0.67^{d}_{t}
Buffel	2.62^{a}_{c}	2.46^{a}_{u}	2.12^{b}_{t}	1.62^{c}_{t}	1.30^{d}_{t}	1.16^{de}_{t}	1.07^{de}_{t}	0.85^{ef}_{t}	0.67^{f}_{t}	0.67^{f}_{t}
Pangola	2.25^{a}_{t}	2.49^{a}_{t}	2.26^{a}_{t}	1.87^{b}_{t}	1.51^{c}_{t}	1.31^{d}_{t}	1.15^{de}_{t}	0.89^{ef}_{t}	0.64^{f}_{t}	0.76^{f}_{t}

\+ Weeks after beginning of trial, April 29, 1975.
‡ Harvest date during the major rainy season of 1975.
o Data followed by the same letters are not different ($P > 0.05$): rows - a,b,c,d,e,f; columns within plant part: leaves - x,y,z; stems - q,r,s; whole plants - t,u,v.

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Appendix LII. Analyses of variance of yield of In Vitro digestible dry matter and nitrogen of whole plants of giant star, buffel and pangola grasses during the minor rainy season of 1974 and the major rainy season of 1975.

(Sums of squares x 10^4)

Source	Minor rainy season 1974: Degrees of freedom	Minor rainy season 1974: Digestible dry matter	Minor rainy season 1974: Nitrogen	Major rainy season 1975: Degrees of freedom	Major rainy season 1975: Digestible dry matter	Major rainy season 1975: Nitrogen
Replications	3	97.90	0.0015	3	53.07	0.0063
Species	1	238.60	0.0002	2	995.90**	0.0973
Error (A)	3	119.10	0.0015	6	99.72	0.0493
Dates	9	1118.80**	0.0040	9	6668.00**	0.2318**
Date x species	9	106.70	0.0013	18	424.10**	0.0346
Error (B)	54	655.10	0.0082	81	539.10	0.1088

* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix LIII. Analyses of variance of weekly yields of In Vitro digestible dry matter (leaves vs. stems) of giant star, buffel and pangola grasses during the minor rainy season of 1974 (upper) and the major rainy season of 1975 (lower).

(Sums of squares x 10^4)

1974 Source	Degrees of freedom	Maturity 3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Reps	3	1.09	3.29	9.35	4.01	6.18	6.19	93.54	12.17	18.35	10.87
Species	1	0.19	10.02	5.28	13.93	3.17	0.56	44.41	34.78	43.46	16.83
Error (A)	3	8.85	4.31	1.55	49.58	26.94	12.83	35.66	24.43	74.22	32.72
Leaves vs. stems	1	24.39*	56.48*	28.15*	0.03	1.31	24.97*	53.24	8.14	62.10	0.20
L-S x species	1	0.30	11.69	0.01	72.64	63.57*	61.25**	137.70	95.61*	330.70**	138.20**
Error (B)	6	15.56	41.43	23.82	46.74	62.69	16.65	276.40	48.41	89.93	56.49

1975 Source	Degrees of freedom	Maturity 3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Reps	3	0.12	3.02	1.98	15.52	18.11	5.74	2.75	33.62	8.55	27.60
Species	2	9.10**	94.44*	46.57*	40.52*	67.62*	3.08	113.40*	159.50**	116.40**	56.19**
Error (A)	6	0.84	9.12	14.34	18.07	22.84	56.32	39.42	19.98	23.66	23.03
Leaves vs. stems	1	19.74**	165.70**	147.80**	59.31**	88.18**	212.50**	132.20**	80.65**	26.72*	0.35
L-S x species	2	9.21**	43.20**	1.09	15.27*	4.00	20.26	65.23**	43.70**	63.50*	42.53*
Error (B)	9	1.08	5.90	4.29	6.30	19.89	25.88	10.70	13.50	51.72	35.92

\+ Weeks from beginning of trial, September 16, 1974; April 29, 1975.
‡ Harvest date during the minor rainy season 1974 or the major rainy season 1975.
* Significant ($P < 0.05$).
** Significant ($P < 0.01$).

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Appendix LIV. Yield of In Vitro digestible dry matter of leaves, stems and whole plants of giant star and buffel grasses during the minor rainy season of 1974.

(Kg/ha)

	Maturity									
	3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Leaves										
Giant star	642^{a}_{x} o	959^{a}_{x}	946^{a}_{y}	1071^{a}_{x}	985^{a}_{y}	869^{a}_{y}	980^{a}_{y}	874^{a}_{y}	1147^{a}_{x}	880^{a}_{y}
Buffel	598^{b}_{x}	1000^{ab}_{x}	1210^{ab}_{x}	1120^{ab}_{x}	1148^{ab}_{x}	1003^{ab}_{x}	1286^{a}_{x}	1163^{ab}_{x}	1143^{ab}_{x}	987^{ab}_{x}
Stems										
Giant star	390^{d}_{q}	531^{d}_{q}	817^{c}_{q}	1054^{abc}_{q}	1177^{ab}_{q}	1286^{a}_{q}	888^{c}_{q}	882^{c}_{r}	781^{c}_{r}	945^{bc}_{r}
Buffel	380^{d}_{q}	741^{c}_{q}	814^{bc}_{q}	1246^{a}_{q}	1126^{a}_{q}	1137^{a}_{q}	1001^{abc}_{q}	1111^{a}_{q}	1006^{abc}_{q}	1064^{ab}_{q}
Whole plants										
Giant star	1032^{c}_{t}	1490^{bc}_{t}	1763^{ab}_{t}	2125^{a}_{t}	2162^{a}_{t}	2046^{ab}_{t}	1868^{ab}_{t}	1756^{ab}_{t}	1928^{ab}_{t}	1825^{ab}_{t}
Buffel	978^{c}_{t}	1741^{b}_{t}	2024^{ab}_{t}	2366^{a}_{t}	2274^{ab}_{t}	2140^{ab}_{t}	2287^{ab}_{t}	2274^{ab}_{t}	2149^{ab}_{t}	2051^{ab}_{t}

+ Weeks from beginning of trial, September 16, 1974.
‡ Harvest date during the minor rainy season of 1974.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d; columns within plant part: leaves - x,y; stems - q,r; whole plants - t,u.

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Appendix LV. Yield of In Vitro digestible dry matter of leaves, stems and whole plants of giant star, buffel and pangola grasses during the major rainy season of 1975.

(Kg/ha)

	Maturity									
	3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Leaves										
Giant star	179^{fo}_{y}	434^{ef}_{y}	669^{de}_{y}	633^{de}_{y}	1188^{bc}_{y}	1561a	1289^{ab}_{y}	1238^{ab}_{y}	1005^{bc}_{y}	855^{cd}_{z}
Buffel	386^{d}_{x}	1157^{bc}_{x}	973^{c}_{x}	928^{c}_{x}	1362^{b}_{x}	1412b	2046^{a}_{x}	1721^{a}_{x}	1775^{a}_{x}	1320^{bc}_{x}
Pangola	93^{d}_{z}	473^{c}_{y}	693^{bc}_{y}	887^{b}_{x}	898^{b}_{z}	1318a	1218^{a}_{y}	1033^{a}_{z}	1075^{a}_{y}	1033^{a}_{y}
Stems										
Giant star	54^{d}_{q}	130^{cd}_{r}	220^{cd}_{r}	431^{bc}_{r}	702^{ab}_{r}	709^{ab}_{q}	923^{a}_{r}	778^{a}_{s}	802^{a}_{r}	865^{a}_{s}
Buffel	34^{e}_{q}	254^{de}_{q}	480^{cd}_{q}	753^{bc}_{q}	942^{ab}_{q}	957^{ab}_{q}	1137^{a}_{q}	1324^{a}_{q}	1144^{a}_{q}	1017^{a}_{r}
Pangola	30^{e}_{q}	104^{de}_{q}	141^{de}_{r}	413^{d}_{r}	626^{c}_{r}	872^{bc}_{q}	1081^{ab}_{r}	1031^{ab}_{r}	1252^{a}_{q}	1387^{a}_{q}
Whole plants										
Giant star	233^{c}_{tu}	564^{bc}_{u}	889^{b}_{u}	1064^{b}_{v}	1890^{a}_{u}	2270^{a}_{t}	2212^{a}_{u}	2016^{a}_{u}	1807^{a}_{v}	1720^{a}_{u}
Buffel	420^{c}_{t}	1411^{c}_{t}	1453^{c}_{t}	1681^{c}_{t}	2304^{b}_{t}	2369^{b}_{t}	3183^{a}_{t}	3045^{a}_{t}	2919^{a}_{t}	2337^{b}_{t}
Pangola	123^{e}_{u}	577^{de}_{u}	834^{cd}_{u}	1300^{bc}_{u}	1524^{b}_{v}	2190^{a}_{t}	2299^{a}_{u}	2064^{a}_{u}	2327^{a}_{u}	2420^{a}_{t}

+ Weeks from beginning of trial, April 29, 1975.
‡ Harvest date during the major rainy season.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e; columns within plant part: leaves - x,y,z; stems - q,r,s; whole plants - t,u,v.

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Appendix LVI. Analyses of variance of weekly yields of nitrogen (leaves vs. stems) of giant star, buffel and pangola grasses during the minor rainy season of 1974 (upper) and the major rainy season of 1975 (lower).

(Sums of squares)

1974 Source	Degrees of freedom	Maturity 3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Reps	3	54.11	54.93	198.80	47.77	35.43	240.20	61.09	119.60	415.00	686.20
Species	2	6.83	97.47	177.90*	103.30	10.60	0.24	114.10	160.40	333.80	158.10
Error (A)	6	79.76	176.90	43.82	251.40	141.90	250.90	99.16	95.10	425.10	264.00
Leaves vs. stems	1	804.70**	1609.00**	1295.00**	776.60**	668.20**	235.30**	667.80	712.10**	1486.00	488.30
L-S x species	2	7.44	94.92	9.70	279.90	106.80	20.66	104.10	146.90	680.70	235.90
Error (B)	9	132.50	251.70	169.10	167.86	261.90	69.07	674.90	307.60	752.70	466.70

1975 Source	Degrees of freedom	Maturity 3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
Reps	3	0.96	29.35	21.09	100.90	131.10	103.00	134.50	137.50	31.23	24.28
Species	2	146.10**	1313.00**	491.10*	180.90	230.60	18.52	381.20	601.60	325.90*	81.05
Error (A)	6	10.21	120.30	144.30	318.70	298.60	935.60	931.40	517.40	114.20	352.70
Leaves vs. stems	1	324.20**	2972.00**	3094.00**	2791.00**	3250.00**	4690.00**	3784.00**	2137.00**	1531.00**	957.90**
L-S x species	2	141.80**	825.30**	34.59	26.95	165.70*	203.30	362.40*	182.00*	56.20	128.40
Error (B)	9	8.92	97.41	125.60	253.60	103.70	338.60	277.60	142.20	87.84	146.30

+ Weeks from beginning of trial, September 16, 1974; April 29, 1975.
‡ Harvest date during the minor rainy season 1974, or the major rainy season 1975.
* Significant (P< 0.05).
** Significant (P< 0.01).

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Appendix LVII. Yield of nitrogen of leaves, stems and whole plants of giant star and buffel grasses during the minor rainy season of 1974.

(Kg/ha)

	Maturity									
	3+ Oct. 8‡	4 Oct. 15	5 Oct. 22	6 Oct. 29	7 Nov. 5	8 Nov. 12	9 Nov. 19	11 Dec. 3	13 Dec. 17	15 Dec. 31
Leaves										
Giant star	21.4^{d}_{x} [o]	28.9^{a}_{x}	24.4^{bc}_{y}	27.0^{ab}_{x}	29.6^{a}_{x}	23.5^{cd}_{x}	24.9^{bc}_{x}	27.0^{ab}_{x}	33.8^{a}_{x}	23.6^{cd}_{x}
Buffel	21.5^{ef}_{x}	30.5^{b}_{x}	37.1^{a}_{x}	26.7^{cd}_{x}	27.8^{c}_{x}	19.9^{f}_{x}	23.6^{e}_{x}	26.9^{c}_{x}	24.1^{de}_{x}	20.0^{f}_{x}
Stems										
Giant star	7.0^{e}_{q}	8.4^{de}_{q}	11.1^{bc}_{q}	12.9^{b}_{q}	15.7^{a}_{q}	14.8^{a}_{q}	10.1^{cd}_{q}	12.1^{b}_{q}	9.1^{d}_{q}	9.2^{d}_{q}
Buffel	7.8^{e}_{q}	11.9^{d}_{q}	14.0^{c}_{q}	14.7^{bc}_{q}	15.7^{bc}_{q}	14.9^{bc}_{q}	14.3^{ac}_{q}	17.8^{a}_{q}	16.6^{b}_{q}	15.8^{bc}_{q}
Whole plants										
Giant star	28.4^{g}_{t}	37.3^{d}_{t}	35.5^{e}_{t}	39.9^{c}_{t}	45.3^{a}_{t}	38.3^{cd}_{t}	35.0^{e}_{t}	39.1^{cd}_{t}	42.9^{b}_{t}	32.8^{f}_{t}
Buffel	29.3^{g}_{t}	42.4^{cd}_{t}	51.1^{a}_{t}	41.4^{d}_{t}	43.5^{bc}_{t}	34.8^{f}_{t}	37.9^{e}_{t}	44.7^{b}_{t}	40.7^{d}_{t}	35.8^{f}_{t}

\+ Weeks from beginning of trial, September 16, 1974.
‡ Harvest date during the minor rainy season of 1974.
o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e,f,g; columns within plant part: leaves - x,y; stems - q,r; whole plants - t,u.

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Appendix LVIII. Yields of nitrogen of leaves, stems and whole plants of giant star, buffel and pangola grasses during the major rainy season of 1975.

(Kg/ha)

	Maturity									
	3+ May 20‡	4 May 27	5 June 3	6 June 10	7 June 17	8 June 24	9 July 1	11 July 15	13 July 29	15 Aug. 12
<u>Leaves</u>										
Giant star	$5.5^{e\,o}_{y}$	14.9^{d}_{z}	31.6^{bc}_{y}	35.4^{ab}_{x}	36.0^{ab}_{x}	43.2^{a}_{x}	38.4^{ab}_{y}	29.9^{c}_{y}	23.9^{c}_{y}	25.2^{c}_{x}
Buffel	14.9^{e}_{x}	44.2^{ab}_{x}	35.8^{cd}_{x}	31.0^{d}_{x}	39.8^{bc}_{x}	38.3^{bc}_{x}	48.8^{a}_{x}	36.7^{bc}_{x}	36.3^{bc}_{x}	23.9^{d}_{x}
Pangola	3.7^{e}_{z}	18.2^{d}_{y}	27.8^{bc}_{z}	33.0^{ab}_{x}	29.5^{b}_{y}	38.5^{a}_{x}	34.1^{ab}_{y}	24.5^{c}_{y}	20.8^{c}_{y}	26.4^{bc}_{x}
<u>Stems</u>										
Giant star	0.7^{b}_{t}	1.6^{ab}_{r}	2.8^{ab}_{r}	5.9^{ab}_{r}	8.6^{a}_{r}	7.1^{ab}_{r}	9.4^{a}_{r}	7.3^{ab}_{r}	7.2^{ab}_{r}	6.7^{ab}_{r}
Buffel	0.8^{c}_{q}	5.6^{bc}_{q}	11.2^{ab}_{q}	13.8^{a}_{q}	15.5^{a}_{q}	15.1^{a}_{q}	17.4^{a}_{qr}	18.4^{a}_{q}	13.1^{ab}_{q}	16.6^{a}_{q}
Pangola	0.6^{c}_{q}	3.1^{c}_{qr}	3.4^{c}_{r}	10.1^{bc}_{qr}	12.4^{bc}_{qr}	15.7^{ab}_{q}	18.5^{a}_{q}	12.9^{ab}_{qr}	8.9^{b}_{r}	13.2^{ab}_{q}
<u>Whole plants</u>										
Giant star	6.2^{e}_{u}	16.5^{d}_{v}	34.4^{bc}_{u}	41.3^{b}_{u}	44.6^{a}_{u}	50.3^{a}_{u}	47.8^{ab}_{u}	37.2^{bc}_{u}	31.1^{c}_{u}	31.9^{c}_{u}
Buffel	15.7^{d}_{t}	49.8^{b}_{t}	47.0^{bc}_{t}	44.8^{c}_{t}	55.3^{b}_{t}	53.4^{b}_{tu}	66.2^{a}_{t}	55.1^{b}_{t}	49.4^{b}_{t}	40.5^{c}_{t}
Pangola	4.3^{f}_{v}	21.3^{e}_{u}	31.2^{c}_{u}	43.1^{b}_{tu}	41.9^{b}_{u}	54.2^{a}_{t}	52.6^{a}_{t}	37.4^{bc}_{u}	29.7^{d}_{u}	39.6^{b}_{t}

+ Weeks from beginning of trial, April 29, 1975.

‡ Harvest date during the major rainy season 1975.

o Data followed by the same letter are not different ($P > 0.05$): rows - a,b,c,d,e,f; columns within plant part: leaves - x,y,z; stems - q,r,s; whole plants - t,u,v.

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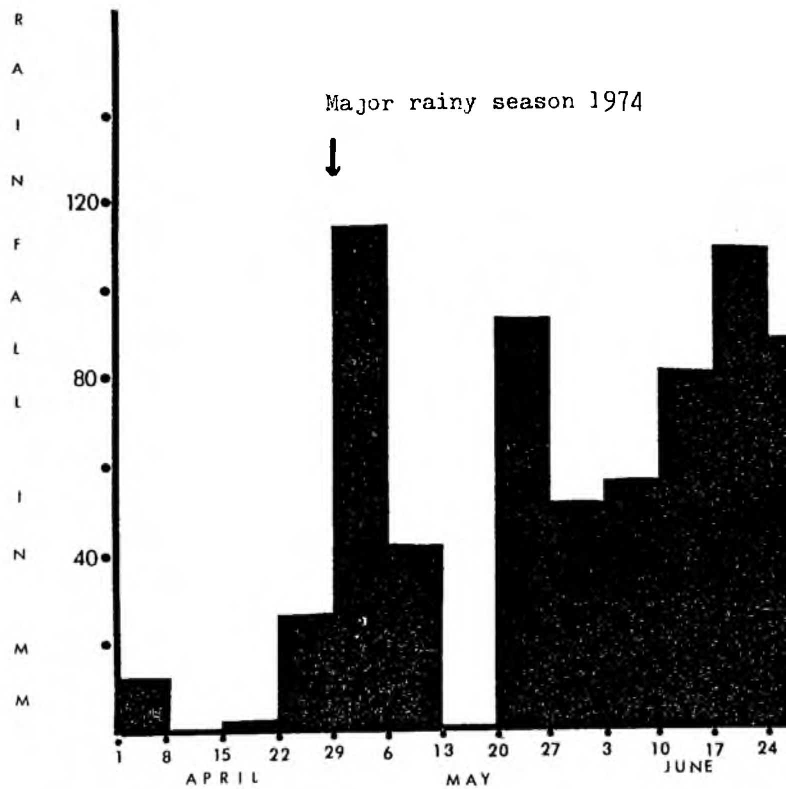

Appendix LIX. Weekly distribution of rainfall during 1974.

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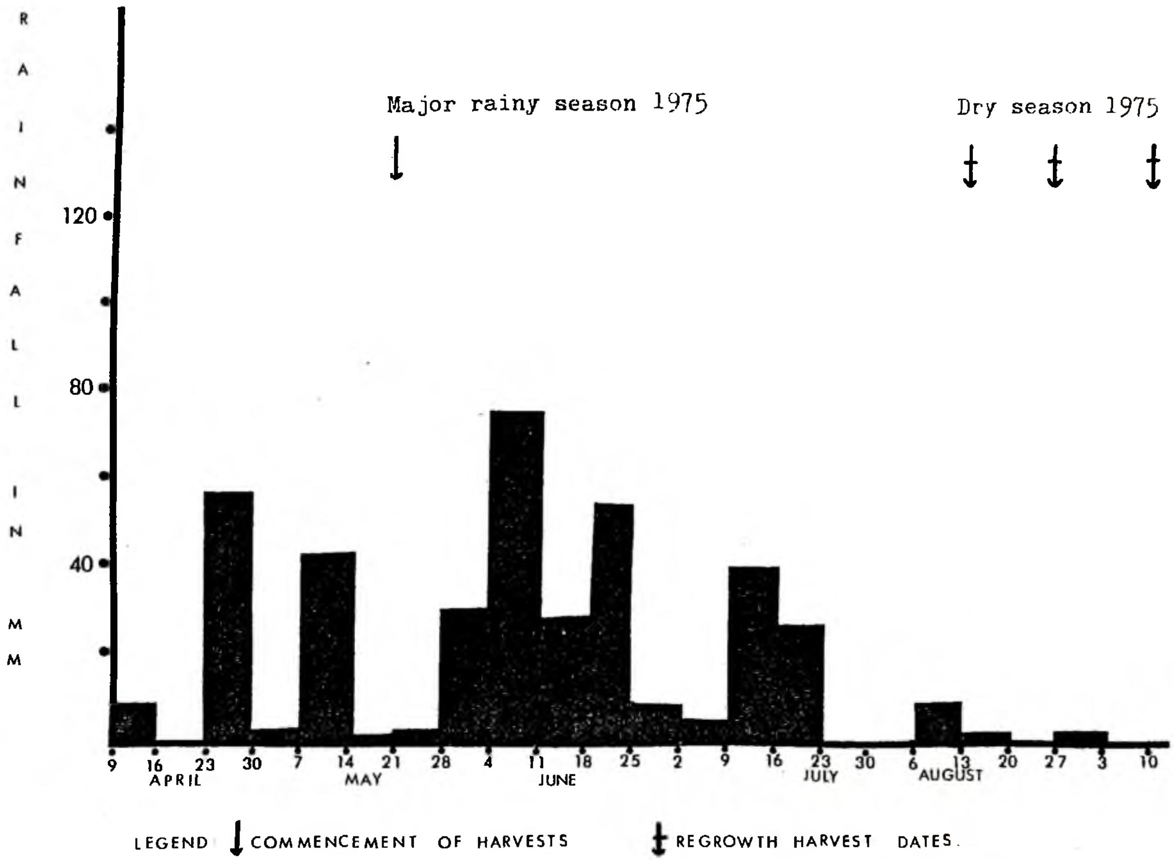

Appendix I/. Weekly distribution of rainfall during 1975.

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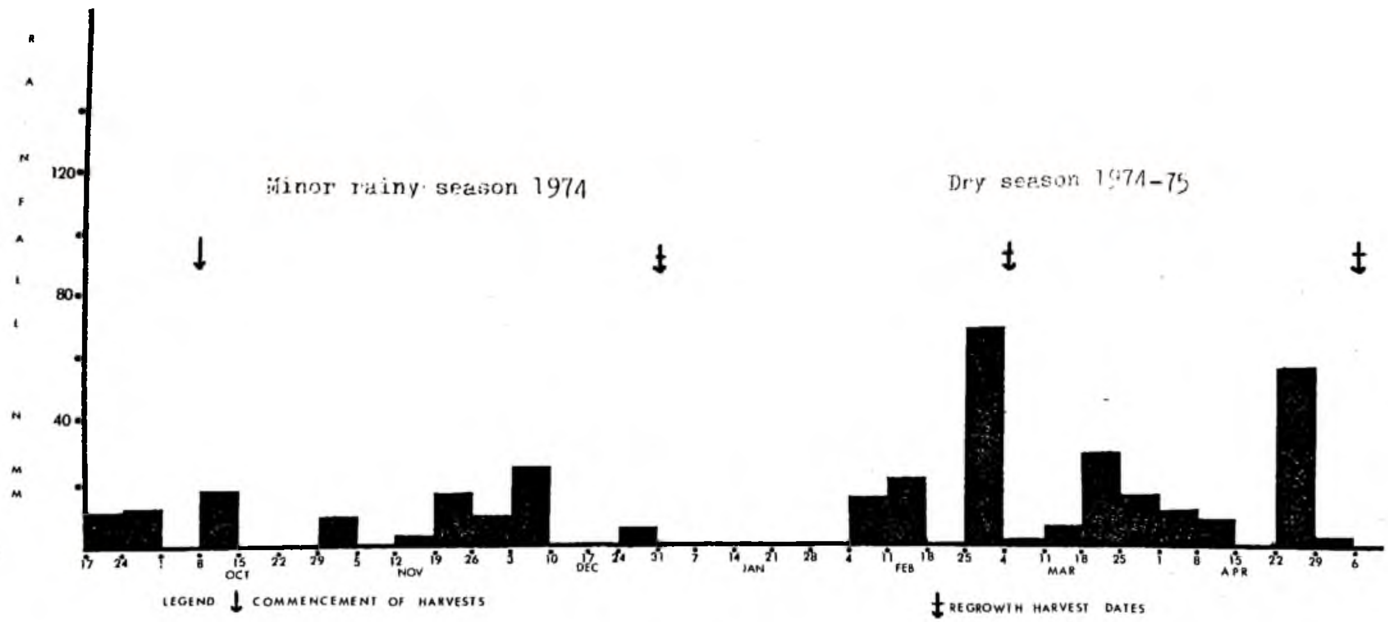

Appendix LXI. Weekly distribution of rainfall during the minor rainy season of 1974 and the ensuing dry period.

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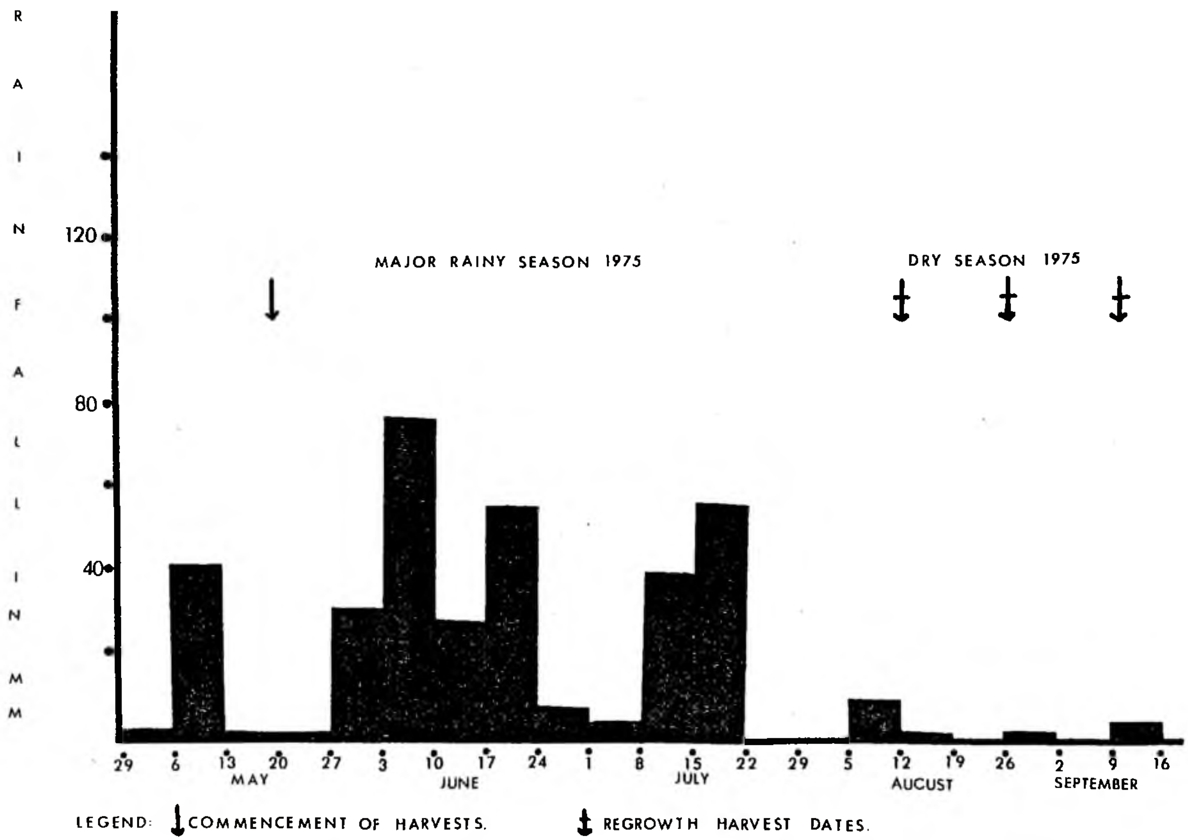

Appendix IXII. Weekly distribution of rainfall during the major rainy season of 1975 and the ensuing dry period.