THE EFFECT OF GRAZING FREQUENCY ON THE PERFORMANCE OF SOME TROPICAL GRASSES

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A B S T R A C T

An experiment was conducted on a grey-brown sandy-clay soil of vertical classification, at the Agricultural Research Station, Legon, to study the effect of 3-, 4-, 5-, 6-, 8- and 10-weekly grazing on the performances of eight tropical grasses namely:- Cynodon aethiopicus, Cynodon nlemfuensis, Cynodon plectostachyus, Cenchrus ciliaris var Biloela, Digitaria decumbens, Digitaria swazilandensis, Panicum maximum and Paspalum plicatulum.

Frequent grazing reduced dry matter and green forage yields. Dry matter content, sward height, root weight and crude fiber (CF) increased with increasing grazing interval. Total ash, phosphorus, crude protein (CP) and in vitro dry matter digestibility (IVDMD) were inversely related to increasing grazing interval Changes in calcium and calcium to phosphorus ratio were erratic.

Over a six-month period, green forage yield increased from 5.5 t/ha at 3-weekly grazing to 9.9 t/ha, at 10-wweekly grazing. Corresponding ranges for other parameters were: dry matter yield 1.4 to 3.3 t/ha, digestible dry matter yield 0.81 to 1.56 t/ha,

dry matter content 24.8 to 33.5%, sward height 74.2 to 124.7cm, root weight 109.3 to 133.1g, whole-plant crude fiber, 27.2 to 31.5%, leaf CF 27.2 to 31.5% and stem CF 32.3 to 41.5%.

Crude protein decreased from 11.7% at 3-weekly grazing to 7.5% at 10-weekly, *in vitro* dry matter digestibility, 61.4 to 47.9%, total ash 10.7 to 7.5%, calcium 0.47 to 0.38% and phosphorus 0.30 to 0.21% for the whole-plant, leaf CP 15.0 to 11.5%, leaf IVDMD 66.3 to 56.1%; stem CP 10.4 to 4.2%, stem IVDMD 58.3 to 45.9%.

P. maximum exhibited the highest dry matter yield (2.9 t/ha), digestible dry matter yield (1.72 t/ha), whole-plant CP (10.9%) and whole-plant IVDMD (62.4%). The least dry matter yield (1.8 t/ha) and digestible dry matter yield (0.90 t/ha) were recorded for *C. aethiopicus*. *D. swazilandensis* and *C. nlemfuensis* exhibited the least whole-plant CP (7.5%) and IVDMD (47.6) respectively. The highest whole-plant CF (37.4%) was recorded for *C. ciliaris* and the least (29.0%) for *D. swazilandensis*.

Weed infestation was low on plots of *D. decumbens* (1.5%) and *D. swazilandensis* (2.5%) and high on *C.*

aethiopicus (9.2%) plots.

Grazing cycles of 5 to 6 weeks and 3 to 9 weeks are recommended for *C. aethiopicus* and *C. ciliaris* respectively. *C. nlemfuensis*, *C. plectostachyus*, *D. decumbens*, *D. swazilandensis*, *P. maximum* and *P. plicatum* may be grazed above 10-weeks. *P. maximum*, *D. decumbens*, *C. ciliaris*, *P. plicatulum* and *C. plectostachyus* are recommended.

Relative palatability decreased with increasing grazing interval. *P. maximum* and *D. decumbens* were prefered to *C. aethiopicus* and *D. swazilandensis*.

In vivo dry matter digestibility and intake of *C. nlemfuensis*, *C. aethiopicus* and *D. swazilandensis* hays harvested between 3 to 6 weeks of age ranged from 53.3 to 64.9% and 50.4 to 69.2g/kg $W^{0.75}$ respectively.

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ASAMOAH LARBI

November, 1982.

D E D I C A T I O N

To the memory

of

A K O S U A

my late niece.

D E C L A R A T I O N

I hereby declare that, except for references to other people's work, which have been duly cited, the work embodied in this thesis is the result of my own investigation.

I further avow that, this thesis either in whole or in part has not already been accepted for any degree and is not being concurrently submitted for any elsewhere.

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LIST OF ABBREVIATIONS

CA	-	*Cynodon aethiopicus*
CN	-	*Cynodon nlemfuensis*
CPS	-	*Cynodon plectostachyus*
CC	-	*Cenchrus ciliaris*
DD	-	*Digitaria decumbens*
DS	-	*Digitaria swazilandensis*
PM	-	*Panicum maximum*
PP	-	*Paspalum plicatulum*
GF	-	Green Forage
GFY	-	Green Forage Yield
DM	-	Dry Matter
DMY	-	Dry Matter Yield
DDMY	-	Digestible Dry Matter Yield
RW	-	Root Weight
SH	-	Sward Height
DMC	-	Dry Matter Content
IVDMD	-	*In vitro* Dry Matter Digestibility
DMD	-	*In vivo* Dry Matter Digestibility
IVOMD	-	*In vitro* Organic Matter Digestibility
Ca	-	Calcium
P	-	Phosphorus
Ca:P	-	Calcium to Phosphorus ratio
DMI	-	Dry Matter Intake

LIST OF ABBREVIATIONS

L	- Leaf
S	- Stem
W	- Whole-plant
R.P	- Relative Palatability
M	- Maturity
CF	- Crude Fiber
CP	- Crude Protein
EE	- Ether Extract
NFE	- Nitrogen Free Extracts
LAI	- Leaf Area Index

CHAPTER ONE

INTRODUCTION

Livestock production (particularly cattle, sheep and goats) in Ghana is mainly concentrated in the savanna areas (Table 1).

The savanna areas are broadly divided into Northern Savanna and Southern Savanna (Rose-Innes, 1962) and account for approximately two-thirds of the total land area of the country.

The savanna zones are characterised by low, erratic and poorly distributed rainfall. The Northern Savanna has annual rainfall averaging 1016mm to 1270mm, most of which comes between May and September. In the Southern Savanna, annual precipitation varies from 630mm to 1000mm; distribution is double-peaked, with major season in June and minor in October (Walker, 1962). The annual drought from November to April may often be severe.

These grasslands are dominated mostly by grass species of low nutritive value (Fianu, Atta-Krah and Koram, 1972), growing on soils which are deficient in nitrogen and phosphorus (Nye and Bertheux, 1957) with little of no legumes.

TABLE 1: Regional Distribution of Cattle, Sheep and Goats in Ghana.

Region	HERD TOTAL			% of G. N. T.
	Cattle	Sheep	Goats	
Upper) Northern) Northern) Savanna	323,973	251,761	229,651	22.2
	314,781	269,004	266,717	23.4
Brong Ahafo	51,183	133,371	252,275	12.1
Ashanti	7,431	135,239	93,152	6.5
Southern Savanna *	179,473	660,043	462,094	35.8
Grand National Total (G.N.T.)	876,841	1449,418	1303,889	100.0

Source: Livestock Census, 1980. Ministry of Agriculture, Animal Health Division, Accra.

* Includes Greater Accra, Eastern, Volta, Central and Western Regions.

During the dry season, the quantity and quality of herbage in the savanna areas fall far below recommended standards for any meaningful animal production (Lansbury, 1960). Consequently, ruminant livestock lose weight during the dry season. The extent of the weight loss depends on the severity and duration of the dry season. Liveweight losses up to 11% and 15% have been reported for cattle and sheep respectively on the Southern Savanna (Rose-Innes, 1961; Otchere, Dadzie, Erbynn and Ayebo, 1977). The recurrent weight losses tend to prolong the age at which ruminant livestock reach maturity.

Despite the above limitations, the grasslands, artificial pastures and fodder crops which must form the basis of any livestock industry, are rarely if ever considered in agricultural development programme (Rose-Innes, 1962; Asare, 1974).

For these reasons, the average Ghanaian diet is grossly deficient in animal protein (F.A.O., 1969), despite the fact that large sums of the country's scarce foreign exchange is used on the importation of animal protein of all sorts (Asante, 1982). Consequently, protein deficiency diseases, such as Kwashiokor, are of common occurrence, leading to high infantile mortality

(Ofosu-Amaah, 1974).

The importation of meat and other animal products could be eliminated and money conserved, if the grassland could be developed. No doubt many observers have suggested the starting point in the development of Ghana's meat industry to be the development of her grasslands (Rose-Innes, 1961; Alhassan, 1970; Adjei, 1973). Unless bold and immediate steps are taken towards this direction, "Ghana will continue to be an importer of meat from countries with climate less favourable, and vegetation less rich, less varied and less watered" (Twum-Barima, 1970).

In the search for high yielding and better quality forages, numerous species have been introduced into the country (Asare, 1970, [illegible]; Antwi, 1977), among these are those of the genera Chloridae and Panicae (Rose-Innes, 1977).

However, there is a gross lack of factual information on the response of the numerous native and introduced forage species to grazing as a method of defoliation in Ghana (Defoliation here means removal of plant shoots by grazing or cutting). Most studies on defoliation have involved cutting or mowing

(Asare, 1970, 1974; Owusu-Ansah, 1976; Fianu, 1977; Asiedu, 1980; Nkrumah-Antiedu, 1981) with very little or nothing on grazing.

Since forages react differently to trampling and treading, selective grazing, animal excretion and soil compaction; it is essential to test species under grazing conditions. Furthermore, the response of forage species to grazing interval must be known if appropriate grazing management recommendations are to be made. The objective of this study was to determine the effect of six grazing intervals on the yield, proximate composition, in vitro digestibility, persistency and dry matter intake of eight tropical grasses.

CHAPTER TWO

LITERATURE REVIEW

2.1 - GENERAL PROCEDURE FOR FORAGE EVALUATION

Pasture cultivars are selected by a screening program of nursery rows, cutting and grazing experiments and commercial assessment. Methodology and criteria vary with the objectives and circumstances of the evaluation. But yield and feeding value are the two main criteria, and any effective assessment program must be designed to give reliable estimates of these two characters (Jones & Walker, 1979).

The conventional approach is generally a sequence of stages, which may be co-ordinated from the start. At each stage, numbers of entries are reduced so that by the final stage of evaluation only a few remain (Hutton & Minson, 1974; Jones & Walker, 1979).

Stage I - Entries are sown in single rows or as spaced plants at one or few sites. Observations are made on agronomic characteristics such as the growth rhythm, leafiness, flowering time, seed production, yield and drought tolerance. Entries are eliminated

from further testing on basis of failure to persist, susceptibility to disease, and low yield in relation to controls.

Stage II - Small sward experiments, at several sites using control species for comparison. Grasses are sown with a legume and legumes with a standard grass. Swards may be subjected to one or more cutting regimes. Entries are eliminated on the basis of their performance under cutting (Edye, Field, Bishop, Hall, Prinsen & Walker, 1976).

Stage III - Large sward experiments, usually at several sites. Swards are subjected to intermittent heavy grazing but sampled for yield, *in vitro* digestibility and proximate analysis immediately before grazing. Fertilizer response and animal preference studies may also be undertaken. Entries are eliminated on basis of performance under grazing (Jones & Rees, 1972).

Stage IV - Swards are subjected to grazing management recommended for the species or area, using different stocking rates. Animal response may be measured. Both *in vitro* and *in vivo* digestibilities, voluntary feed intake as well as detail chemical analyses may be

undertaken (Utley, Chapman, Monson, Merchant & McCormick, 1974; Rees, Jones & Roe, 1976).

Stage V - Grazing management and fodder conservation programs are developed. The economics of pasture development are also studied (Jones & Walker, 1979).

2.2 - THE NEED FOR FORAGE EVALUATION UNDER GRAZING

Unlike the cut sward, grazing imposes additional variables of treading and tearing (Edmond, 1970), return of nutrients in faeces and urine (Gunary, 1968), selectivity both in plant species and plant parts, leading to uneven growth of sward (Frame and Hunt, 1971). Thus although evaluation of forage species by cutting or mowing is relatively simple and inexpensive, it provides an imperfect guide to grazing (Spedding, 1976; Jones & Walker, 1979).

In perennial ryegrass, Aldrich and Elliot (1974) in England, reported mean dry matter yields of 9.86 and 7.50 t/ha for cut and grazed swards respectively. Vicente-Chandler, Caro-Costas, Pearson, Abruna, Figrella and Silva (1964) observed that forages harvested by grazing had much higher crude protein content averaging 17.1% compared to 7.4% in

forages harvested by cutting.

2.3 - EFFECT OF FREQUENCY OF DEFOLIATION ON YIELD AND GROWTH

Green Forage and Dry Matter Yields

The effect of frequency of defoliation on yield has been studied extensively. Earlier findings have been reviewed by Jameson (1964) and Younger (1972). Other studies have been reported by Amadu (1971) and Fianu (1977) in Ghana; Rodriguez-Cavrasquel and Morillo (1977) in Brazil, Shankarnarayan, Kumar and Rai (1977) in India; Mislevy (1977) in Florida; Funes, Ronda, Perez and Aja (1978) in Cuba; Caro-Costas (1981) in Puerto Rico and Omaliko and Obioha (1981) in Nigeria. Generally, both green and dry forage yields of grasses increase with decreasing frequency of defoliation.

Velez-Santiago, Sotomayor-Rios and Torres-Rivera (1979) reported green forage yields of 54.2, 68.6, and 80.5 t/ha/yr when C. aethiopicus was harvested at 30, 45 and 60 days respectively. Similar linear relationships between green forage yield and advancing maturity have been reported by Oyenuga (1957, 1960), Vicente-Chandler, et al (1964), Sotomayor-Rios, Julia, and Arroyo-Aguila (1974).

Dry matter yield (DMY) follows the same trend as GFY with advancing maturity. Fianu (1977) reported dry matter yields of 6.19, 6.80 and 7.08 t/ha for buffel grass harvested every 3, 4 and 5 weeks respectively. For C. nlemfuensis, Ademosun (1973) reported yields of 2.0, 3.8 and 5.1 t/ha when harvested at 28, 49 and 70 days respectively.

Height of defoliation may affect yield. Asare (1970) harvested buffel grass at 10cm and 15cm and found no significant difference between herbage dry matter yields at these cutting heights. Rodel and Scheerhoorn (1976) however reported significant difference between yield of C. nlemfuensis harvested at 5, 15 and 25cm.

Contrary to the findings of other workers, Beaty, Brown and Morris (1970) reported mean dry matter yields of 3,382 and 2,784 kg/ha for P. notatum harvested at 2 and 6 weeks intervals respectively.

Grasses as a group react similarly to defoliation, but individually species vary in their tolerance to close and repeated defoliation. According to Rodel (1970) prostrate, creeping grasses produce more herbage than tufted ones under grazing.

As plants mature, the stem fraction increases at the expense of more nutritious leaves (Fianu, 1977). Vicente-Chandler et al (1964) reported leaf-blade proportions of 63, 53 and 36% and cofresponding values of 38, 39 and 40% for guinea and pangola grasses harvested at 40, 60 and 90 days, respectively.

2. Agronomic Factors that Influence Species Tolerance to Defoliation

Regrowth of forage species after and during defoliation is an interdependent function of: the leaf area index (LAI); organic food reserves; location of meristematic tissues that form the new shoot or leaves; tiller dynamics and pattern of leave senescence (Blaser, Harlan & Love, 1962; Younger, 1972; Sheard, 1973). Because of variation in these factors, forage species respond differently to defoliation.

Light interception by the sward and subsequent photosynthesis and yield are solely dependent upon the LAI (Rhodes, 1971; Wilson, 1973). Yield increases with increasing LAI up to the optimum LAI.

The yield of any crop is the product of the number of plants and the mean yield of each plant

(Jarvis, 1962). Thus in forage grasses tillering may influence the overall yield (Agyare & Watkin, 1967).

Cabohydrate reserves in stem bases, stolons, rhizomes and roots is said to be positively correlated with regrowth (Dovrat & Cohen, 1970). Frequent defoliation creates large metabolic sinks, reserves are frequently tapped and finally get exhausted, leading to a reduction in regrowth potential (Shreads, 1973; White, 1973).

Species with high density of growing points placed slightly below the soil surface are more likely to recover quickly after defoliation than species with few and elevated growing points (Humphreys, 1978).

3. Sward Height (SH)

Plant height is often used as an index of crop growth, and in some circumstances may be more useful than dry weight accumulation (Williams & Joseph, 1974).

Crop growth, measured as crop height generally declines with frequent defoliation (Koocheki, 1975). Oyenuga (1967) reported average sward height off 63cm

and 100cm for P. maximum harvested every 3 and 6 weeks, respectively.

Greenwood, Titman & Campbell (1974) reported that frequent defoliation reduced average relative growth rate of annual grass swards from 17% to 13% per day increase in age. Similarly, Asiegbu (1978) indicated that the height of perennial ryegrass and white clover in mixed swards increased by increasing the interval between defoliation from 3 to 8 weeks. Hanson and Stoddart (1940) recorded sward heights of 51cm and 66.5cm for grazed and ungrazed swards respectively.

Crop height has also been associated with quality and yield. Chin-Tain and Smith (1972) reported that as the height of lucerne crop increased, the proportion of stem increased and nitrogen content declined. The data of Oyenuga (1957) on P. maximum suggest a similar trend.

In his study, Asiegbu (1978) noted that the dry matter yield of S23 perennial ryegrass in mixed swards with white clover was positively correlated with its height at the time of defoliation.

4. Root Weight (RW)

Frequent defoliation of herbage reduces root, stolon and rhizome weight (Cook, Stoddart & Kinsinger, 1958; Schuster, 1964; Beaty, et al, 1970; Taerum, 1971; Owusu-Ansah, 1976; Harridine & Whalley, 1981).

Most grazing studies have shown that root mass, depth of penetration and branching decrease as the intensity and frequency of defoliation increase (Cook, et al, 1958). Schuster (1964) reported root weights of 25.4, 21.44 and 15.1g for ungrazed, moderately grazed and heavily grazed swards respectively.

Using clipping as a method of defoliation, Beaty, et al (1970) reported that root and stolon yields were 50 to 70% higher for herbage clipped every 6-weeks than 1-week harvest of P. notatum. Owusu-Ansah (1976) reported mean root yields of 31.25, 32.46 and 43.65g for Andropogon gayanus and buffel grass harvested every 2, 4 and 6 weeks respectively.

Contrary to the reduction in root weight following severe and frequent defoliation, Pearson (1965) and Smoliak, Dommar & Johnson (1972) reported an increase in root weight with increasing grazing intensity for Stipa comata and Agropyron spitacum among

others. On the other hand, Bartos and Sims (1974) found no significant differences in root mass between four grazing intensity treatments (i.e. ungrazed, light, moderate and heavy).

In an attempt to explain the decline in root weight with intensity and frequency of defoliation, several theories have been proposed. White (1973) and Omaliko and Obioha (1981) attributed it to exhaustion of plant carbohydrate reserves. Cessation of root elongation and branching; reduction in root numbers and root diameter, have been implicated (Schuster, 1964; Taerum, 1970; Dovrat & Cohen, 1970).

5. Botanical Composition and Basal Cover

Changes in the botanical composition and basal cover of sown pastures and native grasslands can be affected by defoliation and fertilizer management as well as soil characteristics (Bryan, 1970; Rodel, 1970).

Frequent defoliation reduces sward vigour and predisposes the sward to high weed infestation (Vicente-Chandler, et al, 1964; Velez-Santiago, et al, 1979). Amadu (1971) studying the effect of defoliation and

irrigation on some tropical forages reported that plots frequently cut were severely infested with weeds. Velez-Santiago, et al (1979) reported mean weed infestation rating of 7.2, 5.3 and 4.3 units for ten Cynodon species harvested every 30, 45 and 60 days respectively.

Rodel (1970) reported that the basal cover of Chloris gayana decreased from 3.8 to 0.7% whereas C. plectostachyus increased from 3 to 11.5% under heavy grazing. He attributed the increase in basal cover to enlargement of tufts and rooting at the nodes of stolons which had been trampled into the ground by the hooves of grazing animals.

Cultivars of the same specie react differently under defoliation. Comparing the effect of defolia - tion on ten Cynodon cultivars, Velez-Santiago et al, (1979) reported significant differences between weed yields on plots of the cultivars.

2.4 - EFFECT OF FREQUENCY OF DEFOLIATION ON NUTRITIVE VALUE OF FORAGES

1. Dry Matter Content (DMC)

The increase in DMC with advancing maturity is well documented in the literature (Oyenuga, 1960;

Vicente-Chandler, et.al, 1964; Sotomayor-Rios, et.al, 1979).

Vicente-Chandler et.al (1964) reported percentage dry matter values of 21, 24 and 32 for guinea grass harvested at 40, 60 and 90-day intervals. Similarly, Velez-Santiago et.al, (1979) reported that the dry matter content of C. aethiopicus increased from 27.9% at 30 days to 32.4% at 60 days.

Rise and fall trends in percentage DMC are not uncommon. Oyenuga (1960) reported that DMC of guinea grass decreased from 27.71% at 6 weeks to 26.18% at 8 weeks, only to rise again to 32.52% at 12 weeks.

The general increase in percentage dry matter content of herbage with age may be due to decreasing proportion of green leaf, with corresponding increase in proportion of stem which have high DMC tham leaf (Zaleski & Dent, 1960). A decrease in the rate of water absorption by the roots and production during respiration with advancing maturity may be contributing factors to this trend.

Climatic factors, especially rainfall, influence the percentage dry matter content. Percentage dry matter content of herbage is generally high during dry than rainy seasons.

Sullivan (1979) reported that high moisture content limited dry matter intake by livestock. Data presented by Framme & Hunt (1971) and Simon (1974) showed that intake was positively correlated with dry matter content.

2. Total Ash

Total ash is the inorganic residue from the ignition of a sample at about 600°C (Crampton & Harris, 1969; Benerjee, 1978). Ash constitutes about 8 to 12% of dry matter and its value is mainly in the contents of phosphorus, calcium or potassium (Fleming, 1973). In grasses silica forms about 50% by weight of the total ash (Bogdan, 1977).

A general decrease in ash content with age has been reported in forages by many workers (Butterworth, 1967; Omaliko & Obioha, 1981; Nkrumah-Antiedu, 1981). Mean ash values of 12.1, 11.7, 14.5, 9.7 and 9.5% were reported for eight tropical grasses when harvested at every 4, 5, 6, 8 and 10 weeks respectively (Nkrumah-Antiedu, 1981). Similarly, Oyenuga (1957) in Nigeria, reporting on the proximate composition of twenty grasses stated that "generally crude ash

was negatively correlated with age".

Significant differences between species defoliated at the same age have also been reported (Devendra, 1977). In his study, Nkrumah-Antiedu, (1981) reported that the highest mean ash value (12.8%) recorded for Pennisetium purpureum (elephant grass) at 3 weeks was significantly different from the lowest ash value (9.2%) for Cynodon plectostachyus (giantstar grass) at the same age.

These differences may partly be due to variation in relative mineral uptake between species or dilution effect as plants grow and yield increases (Fleming, 1973). Moreover, mineral contents vary markedly between plant parts of the same plant, leaves being high in calcium, magnesium and sulphur than stem (Whiteman, 1980). This may partly explain the differences in the ash content in the same plant with maturity. For example in perennial ryegrass, Fleming (1973) reported 0.23%, 0.87% and 0.30% calcium; and 0.42%, 0.32% and 0.27% phosphorus for the head, leaf and stem respectively.

The mineral composition of herbage is affected by by: soil factors such as parent material, soil moisture and soil reaction; the genus, species and variety; fertilizer and sward management as well as climatic factors (Fleming, 1973).

3. Calcium (Ca)

The changes observed in calcium content of forages with age could be best described as erratic or non significant (Gomide, Noller, Mott, Conard & Hill, 1969; Arroyo-Aguilu & Coward-Lord, 1974; Perdomo, Shirley & Chicco, 1977).

In guinea grass, Vicente-Chandler, et al, (1964) reported mean Ca value of 0.88% at 40 days, decreasing to 0.64% at 90 days. Figures reported by Fleming (1973) confirm this inverse relationship between Ca content and age.

On the contrary, Perdomo, et al. (1977) reported that mean Ca values in Digitaria decumbens (pangola grass) decreased from 0.24% at 28 days to 0.20 at 40 days only to increase again to 0.37% at 56 days. Percentage Ca values of guinea grass and Cynodon nlemfuensis (star grass) followed a similar trend with in-

creasing interval between defoliation.

Nkrumah-Antiedu (1981) indicated that mean Ca content of elephant grass increased from 0.99% at 3 weeks to 1.01% at 4 weeks only to decrease to 0.88% at 5 weeks. Similar trends were reported for Paspálum plicatulum (plicatulum) and star grass. He also reported significant differences in Ca content between grass species and different stages of maturity. On the contrary, Arroyo-Aguilu and Coward-Lord (1974), found no significant differences between Ca content of ten grass species and maturity, when harvested at 30, 60, 90, 120 and 150 days intervals.

According to Raymond (1969) concentration of calcium is higher in leaves than stems or flower heads. Thus calcium deficiency rarely occurs under grazing conditions, because the ruminant diet is largely foliar (Arnold, 1960).

4. Phosphorus (P)

Unlike Ca, the P content of forages generally decreased with age. Gomide, et al. (1969) recorded mean P values of 0.26% at 28 days decreasing to 0.12% at 252 days. Arroyo-Aguilu and Coward-Lord

(1974) also observed a decline in mean P content from 0.27% at 30 days to 0.12% at 180 days. They obtained a highly significant correlation (r = -0.82) between percentage P and age.

Nkrumah-Antiedu (1981), reported slight initial rise and fall trends in P for eight species including buffel and pangola with age. Mean values of P for grasses harvested every 3, 4, 5, 6, 8 and 10 weeks were 0.39, 0.40, 0.32, 0.33, 0.27 and 0.22%. No significant differences were recorded between grass species, however, mean P values at the different stages of maturity differed significantly. These observations are in conflict with those of Arroyo-Aguilu and Coward-Lord (1974) who reported that mean P content in buffel and pangola were highly significant.

Because of its important role in intermediary metabolism of carbohydrates and mitosis, actively growing meristematic leaf and root cells contain far more phosphorus than cells that have ceased to divide (Russel, 1973).

According to Buck and Grieve (1974) grains and seeds are richer in P than leaves and stems.

5. Calcium to Phosphorus Ratio (Ca:P)

Calcium and phosphorus are closely related that a dietary deficiency or excess of one may seriously interfere with the utilization of the other (Buck & Grieve, 1974).

The National Research Council (1966) bulletin on dairy cattle concluded that growth rate and feed utilization were entirely satisfactory within a Ca:P ratio of 1:1 to 7:1. However, values between 1:1 to 3:1 are considered desirable (Hillman, Huber, Emery, Thomas & Cook, 1973).

The two minerals are the main constituents of teeth and bones. Milk is very rich in both Ca and P. They are needed for blood clotting and energy transfer. Both require adequate vitamin D for their maximum use.

Deficiencies of either or both of these minerals can depress milk yield, induce milk-fever and lead to reproductive problems (Hignett, 1959). Deficiency of of phosphorus induces pica. Deficiency of Ca and P are overcome by supplemental feeding of bonemeal,

dicalcium phosphate, monocalcium phosphate, deflourinated rock phosphate, limestone, oyster shells and disodium phosphate (Buck & Grieve, 1974).

In forages, the Ca:P ratio increases with age as a result of the general decline in P content with maturity. Arroyo-Aguilu and Coward-Lord (1974) reported mean Ca:P values of 0.89:1, 1.10:1 and 1.62:1 in ten tropical grasses including guinea and pangola grasses when harvested every 30, 60 and 90 days respectively. Devendra (1977) reported that the Ca:P ratio in grasses vary widely.

6. Crude Fiber (CF)

Crude fiber, analytically determined by the Weende procedure is the partitioning of the total carbohydrate of the feed that is resistant to acid and alkali treatment (Crampton & Harris, 1969). It was originally assumed to represent the indigestible portion of the feed material and as such was considered non-nutritive (Banerjee, 1978). But the CF is partially digestible in the Herbivora, the Weende CF therefore, is a misleading index of the overall digestibility of a feed.

The major components of CF are cellulose, hemicellulose and lignin (Banerjee, 1978). Its contents in tropical forages range from 22 to 25% in young herbage and 30 to 40% in matured plant (Bogdan, 1977).

Nutritionally, CF is associated with bulkiness of a ration and thus stimulates peristalsis. It is considered to have laxative properties which facilitate easy passage of the faecal mass through the colon (Maynard & Loosli, 1968).

Crude fiber content of herbage increases with decreasing frequency of defoliation (Ademosun, 1973; Reid, Post, Olsen & Mugerwa, 1972; Olubanjo & Van Soest, 1974; Silva & Silva, 1977; Arroyo-Aguilu & Oporta-Tellez, 1980).

Nkrumah-Antiedu (1981) reported a rise in CF content of eight tropical grasses from 29.9% at 3 weeks to 37.6% at 10 weeks. Significant differences were established among the grasses and the different stages of maturity. Butterworth (1965) in Venezuela reported CF value of 26.1% at 30 days for pangola grass, while Milford (1960) in Australia recorded 34.3% CF at 50 days increasing to 36.8% at 100 days.

The CF of leaf and stem also increases with advancing maturity (Pigden & Heinrichs, 1957; Terry & Tilley, 1964; Vicente-Chandler, et.al, 1964).

Stems and flower-heads of grasses generally have high levels of CF than leaf tissues (Sosulski, Patterson & Law, 1960). Jarrige (1963) cited by Baley (1973) reported cellulose values of 18.9, 22 and 23% for the leaf-blade, stem and flower-head of Lolium perenne, respectively. Plants with large stems tend to have higher CF content than those with small stem (Pigden & Heinrichs, 1957).

Reports by several investigators tend to suggest that the CF content of leaf increases at a slower rate than stem with advancing maturity (Pigden, 1953; Terry and Tilley, 1964; Olubanjo & Van Soest, 1974).

The increase in CF content of the whole-plant has been attributed to increase in cell-wall constituents; mainly cellulose, lignin and hemicellulose (Olubanjo & Van Soest, 1974; Silva & Silva, 1977; Arroyo-Aguilu & Oporta-Tellez, 1980), the same is true for the leaf and stem portions. Vicente-Chandler et.al (1964) attributed the increase in CF with advancing maturity to decreasing leaf to stem ratio.

7. Crude Protein (CP)

Crude protein is a conventional term for all nitrogenous substances: mineral nitrogen, amide nitrogen, amino acids and proteins. It is the figure obtained by multiplying the nitrogen of the sample in question (estimated by Kjeldhal digestion) by the factor 6.25 (Banerjee, 1978). In forages the CP content ranges from 3 to 25% (Bogdan, 1977), and it is positively correlated to digestibility (Minson, 1971a).

Crude protein level in forages declines as the herbage matures (Oyenuga, 1960; Fianu, 1977; Valez-Santiago, et al, 1979; Arroyo-Aguilu & Oporta-Tellez, 1980; Omaliko & Obioha, 1981).

Nkrumah-Antiedu (1981) reported that the CP content of buffel grass (among others) declined from 16.0% at 3 weeks to 6.4% at 10 weeks. Significant differences in mean CP values were also reported among grass species and stages of maturity. Arroyo-Aguilu and Oporta-Tellez (1980) in Puerto-Rico also reported that the CP content of guinea grass declined from 8.8% at 30 days to 7.0% at 60 days. Similar observations have been made by Grieve and Osbourn (1965) in Trinidad, Moore (1975) in Florida,

Rodriguez-Cavrasquel and Morillo (1977) in Venezuela and Aspiolea, Rois and Diaz (1977) in Cuba.

Stems and leaves differ widely in their composition (Bailey, 1973), with leaves having twice as much proteins than stems (Wilmam, Ojuederie & Asare, 1976). The nitrogen content of green leaves and inflorescence is also higher than dead leaves and stems (Baker, Heimberg, Alderman, Eden, 1952), owing to the high proportion of soluble cell contents in green leaves and inflorescence than in dead leaves and stems. Like the whole-plant, CP levels in leaf and stem declines with advancing maturity (Terry & Tilley, 1964).

Reports on the rates of decline in CP of whole-plant, leaf and stem with advancing maturity vary. Vicente-Chandler, Silva & Figarella (1959ab) reported similar rates of decline in both leaves and stems of pangola, signal, elephant and guinea grasses. Fianu (1977) reported that nitrogen levels in the leaves generally fell faster than the stems in pangola, gianstar and buffel grasses. However, data presented by Terry and Tilley (1964) and Mowat, Fulkerson, Tossell & Winch (1965) suggest that CP level declines at a faster rate in stems than in leaves of several grasses,

including perennial ryegrass and orchardgrass.

Height of defoliation also influence the CP composition of herbage (Mowat et al, 1965), Asare (1970) reported nitrogen levels of 1.66 and 1.89% for a 6-week old buffel grass cut at 10cm and 15cm, respectively.

8. Digestibility

Digestibility of whole-plant of forages generally declines with advancing maturity (Minson & McLeod, 1970; Chensot, 1975; Falvey, 1977; Fianu, 1977; Arroyo-Aguilu & Oporta-Tellez, 1980). According to Minson, Raymon and Harris (1960) the rate of fall depends on the type of herbage and the stage of morphological development.

In buffel grass, Fianu (1977) reported whole-plant in vitro dry matter digestibility (IVDMD) of 70.3% at 3 weeks declining to 38.6% at 15 weeks during the major rainy season of 1976. Mislevy (1977) reported in vitro organic matter digestibility (IVOMD) value of 58.6% at 2 weeks, falling to 56.5% at 5 weeks for C. aethiopicus. Ademosun (1973) in Nigeria reported a decline in IVDMD of C. nlemfuensis from 65.3% at 4 weeks to 46.3% at 10 weeks. Arroyo-Aguilu and Coward-Lord (1974) indicated that IVDMD was negatively (r = -0.77) correlated with age for several forage

grasses in Puerto Rico.

Digestibility of leaf and stem portions also decline with age (Terry & Tilley, 1964; Mowat et al, 1965; Fianu, 1977; Hanna, Monson & Gaines, 1981).

Reporting on Italian ryegrass, Wilman, et al (1976) noted that the most digestible fractions of the crop were green leaf, inflorescence and immature stem, and the least digestible fractions were dead leaf and mature stem.

The rate of decline in digestibility with age is faster in stems than in leaves (Vicente-Chandler et al, 1964; Terry & Tilley, 1964; Mowat et al, 1965). The rate of decline of the whole-plant may be intermediate. Terry and Tilley, (1964) reporting on the IVDMD of some temperate grass observed that digestibility declined at the rates of 0.20, 0.4 and 0.8% per day increase in age for the leaf-blade, leaf sheath and stem respectively.

Large difference in digestibility between genera and species at the same stages of maturity have been reported (Marshall, Long & Thonston, 1969; Minson, 1971b; Arroyo-Aguilu & Oporta-Tellez, 1980; Asiedu, 1980). Reid et al (1973) reported that Brachiria species were more digestible at all stages of growth

than the genera Chloris, Seteria and Panicum.

The general assertion that leaves are always digestible than stems does not apply in all cases (Raymond, 1969; Hacker, 1971). Mowat et al, (1964) reported that IVDMD of stems of immature orchardgrass was higher than that of the leaves.

In regrowths of Brachiaria decumbens and D. pentzii, Grieve and Osbourn (1965) reported that in vivo digestibility increases at rates of 0.8 and 0.9% respectively per day increase in age. This observation contradicts with the general assumption that digestibility decreases with age.

Several studies have revealed good correlations between in vitro and in vivo digestibilities for tropical grasses (McLeod, 1972; Arroyo-Aguilu & Oporta-Tellez, 1980). Thus in vitro digestibility can be a very good estimate of in vivo digestibility in forage evaluation studies.

2.5 - SEASONAL EFFECTS ON HERBAGE RESPONSE TO DEFOLIATION

Yield and nutritive value of all herbage species are subjected to the over-riding control of the weather (Oyenuga, 1960; Fianu, 1977; Omaliko & Obioha, 1981).

Fianu (1977) reported that the dry matter and nitrogen yields of buffel, giantstar and pangola grasses were higher in the rainy season than the dry season. Similar observations have been made by Dradu and Harrington (1972) in Uganda and Omaliko and Obioha (1981) in Nigeria.

2.6 - EFFECT OF FREQUENCY OF DEFOLIATION ON DRY MATTER INTAKE (DMI)

Dry matter intake usually decreases as forage matures and digestibility falls (Milford & Minson, 1968; Minson, 1971b). According to Grieve and Osbourn (1965) when digestibility rose with age, voluntary intake also increased.

Although digestibility and intake are generally correlated, the relationship is far from perfect (Minson, 1971c). Milford and Minson (1968) reported that DMI of Chloris gayana remained constant over a period of 42 to 140 days, despite a drop of 9.6% in

dry matter digestibility. Milford (1960) recorded intake values of 48.4g and 72.1g for hay of digestibilities 66% and 60% respectively. Furthermore, Hutton (1962) reported little drop in DMI as digestibility fell from 77.0% to 70%.

Contrary to the findings of Minson (1971b), other workers have indicated that DMI is independent of maturity. Ademosun, (1973) in Nigeria reported intake values of 33.1, 33.4, 30.9 and 34.1g for guinea grass hay harvested at 14, 28, 42 and 91 days respectively. The corresponding intake values for a local Cynodon species were 45.8, 48.3 and 46.6g when harvested at 28, 42 and 70 days respectively. Similar results have been reported by Sonej, Musangi and Olsen (1971) in Uganda.

Percentage leafiness of herbage has been related to DMI by Minson (1971c). He reported that intake increased from 49.1g to 67.3g when leafiness increased from 28 to 53% respectively. This rise in DMI may be attributed to the high acceptability of leaves and the shorter rumen retention time (Poppi, Minson & Ternouth, 1980) of leaf fractions compared to stem fractions.

Intake is depressed if protein is deficient (Ward, 1973; Sharma & Rajora, 1977). The critical CP required in forages before intake is not affected by CP level has been estimated at 6 to 8% (Milford & Minson, 1966). Values below this level has been reported in matured tropical grasses (Butterworth, 1967; Fianu et.al, 1972), this may partially explain the low intake of tropical forages as they mature.

Reviews of intake values for tropical grasses fed to sheep (Minson, 1971b; Moore & Mott, 1973) revealed large variations between and within species. Jeffery and Holder (1971) in their review fixed the upper limit of intake by sheep at 83g of dry matter per kilogramme metabolic weight. Values far below this maximum have been reported (Sonej et al, 1971; Adu & Adamu, 1982).

The mechanisms which control DMI in ruminants have not been fully elucidated (Church, 1972). However, ruminal distention, absorption of digestible energy, appetite, nutritional status of animal, physical structure of the feed, age, quality and type of forage species are some of the numerous plant and animal factors that have been implicated in control of DMI (Conard, 1966; Egan, 1972), and these could

contribute to the irregular relationships observed between DMI and digestibility.

2.7 - EFFECT OF FREQUENCY OF DEFOLIATION ON RELATIVE PALATABILITY OF FORAGES (RP)

Palatability or acceptability describes the readiness with which certain forage species or part of forages are selected and grazed by livestock when given a choice between these and others (Reid, 1951; Asare, 1975). Ivins (1952) described palatability as the connecting link between forage species and the grazing animal. Thus the term palatability describes all the factors (both plant and animal) that make a plant acceptable to the grazing animal (Arnold, 1964), under defined conditions (Joblin, 1962).

Palatability affects intake and hence production of animals as well as the stability of species in a mixed sward (Ivins, 1952). It is therefore important to determine palatability in systematic evaluation of herbage (Jones & Walker, 1979).

The stage of maturity of forage species influence palatability. According to Jones (1952) cited by Asare, (1975) young and actively growing herbage is more palatable than herbage making little growth.

Asare (1975) studied the effect of stage of maturity on relative palatability of pure and mixed stands of forage species including buffel and guinea grass. Guinea grass was reported to be more palatable (grazing frequency of 24.4 per cow per 24 hours) than buffel grass (grazing frequency of 8.7) at 6 weeks of age. No significant difference was reported betwen guinea (grazing frequency, 17.5) and buffel (grazing frequency, 21.5) when grazed at 4 weeks of age.

The growth habit of a plant may also influence palatability. According to Garner (1963) upright growth habit reduces soil and excreta contamination and thus increase palatability. Furthermore, Tetteh (1974) reported that cattle prefered tall grasses to shorter ones. Andropogon gayanus, pangola and guinea grasses were reported to be heavily grazed by cattle, while buffel and Brachiaria lata among others were moderately grazed. Similar studies on palatability of tropical forages have been reported by Mills (1977) in Zimbabwe.

Herbage availability is positively correlated with palatability (Simon, 1974). Association between herbage palatability and variety of species present at grazing has also been suggested (Cowlishaw & Alder, 1960).

Leafiness has been associated with palatability of herbage. Arnold (1960) observed that sheep selected more leaves than stems. Similar observations has been reported by Poppi et al, (1980).

The grazing animal selects materials that are higher in crude protein, organic matter digestibility and energy, and lower in crude fiber (Cowlishaw & Alder, 1960; Hodgson, 1975).

Ivins (1955) reviewed the relationship between palatability and plant chemical analysis. He concluded that palatability was not related to either nitrogen, phosphorus, potassium or calcium content of herbage. Cowlishaw and Alder (1960) reported that palatability was positively correlated with water soluble carbohydrates and negatively correlated with lignin content of herbage.

Palatability of herbage may be depressed by chemicals such as alkaloids and cyanide (Kendall & Sherwood, 1975) as well as the presence of hairs, thorns and spines. Thus Asare (1975) attributed the relatively low palatability of gamba grass compared with guinea grass to the presence of hairs on the leaves and stems.

Palatability may be determined by: recording the number of animals grazing on individual swards at definite intervals of time; determination of herbage consumed by sampling before and after grazing; determination of time interval required per animal to graze a given area and by visual observation and ranking of swards before and after grazing (Reid, 1951; Asare, 1975).

2.8 - FORAGES STUDIED

1. Cynodon aethiopicus Clayton and Harlan (UF-5 stargrass):-

UF-5 stargrass is a stoloniferous perennial that grows on light-textured soils (Bogdan, 1977). It is established by cuttings, and persistent under heavy grazing (Owen & Brozostowski, 1966; Rodel, 1970; Adjei, 1980). Regrowth cycles of 6 to 7 weeks (Bogdan, 1977) and 4 to 5 weeks (Mislevy, 1977) have been recommended.

UF-5 stargrass responds to nitrogen fertilization. In Zimbabwe, Rodel (1970) reported dry matter yield of 14.45 t/ha, while in Puerto Rico, Vélez-Santiago et al (1979) reported 24.8 t/ha when harvested at 60 days intervals.

Herbage analysed by Nkrumah-Antiedu (1981) in Ghana contained 6.7 to 9.8% CP; 24 to 35.4% CF; 0.6 to 1.9% EE; 8.7 to 10.2% ash; while Adjei (1980) obtained IVOMD of 43.9 to 50.5% and 8.7 to 11.8% CP. There are reports that UF-5 like other Cynodon species contains hydrocyanic acid (Bogdan, 1977; Velez-Santiago et.al, 1979).

2. Cynodon nlemfuensis Vanderyst var nlemfuensis (Stargrass):-

The growth habit, establishement and persistency are identical to those of UF-5 stargrass (Bogdan, 1977).

Mills, Rodel, Boultwood (1973) obtained dry matter yields of 9.6 to 10.8 t/ha when given 225KgN/ha in Zimbabwe, while Rodriguez-Cavrasquell et.al. (1977) reported yields of 3.39 t/ha at fertilization levels of 50KgN/ha.

Forage analysed in Ghana contained ranges of 8.5 to 19.4% CP; 31.3 to 38.6% CF; 1.2 to 2.1% EE and 8.2 to 12.9% ash. Ademosun (1973) reported in vivo dry matter digestibility of 52.8 to 65.3% in Nigeria. Adjei (1980) in Florida reported IVOMD range of 44.5 to 50.2% and 7.8 to 11.2% CP. Stargrass is

reported to contain high levels of hydrocyanic acid (Bogdan, 1977; Velez-Santiago et.al, 1979). Not withstanding, there are several reports on feeding without adverse effects. Caro-Costas, Abruna & Vecente-Chandler (1973) reported that steers gained weight when grazed on stargrass without any adverse effects. Similar observations were made by Ademosun (1973) when stargrass was fed to West African dwarf goats and sheep in Nigeria.

3. Cynodon plectostachyus (K.Schum) Pilger (Giantstar grass):-

Giantstar grass is an aggressive, stoloniferous perennial. It is established by stolons (Bogdan, 1977). Giantstar grass is palatable and persistent under grazing. Fianu (1977) in Ghana reported yields of 4715Kg/ha and 5296Kg/ha in the minor and major rainy seasons respectively. He further reported IVDMD of 38.6 to 70.3% during the major rainy season. Velez-Santiago et.al, (1979) obtained dry matter yields of 30.6 t/ha in Puerto Rico when harvested at 60 days intervals.

Herbage analysed in Ghana by Nkrumah-Antiedu (1981) gave ranges of 6.2 to 11.5% CP; 30.0 to

37.9% CF; 0.7 to 2.1% EE and 8.2 to 10.1% ash.

4. Digitaria decumbens Stent (Pangola grass):-

Pangola is a vigorous stoloniferous perennial adapted to the humid and sub-humid tropics, over a wide range of soils and rainfall (Bogdan, 1977). It produces no viable seeds, and therefore established vegetatively (Humphreys, 1980).

Regrowth cycles of 20 to 30 days (Vicente-Chandler et.al, 1964); 30 to 40 days in the rainy season and 60 days in the dry season (Brown, Lyman, & Rotar, 1966) and 8 weeks during the major rainy season (Fianu, 1977) have been recommended. Pangola is persistent under both cutting and grazing (Nestle & Creek, 1962).

Pangola responds to nitrogen fertilization and combines well with Centrosema pubescens. DMY of 32.8 t/ha has been reported in Puerto Rico (Caro-Costas & Vecente-Chandler, 1961). Pangola is highly palatable and produces herbage of high nutritive value (Bogdan, 1977). Nkrumah-Antiedu (1981) recorded the following range of values; 7.1 to 14.9% CP; 35.4 to 39% CF; 1.0 to 2.2% EE and 9.3 to 12.1% ash, for pangola harvested between 3 to 10 weeks.

The yellow sugar-cane aphid (Sipha flava) is reported as the most important insect pest of pangola grass (Bogdan, 1977), also pangola is affected by stunt viral disease (Vicente-Chandler et.al, 1964).

5. Digitaria swazilandensis Stent (Swazigrass):-

Swazigrass is a stoloniferous perennial with erect, leafy-stem, forming low dense swards. It combines well with Trifolium repens. Swazigrass is distributed in South Africa, Swaziland and adjacent territories, where it is mostly used for sheep grazing (Bogdan, 1977; Whyte, Moir & Cooper, 1959). Swazigrass was low yielding, not palatable and thrived on poor soils (Gohl, 1975).

Gohl (1975) reported the following value of proximate composition; 13.3% CP; 34.6% CF; 9.7% EE and 41.2% NFE.

6. Cenchrus ciliaris Linn. (Buffel grass):-

Buffel is a tufted rhizomatous perennial, rhizomes, if present are short and numerous (Bogdan, 1977). It is drought resistant and can grow under rainfall regime of 270mm to 400mm. The drought tolerance of buffel can be explained by the very deep root system (Bogdan, 1977).

Buffel can be established by seed or stolons (Coaldrake & Russel, 1969). Buffel was persistent under grazing and remained green for the greater part of the dry season (Asare, 1970).

Yields up to 26.1 t/ha has been obtained in the humid zone of Ghana (Asare, 1970) with 67KgN, 90KgP and 45KgK/ha. Fianu (1977) reported dry matter yields of 6.2 t/ha, when harvested at 9 weeks intervals.

Herbage analysed by Nkrumah-Antiedu (1981) contained 16.4 to 6.4% CP; 9.6 to 13.2% ash when harvested at 3 and 10 weeks respectively.

7. Panicum maximum Jacq. (Guinea grass)

Guinea grass is an erect shade-tolerant perennial. It is adapted over a wide range of soils in the tropics and subtropics, where rainfall is between 600mm to 1000mm (Bogdan, 1977; Narayanan & Dabaghao, 1972).

It can be established by seed or vegetatively by tuft splits. Although palatable, guinea grass is poorly adapted to heavy grazing. Yields up to 28.0 t/ha with an imput of 224KgN/ha has been reported in Australia (Grof & Harding, 1970).

Bogdan (1977) recommended rotational grazing with 3 to 9 weeks interval between grazing, while

Vicente-Chandler et.al (1964) stated that it should not be harvested at an interval less than 60 days. Guinea grass combines well with most tropical legumes, especially Centrosema pubescens (Grof & Harding, 1970).

Herbage analyses by Nkrumah-Antiedu (1981) in Ghana contained 6.1 to 16.4 CP; 28.6 to 36.0% CF; 1.0 to 2.2% EE and 10.2 to 13.9% ash.

8. Paspalum plicatulum Michx. (Plicatulum):-

Plicatulum is an errect perennial adapted to wet areas receiving a minimum of 750mm rainfall per annum. It is highly adaptable and can grow on relatively poor soil, and tolerates water logging (Bogdan, 1977). Plicatulum has good seed production (Whiteman, 1980).

Amarasiri and Perera (1975) reported dry matter yields of 50.0 t/ha. Proximate analysis of herbage in Ghana by Nkrumah-Antiedu (1981) revealed the following: 31 to 36.1% CF; 7.2 to 13.5% CP; 8.7 to 11.1% ash and 1.1 to 2.1% EE, for plicatulum harvested between 3 to 10 weeks.

CHAPTER THREE

MATERIALS AND METHODS

3.1 - Location:

The study was conducted over a six-month period at the University of Ghana's Agricultural Research Station, Legon, on a grey-brown, sandy clay soil of the Simpa-Agawtaw Complex series (a vertisol). Tests indicated that the soil had a pH of 6.6, and contained 647 and 48 ppm nitrogen and phosphorus respectively and 0.32me g/100g of potassium.

3.2 - Grass Entries:

One-year-old swards of eight tropical grasses were used in the study (Table 2).

3.3 - Experimental Design:

A randomised complete block design was used with two replicates. The total land area (0.26 ha) was divided into six paddocks (0.043 hectare each). Each paddock was fenced with barbwire. The six grazing frequencies were randomly assigned to the paddocks. Each paddock contained sixteen plots which were assigned randomly to the eight grass entries.

TABLE2: Grass entries, and their designations.

Grass Species	Scientific Name	Designation
UF-5 stargrass	Cynodon aethiopicus	CA
Star grass	Cynodon nlemfuensis	CN
Giantstar grass	Cynodon plectostachyus	CPS
Buffel grass	Cenchrus ciliaris var Biloela	CC
Pangola grass	Digitaria decumbens	DD
Swazigrass	Digitaria swazilandensis	DS
Guinea grass	Panicum maximum	PM
Plicatulum	Paspalum plicatulum	PP

Thus each of the eight grasses was replicated two times in a paddock. The plots within a paddock were separated from one another by 3.05m wide alleways.

Details of treatments, replication and randomization are given in figure I and a schedule of activities for the study in Table 3.

3.4 - Management of Plots

Plots in all paddocks were staged once to a height of 7cm for DS and 18cm for the rest of the grasses at the beginning of the study.

A 15 - 15 - 15 (N - P_2O_5 - K_2O) fertilizer was applied at a rate of 540kg/ha after the initial grazing of all plots on the 5th of February. This was followed in April by application of 175 kgN/ha as ammonium sulphate (Table 3).

3.5 - Grazing Management

Forty N'Dama/Sokoto Gudali x Holstein/Fresian dairy cows were allowed to mob-graze the swards intensively. The cows remained on the pasture for 2 to 6 hours depending on the availability of forage. Following removal of cattle, ungrazed standing culms were slashed to stubble heights of 7 to 9cm for DS

Fig 1: Treatments, Replications and Randomization of the Eight Grasses Entries

BLOCKS (GRAZING INTERVALS, WEEKS)

6				3				8				4				5				10			
DD	PP	CPS	CN	DS	CA	DS	CPS	DD	PP	CC	PP	PM	CPS	DS	CA	CA	DD	PP	DD	CN	DD	CN	CPS
PM	CA	DS	CC	PP	PP	CA	CN	CPS	PM	DD	DS	CPS	DD	PP	CC	CA	DS	CN	PP	CC	CA	PP	CPS
CN	DD	CPS	DS	CN	CC	DD	CA	CC	CN	PM	CPS	DS	CC	PM	PP	CC	PM	CPS	PM	DS	CC	PP	PM
CC	PM	CA	PP	PM	DD	PM	CPS	CN	DS	CA	CA	CA	CN	DD	CN	DS	CPS	CN	CC	DS	CA	DD	PM

TABLE 3: Schedule of activities for the study.

Calendar Dates	Grazing Interval (Weeks) 3	4	5	6	8	10	Other Activities on all Plots
5 February	Grazing of all plots (staging)						*1st Fertilization
12							*Collection of soil samples
19							
26	X*						
5 March		X					
12			X				*1st Weed count
19	X			X			
26							
2 April		X			X		
9	X						
16			X			X	
23							*2nd Fertilization
30	X	X		X			
7 May							
14							
21	X		X				
28		X		X			
4 June							
11	X		X				
18							
25		X	X			X	
2 July	X						*Soil cores for root and stolon weight
9							
16							*2nd Weed count
23	X	X		X	X		
30			X				

X Date for grazing.

and 15 to 18cm for PP, CC, CPS, CN, CA, PM and DD.

3.6 - Yield Estimation

Prior to grazing each paddock, two samples per plot, each $1m^2$ in size, were randomly harvested to stubble heights of between 7 to 9cm for DS and 15 to 18cm for the rest of the grasses, and weighed for green forage yield estimation.

Two sub-samples of approximately 400g fresh weight were taken. One was separated into leaf and stem fractions and oven dried in cloth bags for 72 hours at $60^{o}C$, for the determination of IVDMD, CP, and CF of the leaf and stem fractions.
The second sub-sample was not separated but oven dried in a similar manner for DMC and DMY estimation, as well as IVDMD, CP, CF, total ash, Ca and P determinations of the whole-plant. Yield estimation was continued over a six-month period for all treatments.

3.7 - Weed Counts

Percentage basal cover of weeds was estimated by taking two $1m^2$ quadrat counts per plot per paddock in March and July, to study grass species persistence under grazing (Table 3). The increase or decrease in

percentage basal cover of weeds was estimated by substraction of the first weed count from the second count.

3.8 - Sward Height Estimation

Heights of swards were determined prior to grazing of each paddock by taking height measurements at random throughout each plot. The mean of three height measurements, was taken as the height for the plot.

3.9 - Stubble and Root Weight Estimation

Two samples per plot were randomly taken using cylindrical soil-plugs of diameter 12cm in July (Table 3). Soil cores were taken to 30.5cm depth together with the stubble. Samples were soaked for 15 minutes in water and manually washed. All water containing the samples was poured over a mesh screen so that the soil material passed through the screen. The root and stubble portions were then rinsed in clear water, oven dried for 48 hours at $60^{o}C$ and weighed. The average of the two samples for a plot was taken as the plot's stubble and root yield.

Samples were taken at stubble heights of 7 to 9cm for DS and 15 to 18cm for all other species.

3.10 - Relative Palatability Estimation (RP)

Each paddock was grazed by ten N'dama/Sokoto Gudali x Holstein/Friesian dairy cows ranging from 3 to 6 years of age. Observations were made after thirty minutes of introduction of animals into the paddock, at 5 minutes intervals from 8 a.m. to 12 noon involving a total of 48 observations in each trial. The number of animals grazing on each plot was recorded for each of the 48 observations.

Percentage Relative Palatability (%RP) was calculated using the formula:

$$\%RP = \frac{\Sigma G}{NE} \times 100$$

where G = number of animals recorded [illegible] grazing a grass entry in each observation.

NE = total number of animals expected to graze in each trial (10 animals x 48 observation/trial).

Grass entries within a paddock were ranked according to their mean %RP.

The rank correlation co-efficient between replicates was calculated for each paddock using Spearman's formula quoted by Snedecor and Cochran (1967) as:

$$rs = \frac{1 - 6 \sum d^2}{n(n^2 - 1)}$$

where rs = the rank correlation co-efficient

n = number of samples (trials)

d^2 = sum of the squares of deviations.

Relative palatability was assessed at each other grazing cycle for the 3-, 4- and 5-week cycles and at every grazing cycle for the 6-, 8-, and 10-week cycles.

Feed Intake and in vivo Digestibility Trials

Eleven groups of two local West African Dwarf gimmers were allocated to diets (see Table 4) in cages, in a completely randomised design. The gimmers aged between 10 to 12 months and had an initial average weight of 15kg. Animals were weighed at the beginning and end of the experiment. The average of the two weights was used to calculate metabolic weight (KgW 0.75) on which intake was based.

All trials were conducted with a 10-day preliminary period to accustom the gimmers to the environment and get adjusted to the diets followed by a 7-day faecal collection period. Total faeces from each caged gimmer were collected once daily, weighed and samples taken.

TABLE 4: Diets for feed intake and *in vivo* dry matter digestibility trials,

	Diet	Designation
1	Hay from Giantstar at 3 weeks	CPS 3
2	Hay from Giantstar at 4 weeks	CPS 4
3	Hay from Giantstar at 5 weeks	CPS 5
4	Hay from Giantstar at 6 weeks	CPS 6
5	Hay from Stargrass at 3 weeks	CN 3
6	Hay from Stargrass at 4 weeks	CN 4
7	Hay from Stargrass at 5 weeks	CN 5
8	Hay from Stargrass at 6 weeks	CN 6
9	Hay from Swazigrass at 4 weeks	DS 4
10	Hay from Swazigrass at 5 weeks	DS 5
11	Hay from Swazigrass at 6 weeks	DS 6

Animals were supplied diets ad-libitum every morning, after the left-over from the previous days feeding had been weighed and removed. Water and mineral-licks were also supplied ad-libitum in each cage. Animals were drenched and dipped before they were assigned to treatments.

Subsamples from each of the seven daily faecal samples were analysed for each animal after the collection period for the determination of in vivo dry matter digestibility.

Laboratory and Statistical Analysis

The whole-plant, stem and leaf samples were analyses for IVDMD using the modified two-staged Tilley and Terry (1963) prodedure. Inoculum was obtained from two ruminally fistulated West African Dwarf rams. The proximate composition of samples was also determined in accordance with A.O.A.C. (1970) procedures.

Data were subjected to analysis of variance and simple regression and correlation analyses (Snedecor & Cochran, 1967). The Student-Neumann-Keuls multiple range test was used to separate significant differences among means.

CHAPTER FOUR

RESULTS AND DISCUSSION

1. Green Forage and Dry Matter Yields

There were significant ($P < 0.01$) grazing frequency and grass species effect in GFY and DMY. There was no significant grass x grazing frequency interaction in DMY. However, there was significant grass x grazing frequency interaction in GFY (Appendices B1 and B2).

The highest (15.7 t/ha) GFY was obtained for PM at the 10-week grazing frequency and the lowest (4.8 t/ha) for CA at the 3-week grazing (Appendix A1 and Figure 2).

P. maximum produced the highest (2.9 t/ha) DMY over the six month period which differed significantly ($P < 0.05$) from the lowest (1.8 t/ha) produced by CA. However, DMY of CA was not significantly different ($P > 0.05$) from those of CN (2.1 t/ha), CPS (2.0 t/ha), DD (2.0 t/ha) and PP (2.2 t/ha) as shown in Table 5.

The observed species variation in GFY is in accord with the literature (Fianu, 1977; Vellez-Santiago, et.al, 1979). This may be associated with species differences in a multiplicity of agronomic factors including growth habit; tiller dynamics;

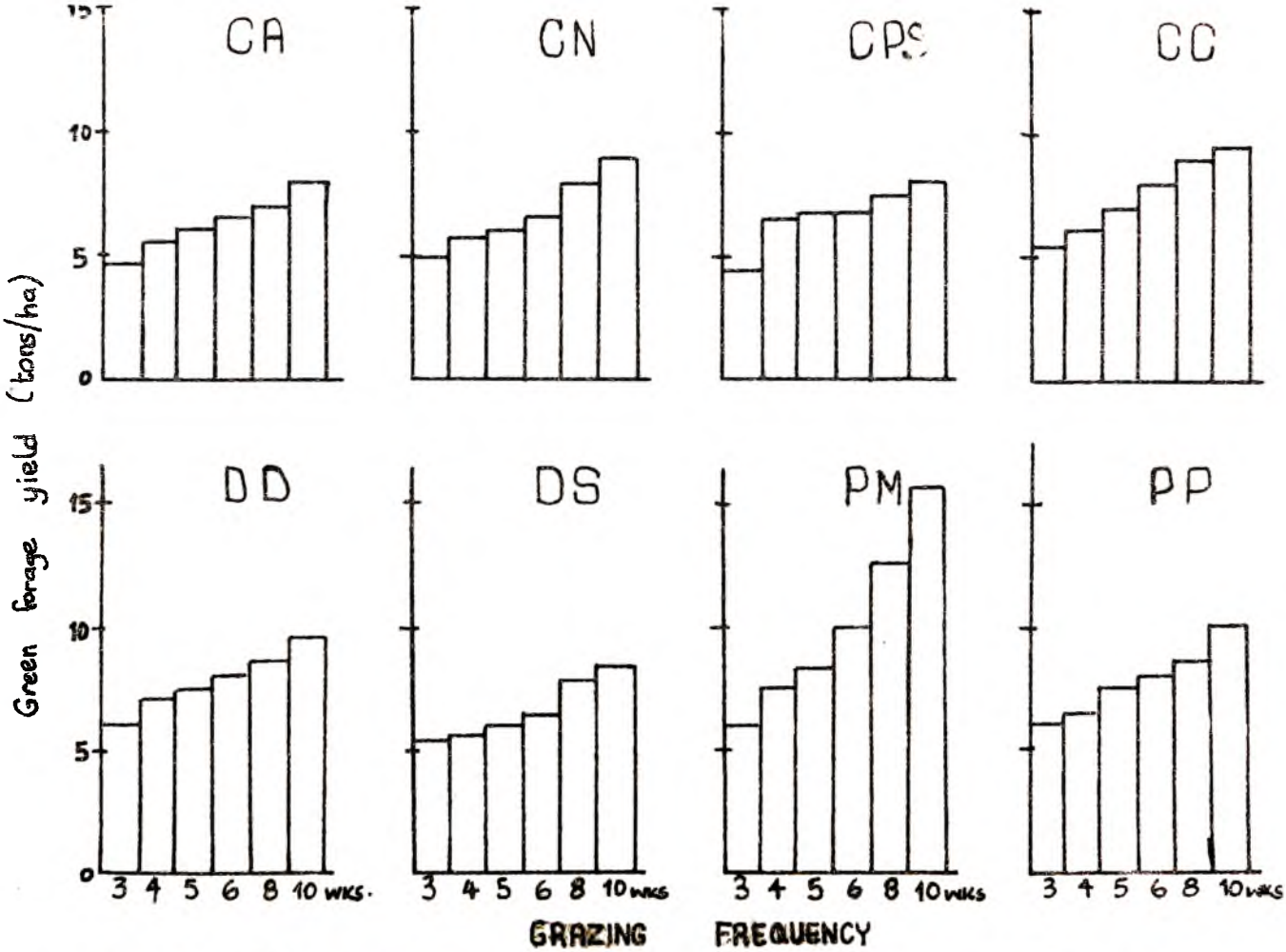

FIG: 2 Effect of grazing frequency on green forage yield for each grass entry.

TABLE 5: Mean green forage and dry matter yield, dry matter content, sward height and root weight of eight tropical grasses.

Grass Species	Green Forage t/ha	Dry Matter t/ha	Dry Matter Content %	Sward Height cm	Root ++ Weight gm
C. aethiopicus	6.4+c	1.8c	30.0a	76.0e	62.0g
C. nlemfuensis	6.9c	2.1bc	29.4ab	92.6d	82.9f
C. plectostachyus	6.7c	2.0bc	30.2a	103.5c	87.7e
C. ciliaris	7.6b	2.4b	31.3a	125.8b	144.9c
D. decumbens	7.8b	2.0bc	25.9d	66.7f	94.0d
D. swazilandensis	6.7c	2.1bc	28.0bc	34.8g	145.4c
P. maximum	10.1a	2.9a	30.5a	143.3a	161.8b
P. plicatulum	7.9b	2.2bc	27.4cd	105.5c	187.3a

+ Means in the same column with one or more common letter(s) are not significantly different at the 5% level.

post-grazing residual LAI; length of stubble left after grazing; position of growing points and the carbohydrate reserve status at the time of defoliation.

C. aethiopicus had the lowest overall GFY (6.4 t/ha) and DMY (1.8 t/ha). This may be associated with the high weed infestation and comparatively low root and stolon weight (Table 5).

Green forage yield and DMY of the three Cynodon species and DS did not differ significantly (Table 5). However DS was defoliated to stubble height of 7 to 9cm and the Cynodons to stubble heights of 15 to 18cm. Since height of defoliation affects GFY and DMY (Rodel & Scheerhoorn, 1976), significant differences might have been established if species were defoliated to similar heights.

Figures 2 and 3 show the GFY and DMY of all species at the different grazing frequencies. GFY and DMY of all species increased significantly with increasing grazing interval (Table 6). DMY was highly correlated to grazing frequency (r = 0.98, Table 7). This observation agrees with reports by other workers (Oyenuga, 1960; Vicente-Chandler, et.al, 1964; Fianu, 1977; Velez-Santiago et.al, 1979; Omaliko & Obioha, 1981). It differs however, from findings by Beaty et

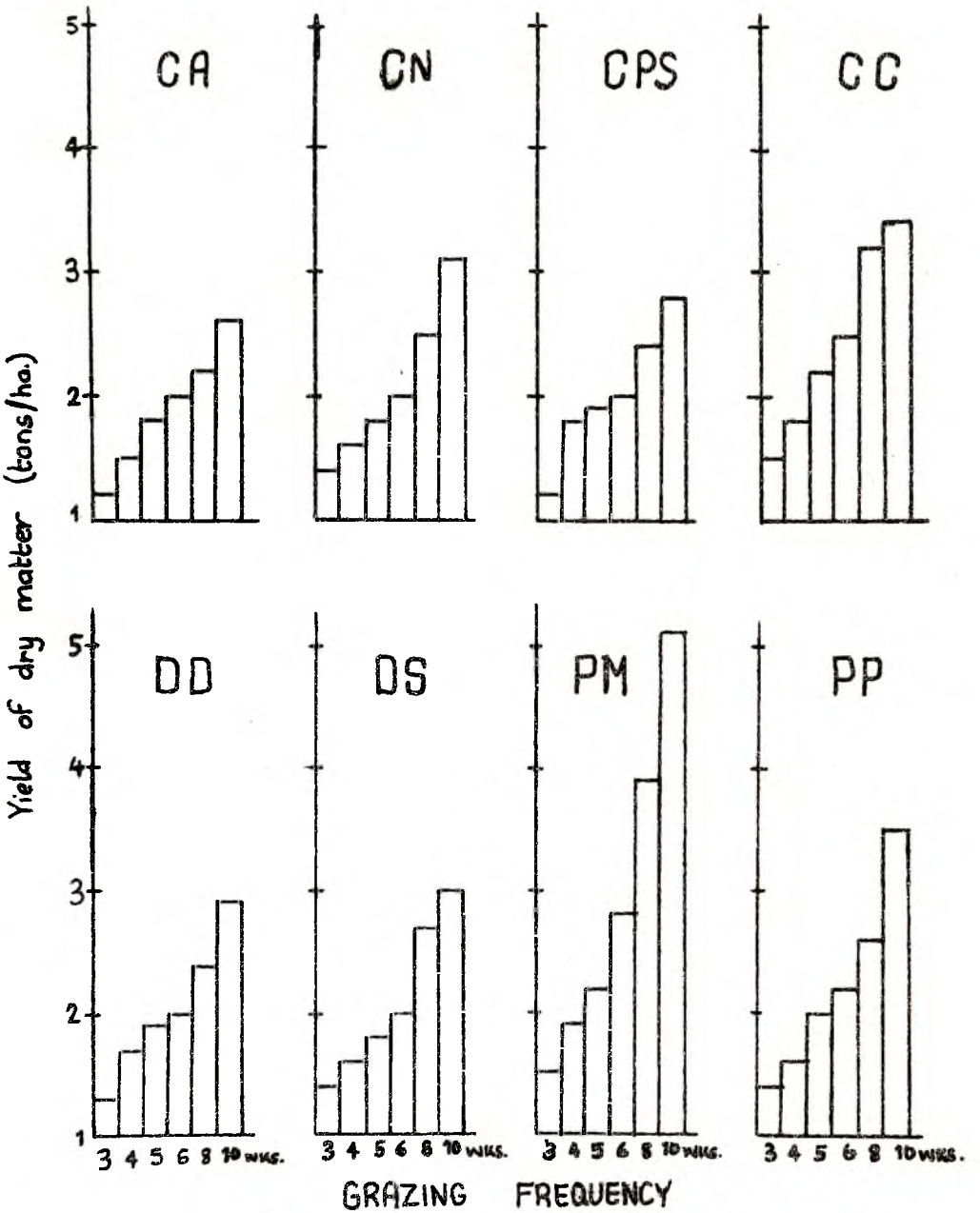

Fig:3 Effect of grazing frequency on dry matter yield for each grass entry.

TABLE 6: Mean green forage and dry matter yield, dry matter content, sward height and root weight at six grazing frequencies.

Grazing Frequency (wks)	Green Forage t/ha	Dry matter t/ha	Dry Matter Content %	sward Height cm	Root++ Weight gm
3	5.5+f	1.4e	24.8e	74.2f	109.3e
4	6.5e	1.7d	26.5d	83.1e	112.8d
5	7.0d	2.0c	28.1c	87.3d	116.3c
6	7.6c	2.2c	29.2c	93.2c	121.9b
8	8.6b	2.7b	31.7b	101.7b	130.9a
10	9.9a	3.3a	33.5a	124.7a	133.1a

+ Means in the same column with one or more common letter(s) are not significantly different at the 5% level.

++ Include stubble, root, rhizome and stolon.

TABLE 7: Regression equations of form Y = a + bX for estimating dry matter yield (Y t/ha) from age (X wks) in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coefficient of correlation r
C. aethiopicus	0.86	0.16	0.15	0.96
C. nlemfuensis	0.62	0.24	0.26	0.98
C. plectostachyus	0.80	0.20	0.22	0.97
C. ciliaris	0.72	0.29	0.31	0.98
D. decumbens	0.76	0.21	0.23	0.99
D. swazilandensis	0.64	0.24	0.26	0.99
P. maximum	-0.22	0.52	0.56	0.98
P. plicatulium	0.49	0.29	0.31	0.98
All entries	0.64	0.26	0.28	0.98

+ SE : Standard error

al, (1970) who reported an inverse relationship between increasing defoliation interval and DMY for P. notatum.

The higher forage yields associated with the longer grazing intervals may be attributed to greater growth rates associated with the longer rest periods, as suggested by Greenwood et.al (1974).

According to Asiegbu (1978), dry matter yield is positively correlated to sward height. In the present study, frequent grazing resulted in reduced sward height for all species. Thus the smaller forage yields obtained under frequent grazing may be partly associated with the reduction in sward height.

Herbage carbohydrate reserves are said to be linearly correlated with regrowth following defoliation (Dovrat and Cohen, 1970). Frequent defoliation results in rapid depletion of reserves, reduction in regrowth potential and subsequently, yield after defoliation. Thus the low forage yield associated with frequent grazing may partly be due to exhaustion of carbohydrate reserves.

Light interception by the sward and subsequently, net photosynthesis and yield are functions of LAI (Brougham, 1956 ; Rhodes, 1971; Wilson, 1973). The

higher the LAI the higher the yield up to the optimum LAI. Thus the higher forage yield with increasing grazing interval may be associated with high LAI compared with the low LAI of the more frequent grazing interval. Apparently the optimum LAI was not exceeded for any grass entry since DMY continued increasing even up to the 10-week rest period.

According to Jarvis (1962), the yield of any crop is the product of the number of plants and the mean yield of each plant. Thus the longer grazing interval might have resulted in higher tiller production, resulting in greater plant numbers or better development of available tillers and consequently higher yields compared with the shorter grazing intervals.

Increase in overall cell population in the herbage, owing to longer periods for mitotic activity may partly explain the higher yields associated with the longer grazing intervals.

Frequent defoliation results in cessation of root growth, mineral and water absorption (Cook et. al, 1958; Schuster, 1964). Water comprises about 60 to 80% by weight of green herbage. The reduction in GFY and subsequently DMY under frequent grazing may be attributed to a decline in water and mineral absorption, and their subsequent effect on growth.

The linear relationship between DMY and increasing grazing frequency may be related to the increasing DMC with advancing maturity.

Mean GFY and DMY reported for species in present study are a bit lower than those in the literature for one or more of the species at the same age (Fianu, 1977; Mislevy, 1977; Omaliko & Obioha, 1981). The differences in yield may be partly due to the fact that most of these workers used clipping or mowing as the method of defoliation.

Differences in fertilizer rates and climatic conditions could also induce such yield differences. It may as well be due to the fact that in the present study, yield for all species was estimated over a six month period, as against annual estimates in the literature.

2. Percentage Dry Matter Content

Analysis of variance of the DMC data indicated significant ($P < 0.01$) grass species and grazing frequency effects. There was no grass x grazing frequency interaction (Appendix B3).

The DMC of CO (31.3%) was not significantly different ($P > 0.05$) from

CA (30.0%), CN (29.4%), CPS (30.2%) and PM (30.5%). DMC of PP (27.4%) was not significantly different ($P > 0.05$) from the mean value of DS (28.0%, Table 5).

Percentage DMC for all grass species increased linearly with increasing grazing interval (Figure 4 and Table 6). This is in agreement with reports by Oyenuga (1960); Vicente-Chandler et.al, (1964); Velez-Santiago et.al, (1979). The highest (33.5%) DMC recorded for the 10-week grazing frequency differed significantly ($P < 0.05$) from the lowest (24.8%) recorded for the 3-week grazing frequency.

This may be associated with decreasing proportion of leaf with corresponding increase in proportion of stem, which has higher DMC than leaf, as suggested by Zaleski and Dent (1960). A decrease in rate of water absorption by roots following frequent defoliation may also be a contributing factor. With advancing maturity, cell-wall contents increase at the expense of the aqueous protoplasm. Hence increasing cell-wall contents may be responsible for the increasing DMC with increasing grazing interval.

Percentage DMC values should be interpreted with caution, for it is highly influenced by soil and at-

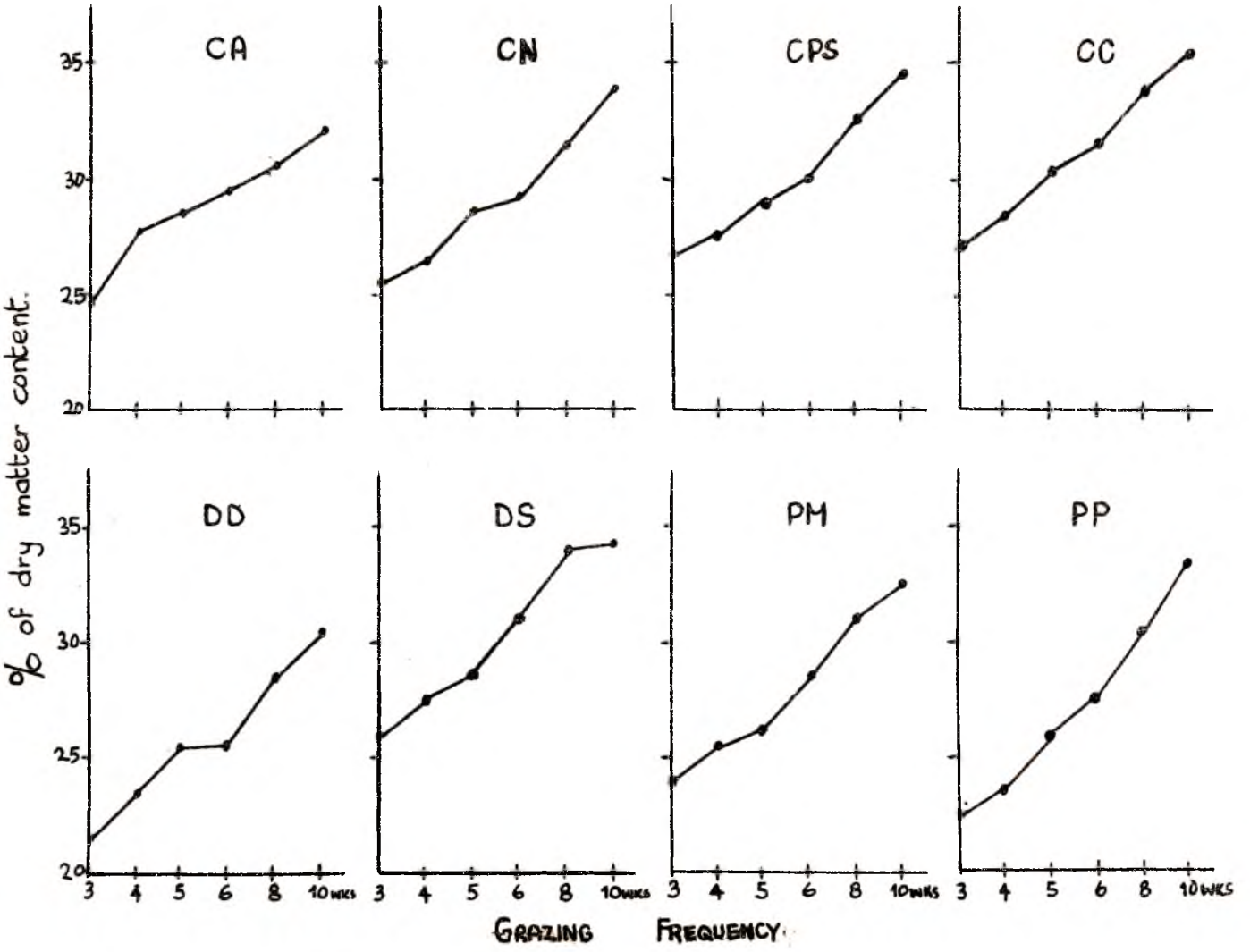

FIG: 4 Effect of grazing frequency on dry matter content for each grass entry

mospheric factors as well as fertilization and the time of the day herbage is harvested.

3. Sward Height (SH)

Significant differences ($P < 0.01$) were obtained between grass species and grazing frequency. There was significant ($P < 0.01$) grass x grazing frequency interaction (Appendix B4).

Species variation in height was not unexpected and is mostly due to genetic variation. The highest SH (256.0cm) was obtained for PM (an errect specie) at the 10-week grazing frequency and the lowest (29.5cm) for DS (a sod-forming specie) at the 3-week grazing frequency (Appendix A4 and Figure 5). The highest (20.13cm per week increase in age) and the lowest (1.79cm) rate of increase in SH with advancing maturity was recorded for PM and DS respectively (Table 8). The positive correlation between SH and increasing grazing interval is in conformity with the literature (Oyenuga, 1957; Koocheki, 1975; Asiedu, 1980).

According to Williams and Joseph (1974), plant height is a useful index of crop growth. Hence the general decline in SH following frequent grazing

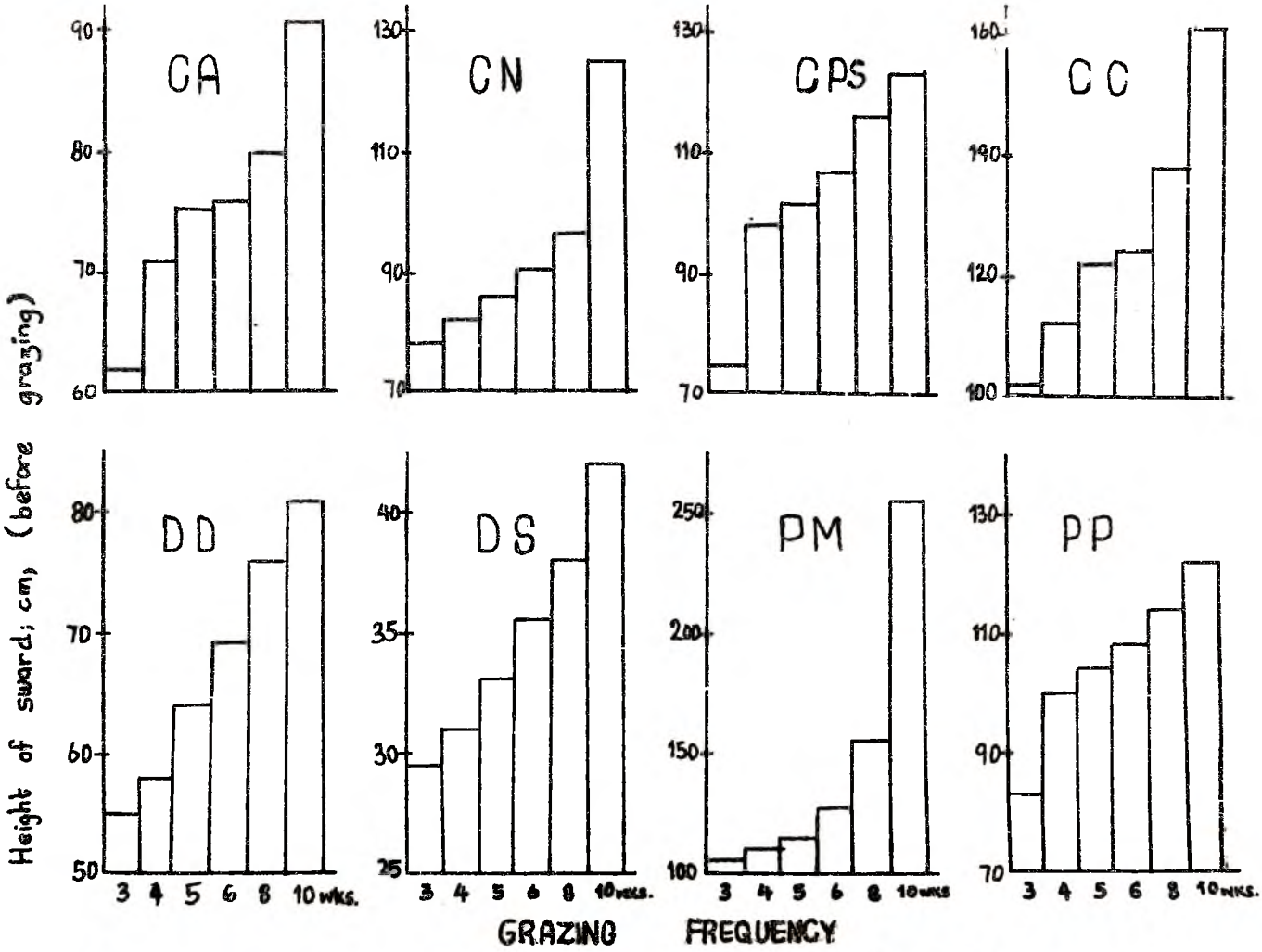

Fig:5 Effect of grazing frequency on sward height for each grass entry.

TABLE 8: Regression equations of form Y = a + bX for estimating sward height (Ycm) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coeffecient of correlation r
C. aethiopicus	43.20	4.63	4.13	0.74
C. nlemfuensis	59.58	5.50	6.12	0.96
C. plectostachyus	68.21	5.88	6.75	0.94
C. ciliaris	78.36	7.93	8.54	0.98
D. decumbens	44.24	3.79	4.14	0.98
D. swazilandensis	24.07	1.79	1.93	0.98
P. maximum	26.21	20.13	23.09	0.92
P. plicatulum	79.03	4.41	4.90	0.95

+ SE: Standard error

may be partly due to retardation in crop growth. The retarded crop growth might have been the consequence of: a dearth of carbohydrate reserves; smaller LAI and consequent reduction in net photosynthetic rate; decreased root weight, root elongation and mineral absorption.

4. Root Weight (RW)

There were significant ($P < 0.01$) grass and grazing frequency effects on root weight. Grass x grazing frequency interaction was not significant (Appendix B5).

P. plicatulum had the highest RW (187.3g) which differed significantly ($P < 0.05$) from the lowest (62.0g) recorded for CA. The mean RW of CC (144.9g) was not significantly different ($P > 0.05$) from that of DS (145.4g) Table 5.

Figure 6 shows the progressive increase in root weight of all grass species with increasing grazing interval. Root weights increased from 109.3g (at the 3-week) to 133.1g (at the 10-week grazing frequency) Table 6. This observation agrees with reports in the literature (Schuster, 1964; Beaty et.al, 1970; Taerum, 1971; Owusu-Ansah, 1976; Harridine & Whally, 1981). However, it contradicts with reports by Pearson (1965)

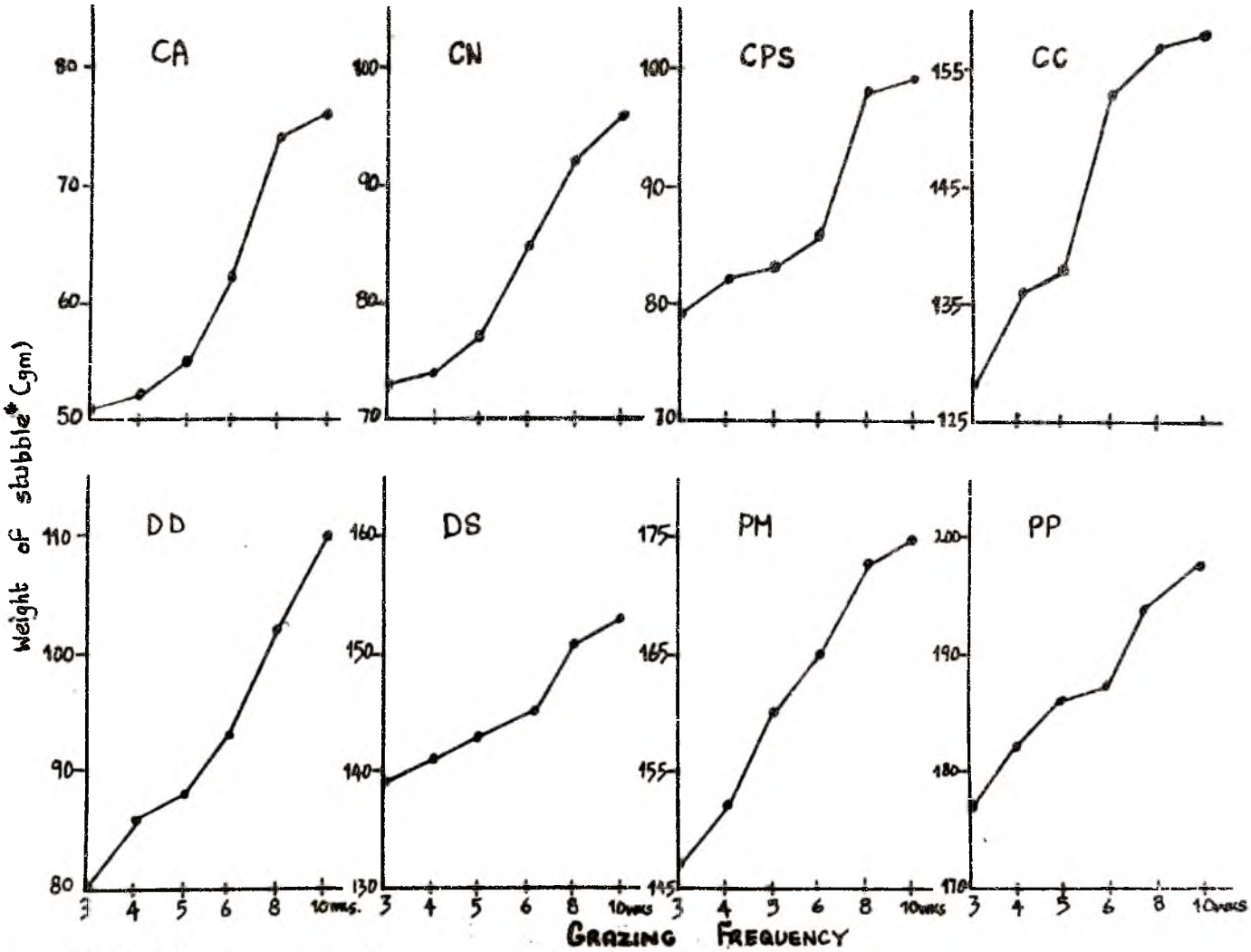

FIG: 6 Effect of grazing frequency on stubble* weight for each grass entry
(*Stubble: may include root, stolons & culms)

and Smoliak et.al, (1972), who reported an increase in herbage root weight under increasing intensity of grazing for Stipa comata and Agropyron spitacum among others.

The decline in root weight may be partly attributed to exhaustion of plant carbohydrate reserves, reduction in root numbers, diameter, elongation and branching following frequent defoliation as suggested by many workers including Schuster, (1964), Dovrat & Cohen, (1970), Greenwood et.al, (1974) and Omaliko and Obioha (1981).

Literature comparing the GFY, DMY, DMC, SH and RW of the eight grass species used in the present study under the same environmental conditions is scanty. Hence the present results should be considered as basic to these studies.

5. Weed Infestation

Grazing resulted in an increase in basal cover of weeds in all species at all the grazing frequencies (Appendix A6). The increase in weed infestation suggests an apparent deterioration and loss of vigour under grazing. The results of Bryan (1970) and Rodel (1970) are similar.

Analysis of variance of the weed infestation data indicated significant ($P < 0.01$) grass species effect. There was no significant grazing frequency effect, Grass x grazing frequency interaction was not significant (Appendix B6).

Weed infestation occurred at a minimum on plots of DD (1.5%), significantly not different ($P > 0.05$) from DS (2.5%).

C. aethiopicus exhibited the highest (9.2%) increase in weed infestation following grazing, which differed significantly ($P < 0.05$) from all other species means. Means of CN (5.0%), CPS (4.9%) and PM (4.0%) were not significantly different ($P > 0.05$). The same is true for the means of DS (2.5%) and PM (4.0%, Appendix A6).

The highly significant species variation in weed infestation, concords with reports by other workers (Bryan, 1970; Velez-Santiago, 1979). This may be related to species variation in: growth, habit; tillering and residual LAI after grazing which is a function of regrowth potential.

Figure 7 shows the ranking of species in a decreasing order of persistency (measured as percentage increase in basal cover of weeds). The Digitaria

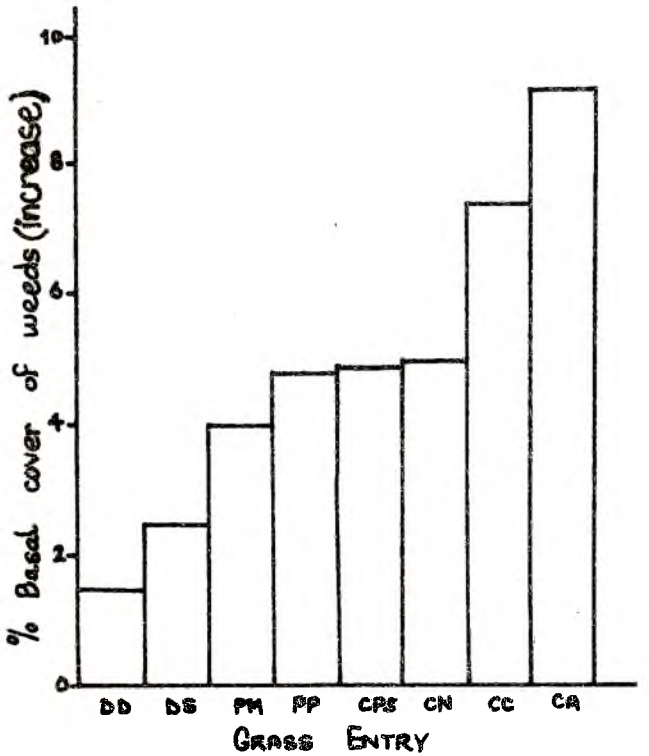

Fig: 7 + Percentage increase in basal cover of weeds on plots of eight tropical grasses under six grazing frequencies.

+ Species mean.

species were the most persistent and the Cynodon species the least. The dense-sods formed by the Digitaria species during the study period might have smothered the weeds, hence their high persistency. The data tend to suggest that CA is less adapted to grazing than the other species. This assertion is supported by field notes and observations (unpublished) during the study period.

The absence of significant grazing frequency effect is rather unexpected and contradicts with other reports (Vicente-Chandler et.al, 1964); Velez-Santiago et.al, 1979). It may be partly explained on the basis of the time limit of this experiment (6 months). However, weed infestation was higher (5.4%) at the 3-weekly (more frequent) than the 10-weekly (less frequent) grazing (4.6%). This observation agrees with that of Amadu (1971).

Percentage increase in basal cover of weeds was negatively correlated with grazing frequency in all species except CPS, DD and PP (r = 0.08, 0.92 and 0.59 respectively, Appendix A6). The reported negative correlation between weed infestation and grazing frequency for some of the studied species only confirms the basic principle in pasture and range management,

that frequent grazing results in weed infestation and subsequent deterioration of pastures. The positive relationship may be difficult to explain, but poor establishment, reduced aggressiveness with canopy accumulation and the on set of rains during the latter stages of the study may be contributing factors.

Principal weeds observed in order of importance in the experimental plots were Chloris pilosa, Chloris barbata and Cyperus rotundus.

6. Total Ash

Analysis of variance of the total ash data indicated highly significant ($P < 0.01$) differences between grass entries and grazing frequency. There was no grass x grazing frequency interaction (Appendix B7).

Mean total ash of PM (10.4%) was not significantly different ($P > 0.05$) from mean values recorded for DS (10.3%), CC (9.7%) and PP (9.3%), Table 9.
Mean total ash of CA (7.7%) was not significantly different ($P > 0.05$) from mean values for CPS (8.5%), DD (8.6%) and CN (8.7%).

TABLE 9: Mean total ash, calcium, phosphorus and calcium to phosphorus ratio of eight tropical grasses.

Grass Species	Percentage			
	Total Ash	Ca	P	Ca : P
C. aethiopicus	7.7c+	0.33cd	0.26cd	1.50:1++
C. Mlemfuensis	8.7bc	0.44b	0.25d	1.81:1
C. plectostachyus	8.5bc	0.33e	0.27bc	1.31:1
C. ciliaris	9.7ab	0.34e	0.28b	1.18:1
D. decumbens	8.6bc	0.44b	0.25d	1.78:1
D. swazilandensis	10.3a	0.35de	0.25d	1.52:1
P. maximum	10.4a	0.40c	0.30a	1.33:1
P. plicatulum	9.3ab	0.56a	0.19e	2.92:1

\+ Means in the same column followed by one or more common letter(s) do not differ significantly at the 5% level.

++ No statistical analysis conducted.

The observed species variation in mean total ash is in conformity with reports by (Devendra, 1977) and Nkrumah-Antiedu, (1981). This may be due to differential rates of mineral absorption with age and the physiological stage of herbage at which harvesting was done.

Soil contamination by the grazing animals, due to its low-growth habit may be a possible explanation for the relatively high total ash value recorded for DS.

P. plicatulum showed the least decline in ash content with advancing age. This confirms findings by Nkrumah-Antiedu (1981), and may be related to profuse tiller production and a fairly constant rate of mineral absorption with advancing age than the other species.

Total ash in CC, CPS, DD and PP tended to increase slightly from the 3- to 4-week grazing frequencies, before declining. This confirms findings by Nkrumah-Antiedu (1981). Further investigations are needed to find out whether this is due to a high mitotic activity of the meristematic cells and therefore high mineral requirements and consequent absorption.

Herbage harvested at the 3- and 4-week grazing frequencies gave the highest mean total ash (10.7 and 10.4% respectively). This differed significantly ($P < 0.05$) from the mean values recorded for all the other grazing frequencies except the 4-week (10.4%). The lowest mean total ash (8.3%) was recorded for the 8- and 10-week grazing frequencies (Table 10). Total ash was negatively correlated with age ($r = -0.97$) and Figure 8 confirms this observation. The highest rate of decline (0.92%) and the lowest (0.20%) per week increase in age were recorded for DS and PP respectively (Table 11).

The general decline in mean total ash with advancing maturity is in consonance with findings of other workers (Oyenuga, 1957; Butterworth, 1967; Omaliko & Obioha, 1981; Nkrumah-Antiedu, 1981). According to Fleming (1973), phosphorus, magnesium and potassium are major constituents of total ash. These elements decrease with age (Arroyo-Aguilu & Coward-Lord, 1974). Thus the decline in total ash with advancing maturity may be a consequence of the general decline in majority of the component elements. Dilution effects of high yields in the presence of relatively constant amount of available mineral in the soil, and a general decline in the efficiency of mineral absorption with advan-

TABLE 10: Mean total ash, calcium, phosphorus and calcium to phosphorus ratio at six grazing frequencies.

Grazing Frequency (wks)	Percent			
	Total Ash	Ca	P	Ca:P
3	10.7a	0.47a	0.30a	1.62:1++
4	10.3ab	0.39bcd	0.29b	1.40:1
5	9.4bc	0.40bc	0.28c	1.42:1
6	8.7c	0.42b	0.24d	1.70:1
8	8.3cd	0.38cd	0.23e	1.80:1
10	7.5d	0.38cd	0.21f	1.98:1

\+ Means in the same column followed by one or more common letter(s) do not differ significantly at the 5% level.

++ No statistical analysis conducted.

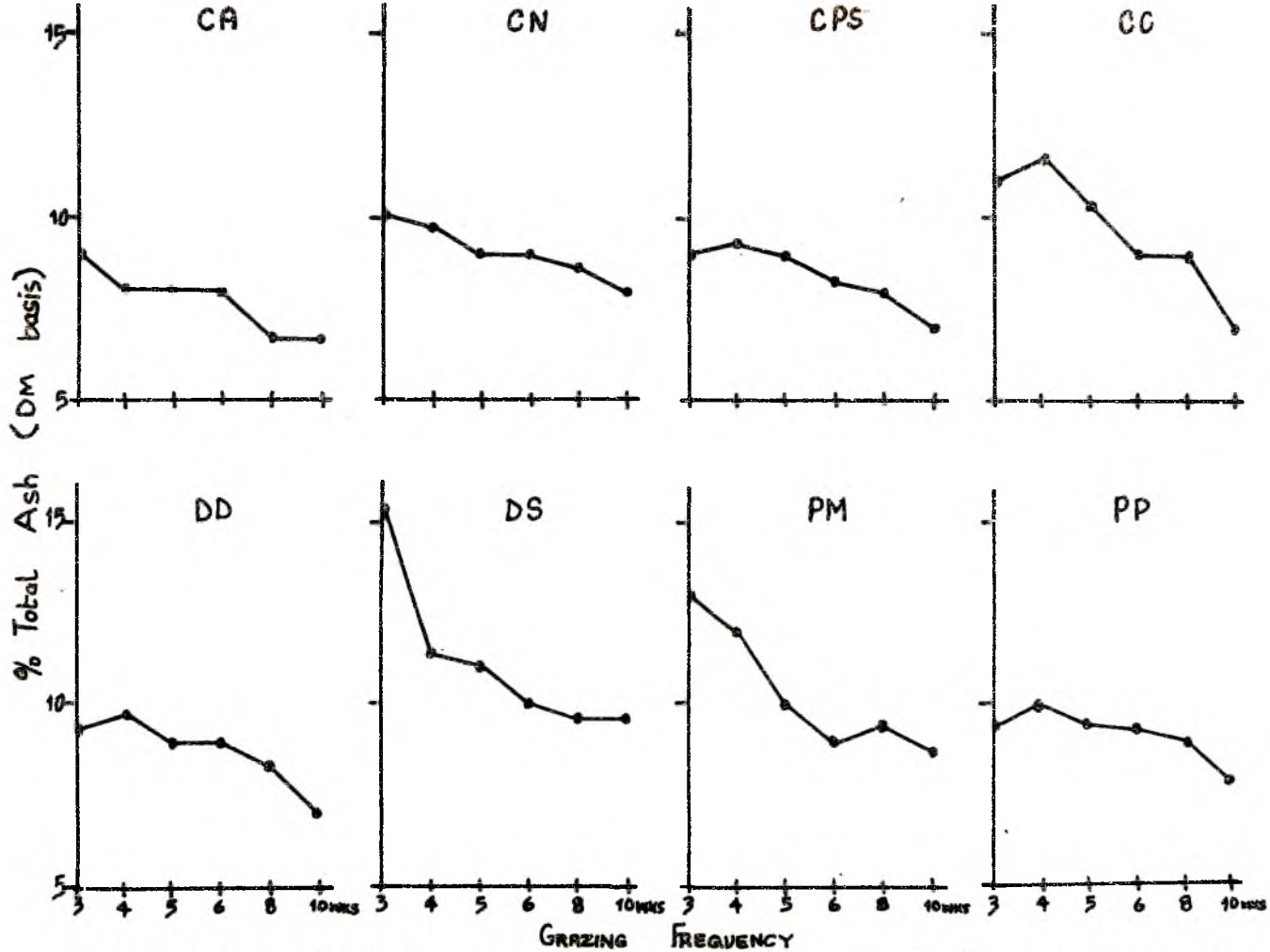

Fig: 8 Effect of grazing frequency on percentage total ash for each grass entry.

TABLE 11: Regression equations of form Y = a + bX for estimating percentage total ash (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Regression Coefficient b	SE+	Correlation Coefficient r
C. aethiopicus	9.48	-0.30	0.32	-0.99
C. nlemfuensis	10.77	-0.35	0.39	-0.95
C. plectostachyus	10.51	-0.33	0.36	-0.97
C. ciliaris	13.36	-0.62	0.70	-o.94
D. decumbens	10.70	-0.35	0.41	-0.91
D. swazilandensis	15.86	-0.92	1.20	-0.83
P. maximum	13.73	-0.55	0.70	-0.85
P. plicatulum	10.57	-0.20	0.24	-0.89
All entries	11.96	-0.46	0.50	-0.97

+ SE: Standard error.

cing maturity of herbage may be contributing factors.

In conclusion, the nutritional significance of total ash per se of herbage is limited, because total ash contains high levels of silica and therefore may be a misleading criterion of Ca, P, Mg and K. The modern trend therefore is the separation of total ash into soluble ash (which contains most of the nutritionally important elements) and insoluble ash, which contains mostly silica.

7. Calcium (Ca)

Percentage Ca content differed significantly ($P < 0.01$) between grass species and grazing frequency. There was significant ($P < 0.01$) grass x grazing frequency interaction (Appendix B8).

The highest Ca content (0.67%) was obtained for PP at the 3-week grazing frequency and the lowest (0.26%) for CC at the 10-week grazing frequency (Appendix A8).

The highly significant differences in mean Ca content between species (Table 9) agrees with reports in the literature (Gomide et al, 1969; Arroyo-Aguilu & Coward-Lord, 1974; Nkrumah-Antiedu, 1981). This may be attributed to differences in leaf to stem ratio of the species with advancing maturity.

Percentage Ca in all species followed an erratic trend with age (Figure 9 and Table 10), which is in accord with the literature (Arroyo-Aguilu & Coward-Lord, 1974; Perdomo et.al, 1977; Nkrumah-Antiedu, 1981). Raymond (1969) reported high Ca concentrations in leaves than stems and flower-heads. Thus differences in leaf to stem ratio and on set of flowering with advancing maturity may partly explain the erratic trends. Variations in climatic conditions, especially rainfall may also be responsible. According to Russel (1973), Ca is a constituent of the middle lamellae of plant cell-wall as calcium pectate. Variations in the amounts of calcium pectate levels of the sward due to the tiller dynamics may also be a contributing factor to the erratic Ca trends.

Mean percentage Ca ranges for grass species (0.33 to 0.56%) and grazing frequency (0.38 to 0.47%) Tables 9 and 10 are fairly close to ranges (0.33 to 0.43%; 0.34 to 0.7% and 0.36 to 0.84%) reported by Grieve and Osbourn (1965), Gomide et.al (1969) and Nkrumah-Antiedu (1981), respectively. Variations in soil composition, sward management, variety and age of species used and climatic conditions may account for minor discrepancies.

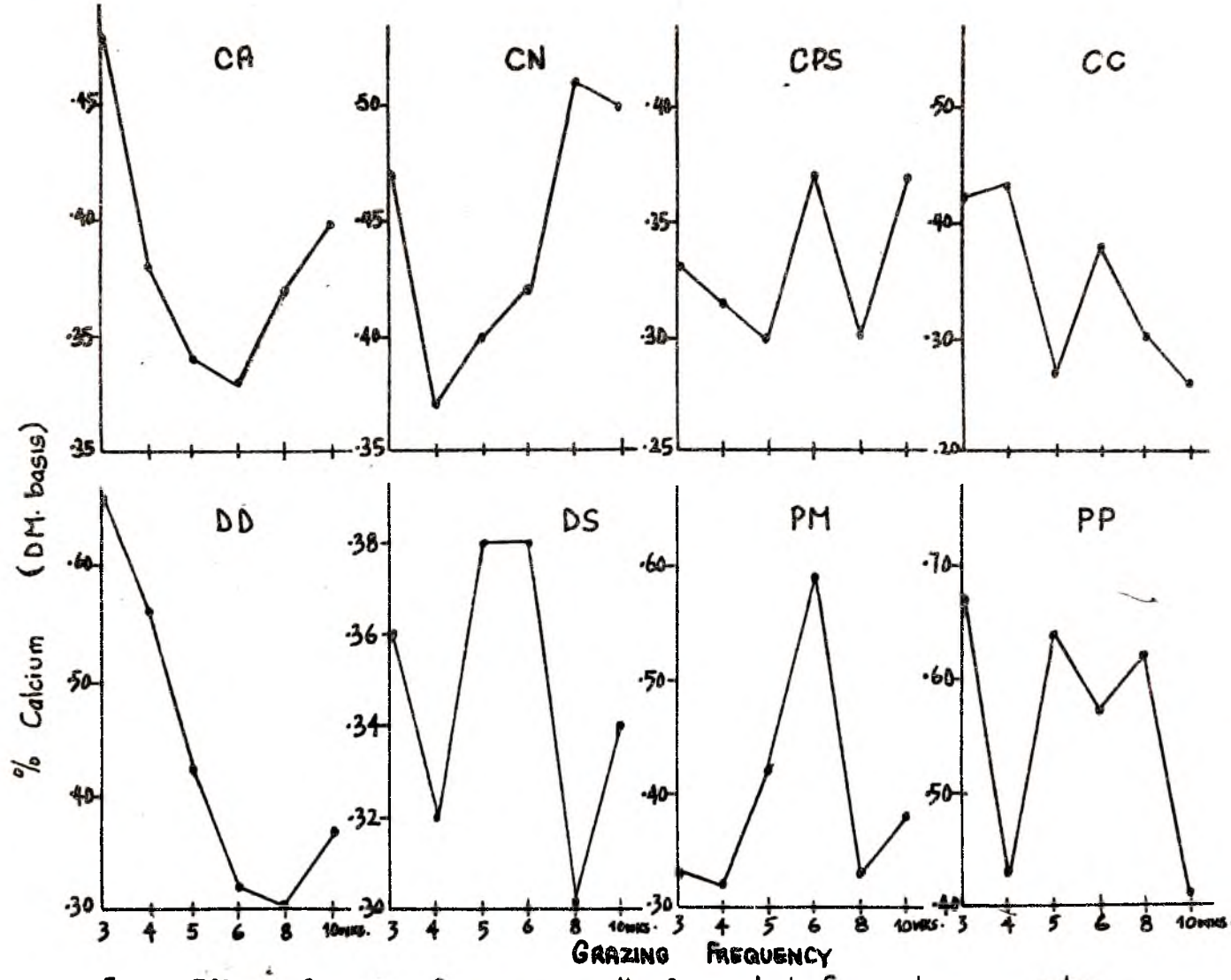

Fig:9 Effect of grazing frequency on the Ca content for each grass entry.

Dietary Ca requirement vary from (0.16 to 0.60%) for beef and from (0.14 to 0.50%) for dairy cattle (N.R.C. 1966, 1970), depending on growth and/or production level of the animal. Growing and nursing ewes require 0.24 to 0.30% (Crampton & Harris, 1968). Percentage Ca ranges reported for grass species and grazing frequency in this study fall within these recommended ranges. The data seem to suggest that between 3 to 10 weeks of age, all the grasses can satisfy the Ca requirements of sheep and cattle.

C. nlemfuensis had the highest rate of increase in Ca content with age (0.04% per week increase in age) and PM had the least (0.004% per week). DD registered the highest rate of decline (0.042% per week increase in age) and the least (0.004% per week) was recorded for DS (Table 12).

8. Phosphorus (P)

Highly significant differences ($P < 0.01$) were established in P content between grass entries and grazing frequency. Significant interaction was also found for grass x grazing frequency (Appendix B9).

The highest P (0.37%) was recorded for PM at the 3-week grazing frequency and the lowest (0.16%) for

TABLE 12: Regression equations of form Y = a + bX for estimating percentage calcium (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coefficient of correlation r
C. aethiopicus	0.42	-0.006	0.02	-0.28
C. nlemfuensis	0.36	0.04	0.02	0.63
C. plectostachyus	0.31	0.004	0.01	0.36
C. ciliaris	0.48	-0.022	0.03	-0.76
D. decumbens	0.69	-0.042	0.06	-0.77
D. swazilandensis	0.37	-0.004	0.01	-0.33
P. maximum	0.37	0.004	0.04	0.10
P. plicatulum	0.66	-0.019	0.05	-0.44

+ SE: Standard error.

DD at the 10-week grazing frequency (Appendix A9).

Significant ($P < 0.05$) species differences in percentage P presented in Table 9 agrees with reports by Gomide et.al, (1969), Arroyo-Aguilu and Coward-Lord (1974). It differs however from findings by Nkrumah-Antiedu (1981), who found no significant differences in mean P content between eight grass species with advancing maturity. Differential rates of fall in leaf to stem ratio as well as the mitotic activity of meristematic cells with advancing maturity may account for the observed species variation.

PM, CC and PP flowered and set seed profusely throughout the experimental period. Flowering in all cases started from the age of 3 weeks. Shedding of seeds was of common occurence, especially in CC at the 8-week and 10-week grazing frequencies. According to Buck and Grieve (1974) grains and seeds are higher in P than stems. Thus the presence of seeds, may partly explain the high means P values recorded for the early flowering (PM and CC) than late-flowering (DS) species. In PM and CC the decline in mean P with age may be partly due to shedding of ripe seeds with advancing maturity.

Although PP flowered and produced seeds profusely at all grazing frequencies, it registered the lowest

mean P value. This is an indication that the presence of seeds cannot fully explain the differences in P levels between grass species.

Generally, percentage P declined with increasing grazing interval in all species (Figure 10 and Table 10). This observation is in harmony with the litera- (Gomide et al, 1969; Arroyo-Aguilu & Coward-Lord, 1974).

Leaves are said to be higher in P than stems (Velez-Santiago et al, 1979). As forages mature, the leaf to stem ratio decreases. Thus the decline in percentage P with age may be partly due to a general decrease in leaf to stem ratio.

According to Russel (1973) actively dividing cells are higher in P than older and less active cells. Cells of herbage at the 3-weekly grazing might have been younger and therefore more active than cells of herbage at the 10-week grazing frequency. Consequently, cells of the younger herbage (3-weekly grazing) might have contained higher levels of P than the older herbage (10-weekly grazing). This may partly explain the general decline in P content with increasing grazing interval.

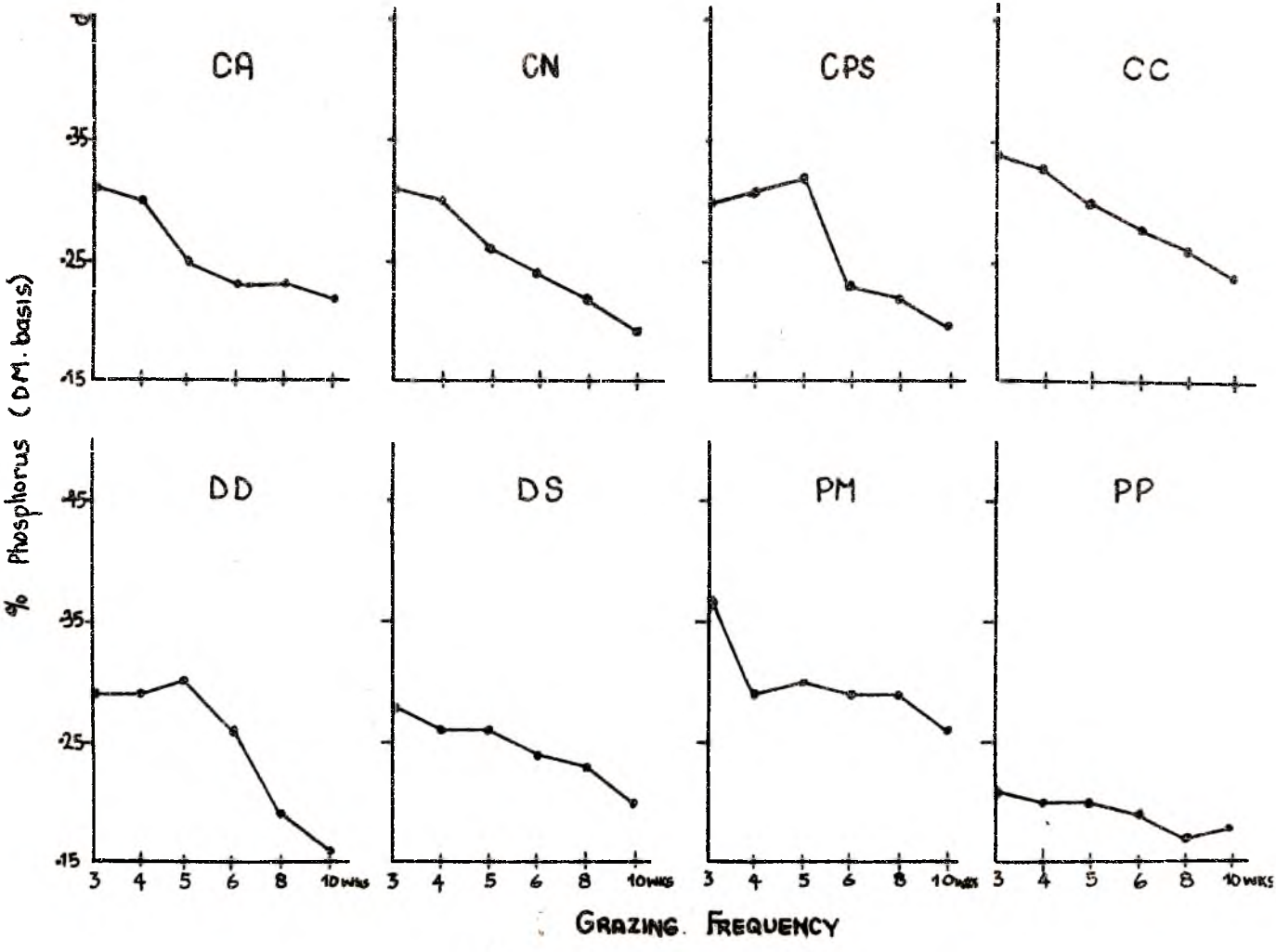

FIG: 10 Effect of grazing frequency on the P content for each grass entry.

Furthermore, dilution effects of high yields with relatively constant amount of P in the soil and a decrease in the efficiency of mineral absorption with age may partly explain the decreasing P trend.

Rise and fall in P content with age exhibited by CPS and DD agrees with reports by Nkrumah-Antiedu (1981).

Mean percentage P ranges for species (0.19 to 0.30%) and grazing frequency (0.21 to 0.30%) reported in this study (Tables 9 and 10) differ from ranges (0.12 to 0.24%) and (0.25 to 0.37%) recorded by Arroyo-Aguilu and Coward-Lord (1974) and Nkrumah-Antiedu (1981), respectively, and (0.14 to 0.18%) reported by Gomide et.al (1969), probably due to variations in soil and sward management and variety and age of species used.

Dietary P requirements range from (0.16 to 0.43%) for beef cattle, (0.14 to 0.38%), for diary cattle (N.R.C. 1966, 1977) and (0.19 to 0.22%) for lambs and nursing ewes (Crampton & Harris, 1968). From the foregoing, it is safe to conclude that all the grass species in the present study, except PP appear to contain sufficient amounts of P between 3 to 10 weeks of age to meet the demands of sheep and cattle.

The highest (o.021%) and the lowest (0.005%) decline in percentage P per week increase in age were exhibited by DD and PP respectively (Table 13).

9. Calcium to Phosphorus Ratio

P. plicatulum had the highest (2.92:1) Ca to P ratio. This is related to the low mean P content exhibited by this specie (Table 9). CPS had the lowest (1.31:1) Ca to P ratio.

The Ca to P ratio for grazing frequencies ranged from 1.40:1 to 1.98:1 (Table 10). A somewhat "fall and rise" trend would better describe the changes in the Ca to P ratio with age. This contradicts with reports by Arroyo-Aguilu and Coward -Lord (1974) who reported a decreasing trend with advancing maturity. The erratic trends may be the consequence of the highly erratic changes in percentage Ca with advancing maturity (Tables 9 & 10).

The ranges of Ca to P ratio reported in this study (Tables 9 & 10) fall within the recommended ranges for cattle (N.R.C. 1966; Hilman et al, 1977).

TABLE 13: Regression equations of form Y = l + bX for estimating percentage phosphorus (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Regression coefficient b	SE+	Correlation coefficient r
C. aethiopicus	0.33	-0.013	0.02	-0.87
C. nlemfuensis	0.36	-o.017	0.02	-0.98
C. plectostachyus	0.38	-0.019	0.03	-0.90
C. ciliaris	0.38	-0.16	0.02	-0.84
D. decumbens	0.38	-0.021	0.03	-0.95
D. swazilandensis	0.31	-0.011	0.01	-0.98
P. maximum	0.37	-0.011	0.02	-0.77
P. plicatulum	0.22	-0.005	0.01	-0.89

+ Standard error.

10. Crude Fiber (CF)

Grass species and grazing frequencies differed significantly ($P < 0.01$) in leaf, stem and whole-plant CF content (Appendices B10, B11 & B12). There were significant grass x grazing frequency interactions for stem CF ($P < 0.01$) and whole-plant CF ($P < 0.05$). There was no grass x grazing frequency interaction for leaf CF (Appendices B10, B11 & B12).

C. ciliaris had the highest mean leaf CF content (32.6%) which differed significantly ($P < 0.05$) from the lowest (27.9%), recorded for DS. The highest mean stem CF (41.5%) recorded for CC and PM differed significantly ($P < 0.05$) from the lowest (32.4%) recorded for DS. Stem CF did not vary between the Cynodon species and DD. CC exhibited the highest whole-plant CF (37.4%), which differed significantly from the lowest (29.0%) recorded for DS (Table 14).

Observed species variation in whole-plant CF may be attributed to differences in: leaf to stem ratio; retention of senescent leaves; tillering; growth habit; rate of increase in leaf and stem CF with advancing maturity; the presence or absence of inflorescence at the time of harvest and differences in size of culms.

TABLE 14: Mean crude fiber of leaf, stem and whole-plant of eight tropical grasses.

Grass Species	Percentage CF		
	Leaf	Stem	Whole-Plant
C. aethiopicus	28.7+c	36.6b	32.7b
C. nlemfuensis	28.0c	36.2b	33.1b
C. plectostachyus	29.0c	36.2b	33.4b
C. ciliaris	32.6a	41.5a	37.4a
D. decumbens	30.6b	36.2b	32.3bc
D. swazilandensis	27.9c	32.4d	29.0d
P. maximum	30.8b	41.5a	33.2b
P. plicatulum	28.9c	34.5c	31.2c

+ Means in the same column followed by one or more common letter(s) do not differ significantly at the 5% level.

The high mean percentage stem CF of PM and CC (41.5% for both) compared with DS (32.4%) needs special mentioning (Table 14). According to Pigden and Heinrichs (1957) plants with large stems contain higher lignin than those with smaller stems. Culms of PM and CC are bigger and more erect than DS. Thus the differences in stem CF between these species may be associated with the differences in stem size and morphology. PM and CC being erect, require more cell-wall constituents in their stem to maintain the upright growth habit compared to the low-growing and stoloniferous species e.g. DS.

Similarly, the relatively high mean leaf CF content of CC (32.6%), PM (30.8%) and DD (30.6%) compared with DS (27.9%) may be attributed to the larger leaf-blades and prominent midribs and veins, an apparent indication of higher cell-wall constituents (Table 14).

Figure 11 and Table 14 show that leaf and whole-plant CF of DS did not show wide variation. The high proportion of senescent leaves and very tiny culms and leaves which made complete separation of whole-plant into leaf and stem difficult may account for this.

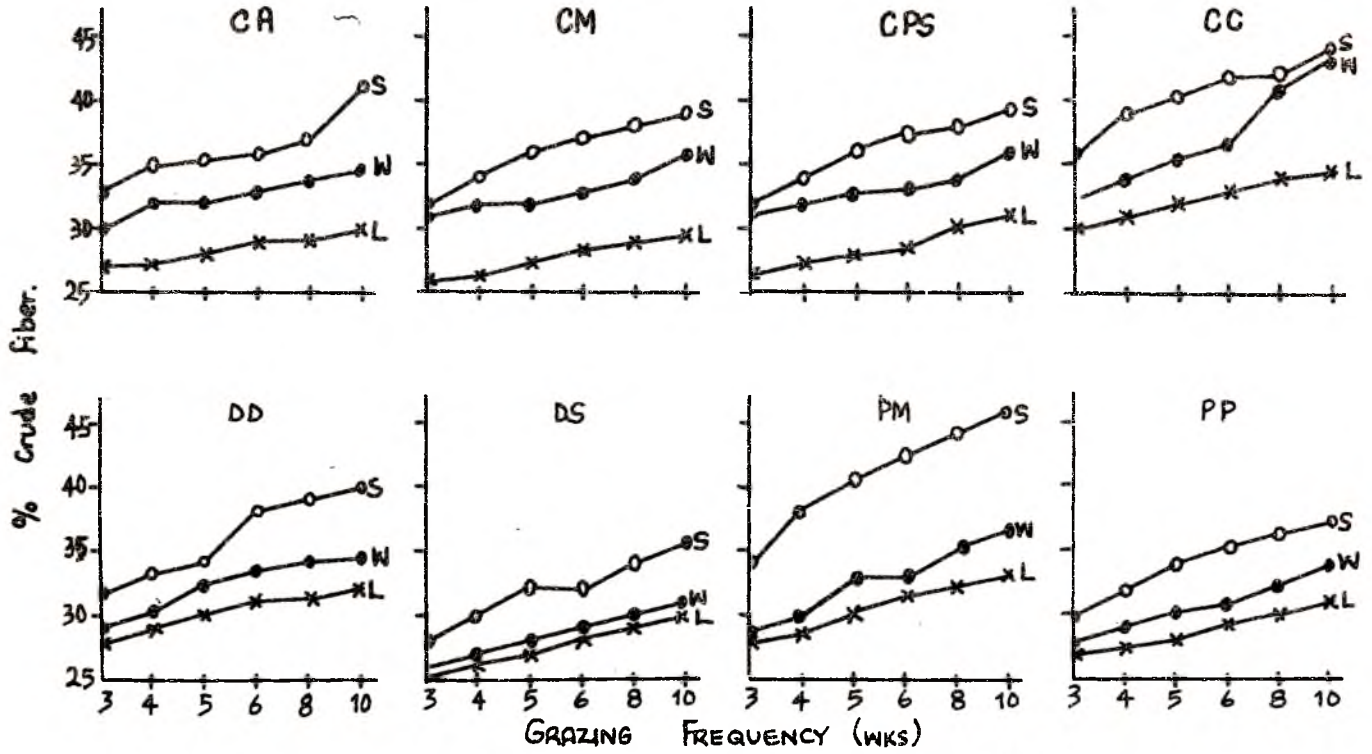

FIG: 11 Effect of grazing frequency on crude fiber of leaf (L), stem (S) and whole plant (W) of each grass entry.

There was a general progressive increase (r = 0.89 to 0.97; 0.90 to 0.97 and 0.87 to 0.98) in leaf, stem and whole-plant CF, respectively with advancing maturity (Figure 11 and Table 15). Mean leaf CF did not differ significantly ($P > 0.05$) between the (6- & 8-week) and (8- & 10-week) grazing frequencies respectively. However the stem and whole-plant CF differed significantly ($P < 0.05$) among all grazing frequencies, with the 3-week always having the lowest and the 10-week grazing frequency the highest (Table 15), except in the case of the leaf at 8- to 10-weeks.

The general increase in leaf, stem and whole-plant CF with advancing maturity is in accord with the literature (Pigden & Heinrichs, 1957; Terry & Tilley, 1964, Silva & Silva, 1977; Arroyo-Aguilu & Oporta-Tellez, 1980; Nkrumah-Antiedu, 1981). The whole-plant CF values obtained in the present study are fairly close to those reported by Nkrumah-Antiedu, (1981).

The linear relationship between whole-plant CF and advancing maturity may be due to a multiplicity of factors including increasing CF content of component leaf and stem and decreasing leaf to stem ratio. Increasing percentage of dead leaves in the award with advancing maturity due to mutual shading of lower

TABLE 15: Mean crude fiber of leaf, stem and whole-plant at six grazing frequencies.

Grazing Frequency (wks)	Percentage CF		
	Leaf	Stem	Whole-plant
3	27.2+e	32.3f	29.7f
4	28.2d	34.7e	31.1e
5	29.2c	36.5d	32,4d
6	30.3b	37.9c	33.1c
8	30.9ab	38.9b	34.6b
10	31.5a	41.5a	36.0a

+ Means in the same column followed by one or more letter(s) do not differ significantly at the 5% level.

leaves by higher ones, may partly account for such increasing CF trends, since dead leaves are higher in cell-wall constituents than green leaves (Baker et.al, 1952). Flower-heads are also higher in cell-wall constituents than leaf-blades (Sosulski et.al, 1960). Thus the onset of flowering in some species, particularly PM, CC and PP with advancing maturity may partly explain the increasing trend of CF with age. Increasing height of herbage with advancing maturity, which is positively correlated to the stem fraction (Chin-Tain & Smith, 1972) may partly explain the increasing CF trends, particularly for the erect growing species. The general increase in leaf and stem CF with age may be associated with increasing cell-wall constituents.

Mean CF of leaf in all species at the same stage of maturity was lower than the whole-plant CF, which was in turn lower than the CF of stem (Figure 11 and Table 15). The rate of increase in CF with age was faster in the stem than the whole-plant and leaf respectively (Tables 16, 17 & 18). This is in consonance with the literature (Sosulski et.al, 1960; Bailey, 1973). This may be accounted for by the fact that, functionally, the stem is for support and therefore contains higher amounts of structural

TABLE 16: Regression equations of form Y = a + bX for estimating percentage crude fiber of leaf (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coefficient of correlation r
C. aethiopicus	26.34	0.39	0.46	0.89
C. nlemfuensis	24.56	0.56	0.63	0.95
C. plectostachyus	25.12	0.65	0.71	0.96
C. ciliaris	28.52	0.68	0.76	0.95
D. decumbens	26.96	0.61	0.71	0.91
D. swazilandensis	24.00	0.65	0.71	0.97
P. maximum	26.35	0.74	0.71	0.94
P. plicatulum	25.4	0.58	0.63	0.97

+ SE : Standard error

TABLE 17: Regression equations of form Y = a + bX for estimating percentage crude fiber of stem (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coefficient of correlation r
C. aethiopicus	30.65	1.00	1.18	0.95
C. nlemfuensis	30.45	0.96	1.10	0.92
C. plectostachyus	30.92	0.93	1.06	0.96
C. ciliaris	31.98	1.59	1.75	0.90
D. decumbens	28.56	1.28	1.46	0.93
D. swazilandensis	26.7	0.95	1.07	0.94
P. maximum	30.12	1.90	1.17	0.92
P. plicatulum	28.45	1.01	1.17	0.92

+ SE : Standard error.

TABLE 18: Regression equations of form Y = a + bX for estimating crude fiber of whole-plant (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coefficient of correlation r
C. aethiopicus	29.08	0.62	0.68	0.95
C. nlemfuensis	28.83	0.71	0.77	0.98
C. plectostachyus	29.31	0.68	0.74	0.97
C. ciliaris	28.2	1.53	1.64	0.98
D. decumbens	27.13	0.86	1.03	0.87
D. swazilandensis	27.87	0.69	0.73	0.98
P. maximum	26.82	1.08	1.23	0.90
P. plicatulum	26.62	0.78	0.84	0.98

+ SE : Standard error.

carbohydrates and lignin than the leaf, which is mainly for photosynthesis. The high mean CF content of the whole-plant than the leaf may be due to "concentration effects" form the stem CF. The faster rate of increase in CF in the stem than the leaf, may be associated with high rates of lignification in the stem than the leaf.

P. maximum had the highest rate of increase in leaf (0.74% per week increase in age) and stem (1.90%) CF contents with advancing maturity. CA and CPS registered the lowest leaf (0.39% per week increase in age) and stem (0.93%) CF contents with advancing maturity respectively (Tables 16 & 17). CC had the highest rate of increase (1.53% per week increase in age) in whole-plant CF with advancing maturity while CA had the lowest (0.68%, Table 18).

11. Crude Protein (CP)

Mean leaf, stem and whole-plant CP levels for the grass species and grazing frequencies are presented in Tables 19 and 20. Percentage CP of leaf, stem and whole-plant varied ($P < 0.01$) between grass species and grazing frequencies. There were no

TABLE 19: Mean crude protein of leaf, stem and whole-plant of eight tropical grasses.

Grass Species	Percentage CP		
	Leaf	Stem	Whole-plant
C. aethiopicus	16.3a+	7.1ab	8.4b
C. nlemfuensis	13.4b	7.3ab	9.6a
C. plectostachyus	13.5b	7.0ab	10.2a
C. ciliaris	13.7b	6.8b	10.6a
D. decumbens	13.6b	7.9a	10.1a
D. swazilandensis	12.0c	7.4ab	7.8b
P. maximum	13.6b	6.8b	10.9a
P. plicatulum	11.3c	6.6b	8.5b

+ Means in the same column followed by one or more common letter(s) do not differ significantly at the 5% level.

TABLE 20: Mean crude protein of leaf, stem and whole-plant at six grazing frequencies.

Grazing Frequency (wks)	Percentage CP		
	Leaf	Stem	Whole-plant
3	15.0a+	10.4a	11.7a
4	14.7ab	8.3b	11.1a
5	14.0b	7.4c	9.8b
6	13.0c	6.5d	8.9c
8	12.3d	5.9d	8.0d
10	11.5d	4.2e	7.5d

+ Means in the same column followed by one or more common letter(s) do not differ significantly at the 5% level.

significant grass x grazing frequency interactions in CP levels (Appendices B13, B14 & B15), probably due to the overriding effect of uniform nitrogen application to all plots.

C. aethiopicus registered the highest mean leaf CP content (16.3%) which differed significantly ($P < 0.05$) from the lowest (11.3%), registered for PP. DD had the highest mean stem CP content (7.9%), which was significantly different ($P < 0.05$) from the means of CD (6.8%), PM (6.8%) and PP (6.6%). PM exhibited the highest mean whole-plant CP content (10.9%) which was significantly different ($P < 0.05$) from the mean values of PP (8.5%), CA(8.4%) and DS (7.8%), Table 19.

The observed species variation in the whole-plant CP may be attributed to species differences in: leaf to stem ratio; rates of decline in leaf and stem CP; the presence or absence of inflorenscence at the time samples were harvested for analyses; the retention of senescent leaves and tiller dynamics with advancing maturity. Excess nitrogen are chanelled from the shoot system to storage organs with advancing maturity in perennial grasses (Henzell, 1971). Species may vary in the performace of this process, hence the species variation in the whole-plant CP.

The comparatively low mean CP exhibited by the whole-plant (7.8%) and leaf (12.0%) of DS may be associated with the high proportion of senescent leaves and partly due to the very low height at which samples were cut for analyses. It is probable that the inclusion of lower stem region might have contributed to this.

Stem and whole-plant CP did not show wide variation in DS (Figure 12 and Table 19). This may be associated with the very tiny culms and leaves of DS which made separation into leaf and stem fractions very difficult. It is probable that parts of the leaf-blade might have been left on the culms.

The low mean stem CP of the tuft-forming erect species, namely CC (6.8%), PM (6.8%) and PP (6.6%) compared with the stoloniferous species is noteworthy. Being erect, the stems of these species require high levels of cell-wall constituents to maintain their upright growth, than the stoloniferous species. Cell-wall constituents are however low in nitrogen, hence the low mean stem CP values for the species with erect growth habit.

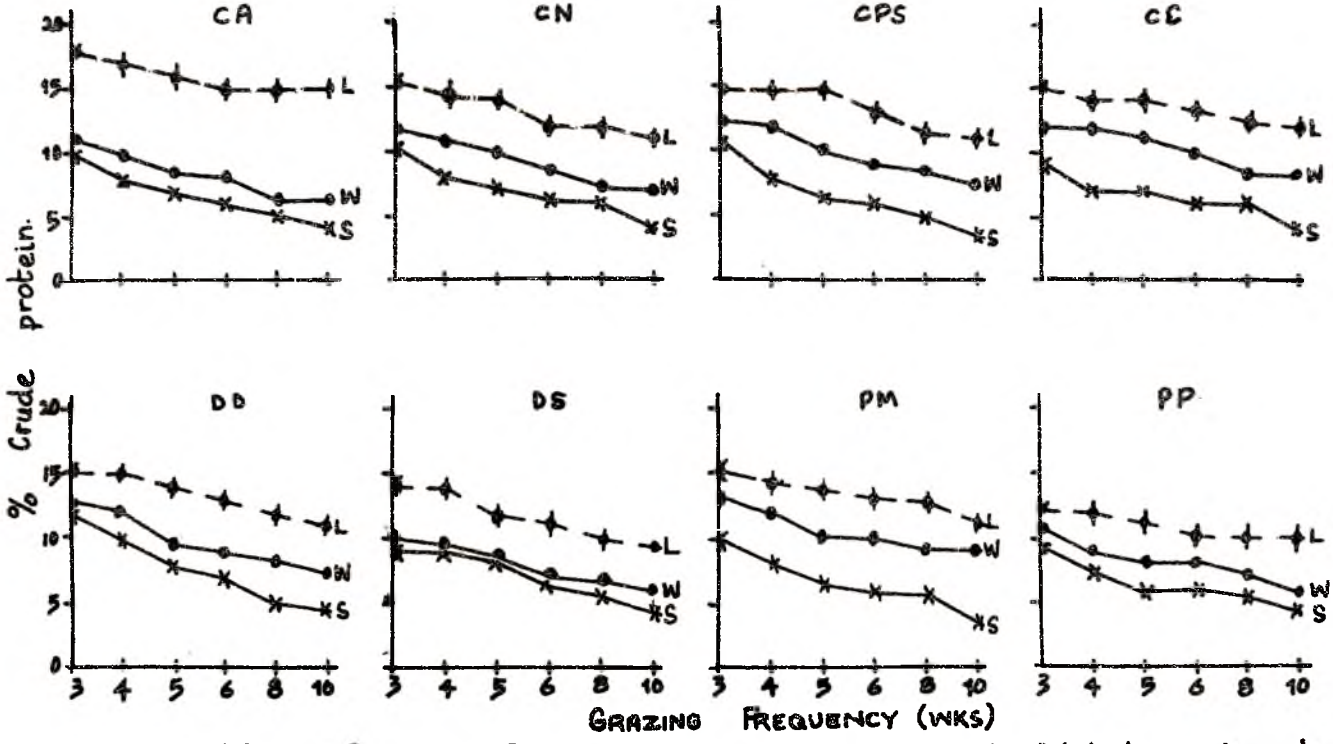

FIG: 12 Effect of grazing frequency on crude protein of leaf (L) stem (S) and whole plant (W) of each grass entry

In the separation of the whole-plant into stem and leaf, some leaf-sheaths might have been left on the culms. Since leaf-sheaths are higher in CP than culms (Terry & Tilley, 1964), it is possible that the actual species stem CP levels may be lower than the values presented in this study.

Generally, the mean CP of leaf, stem and whole-plant declined (r = -0.98, -0.96 and -0.96 respectively) with increasing grazing interval (Fig. 12 & Table 20). The general decline in CP of leaf, stem and whole-plant with advancing maturity is in agreement with reports in the literature (Terry & Tilley, 1964; Mowat et.al, 1965; Fianu, 1977; Velez-Santiago et.al, 1979; Nkrumah-Antiedu, 1981; Omaliko & Obioha, 1981).

Mean leaf CP levels between the (3- & 4-week), (4- & 5-week) and (8 & 10-week grazing frequency) were not significantly different ($P > 0.05$). The same is true for mean stem CP between the (5- & 6-week) and mean whole-plant CP between the (3- & 4-week) and (8- & 10-week grazing frequency), Table 20.

The general decline in whole-plant CP may partly be due to decreasing leaf to stem ratio; decline in the CP content of the leaf and stem fractions and the dilution effects of higher yield with advancing

maturity. The on-set of flowering with maturity may also be a contributing factor in PM, CC and PP.

With advancing maturity, the proportion of dead leaves in the sward increases due to mutual shading of lower leaves by higher ones. Thus the increasing percentage of dead leaves which are lower in nitrogen compared with the green leaf (Baker et. al, 1952), may partly explain the general decline in whole-plant CP with age.

The general decline in leaf and stem CP with advancing maturity may be due to increasing cell-wall constituents at the expense of cell contents.

The mean CP of leaf in all species at the same stage of maturity was higher than the whole-plant and stem CP in that order (Fig. 12 & Table 20). This is in conformity with the literature (Terry & Tilley, 1964; Mowat et.al, 1965; Fianu, 1977). This may be attributed to high levels of cell contents in the leaf than the whole-plant and stemm respectively.

The rate of decline in CP was faster in the stem than the whole-plant and leaf respectively (Tables 21, 22 & 23). This observation agrees with reports by Terry & Tilley (1964) and Mowat et.al (1965). It differs however from the findings of

TABLE 21: Regression equations of the form Y = a + bX for estimating percentage crude protein of leaf (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Regression Coefficient b	SE+	Correlation Coefficient r
C. aethiopicus	19.16	-0.48	0.59	-0.87
C. nlemfuensis	16.40	-0.50	0.56	-0.96
C. plectostachyus	17.22	-0.62	0.71	-0.92
C. ciliaris	14.97	-0.43	0.48	-0.94
D. decumbens	17.87	-0.71	0.74	-0.98
D. swazilandensis	15.74	-0.62	0.68	-0.98
P. maximum	16.34	-0.46	0.51	-0.95
P. plicatulum	13.22	-0.32	0.39	-0.87
All entries	16.52	-0.52	0.57	-0.98

+ SE : standard error.

TABLE 22: Regression equations of form Y = a + bX for estimating percentage crude protein of stem (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Regression Coefficient b	SE+	Correlation Coefficient r
C. aethiopicus	11.69	-0.77	0.85	-0.97
C. nlemfuensis	11.82	-0.75	0.87	-0.94
C. plectostachyus	12.33	-0.89	1.01	-0.93
C. ciliaris	10.62	-0.65	0.76	-0.88
D. decumbens	13.06	-0.99	1.10	-0.96
D. swazilandensis	11.83	-.74	0.80	-0.98
P. maximum	11.12	-0.84	0.99	-0.91
P. plicatulum	10.44	-0.64	0.75	-0.90
All entries	11.79	-0.78	0.87	-0.96

+ SE : Standard error.

TABLE 23: Regression equations of the form Y = a + bX for estimating percentage crude protein of whole-plant (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Regression Coefficient b	SE+	Correlation Coefficient r
C. aethiopicus	11.59	-0.53	0.61	-0.93
C. nlemfuensis	13.85	-0.71	0.62	-0.96
C. plectostachyus	14.4	-0.70	0.62	-0.84
C. ciliaris	14.5	-0.64	0.71	-0.96
D. decumbens	14.63	-0.78	0.90	-0.97
D. swazilandensis	10.76	-0.49	0.58	-0.90
P. maximum	14.13	-0.54	0.65	-0.88
P. plicatulum	11.78	-0.56	0.61	-0.98
All entries	13.22	-0.62	0.69	-0.96

Fianu (1977) who reported faster rates of decline in leaves than stems, and Vicente-Chandler et.al, (1959, a, b) who obtained similar rates of fall in leaves and stems. These variations may be partly attributed to the fact that, Fianu's study (1977) was conducted over two different seasons (Major and Minor rainy seasons), while the study of Vicente-Chandler et.al (1959, a, b) involved high levels of fertilizer nitrogen. Thus the season and fertilization in these reports might have affected the rates of decline.

The highest rates of decline in leaf (0.71% per week increase in age), stem (0.99%) and whole-plant (0.78%) CP with age were recorded for DD. The lowest decline im leaf (0.32%) and stem (0.64%) CP with age were recorded for PP, while CA had the lowest (0.53%) decline in whole-plant CP with increasing grazing interval (Tables 21, 22, 23).

The suggested dietary requirements of CP for finishing beef steers of 300 to 550kg liveweight is 11% (N.R.C., 1970). This requirements can be met by whole-plants of only PM, CPS, DD up to 4 weeks, and CC up to 5 weeks of maturity (Appendix A.16). However, the mean leaf CP of all species except DS (at 8 & 10-weeks) and PP (at 6, 8 & 10-weeks) is

higher than the recommended level at all the grazing frequencies (Appendix A.14). Since the diet of the grazing animal is mainly foliar (Arnold, 1964), it is probable that pure stands of all the grasses except DS (at 8- and 10-weeks) and PP (at 6-, 8- & 10-weeks) may supply the recommended CP levels under grazing conditions.

The data suggest that selection of herbage plants for leafiness and low stem fraction may increase the CP level.

12. In Vitro Dry Matter Digestibility (IVDMD)

Analysis of the IVDMD data for leaf, stem and whole-plant indicated significant ($P < 0.01$) differences between grass species and grazing frequencies. Significant ($P < 0.01$) grass x grazing frequency interactions were also established for all plant parts (Appendices B16, B17 & B18).

C. ciliaris had the highest mean leaf IVDMD (67.6%) which differed significantly ($P < 0.05$) from the lowest (56.4%) recorded for DS. PM had the highest mean stem IVDMD (60.6%) which was significantly different ($P < 0.05$) from the lowest (47.0%) recorded for CN. PM had the highest (62.4%) whole-plant IVDMD, which differed significantly ($P < 0.05$) from the lowest mean (47.6%) recorded for CN

(Table 24).

Species variation in IVDMD for leaf, stem and whole-plant concords with reports in the literature (Terry & Tilley, 1964; Mowat et.al, 1965; Fianu, 1977).

Observed species variations in whole-plant IVDMD may be due to variation in a host of agronomic characters, namely; leaf to stem ratio; retention of senescent leaves; growth habit; tillering; rates of decline or increase of leaf and stem CP and CF, respectively; the presence or absence of inflorensce at the time samples were harvested for analysis and height of harvesting. Rumen microbes preferentially digest soluble carbohydrates at the expense of cell-wall constituents. Thus species variation in soluble carbohydrates with advancing maturity may partly account for the varying species IVDMD.

IVDMD of stem of PM (60.6%) and PP (53.3%), among others were higher than the stem IVDMD of DS. It must be noted that the culms of PM and PP are bigger than DS. Thus the commonly held concept that bigger culms are less digestible than smaller culms was not evident in this study.

TABLE 24: Mean IVDMD of leaf, stem and whole-plant of eight tropical grasses.

Grass Species	Percentage IVDMD		
	Leaf	Stem	Whole-plant
C. aethiopicus	61.3c+	49.8e	51.5e
C. nlemfuensis	61.8c	47.0f	47.6f
C. plectostachyus	58.5d	49.7e	51.4e
C. ciliaris	67.6a	54.6c	60.8b
D. decumbens	61.5c	58.0b	59.7c
D. swazilandensis	56.4e	49.3e	55.6d
P. maximum	63.96	60.6a	62.4a
P. plicatulum	57.d	53.3d	53.5d

+ Means in the same column followed by one or more common letter(s) do not differ significantly at the 5% level.

This discrepancy may be difficult to explain. However, Pigden (1953) suggested that the distribution and extent of lignification may be more important than the quantity of lignin present in determining nutritive value of a plant. Furthermore, Van Soest (1964) suggested that lignin may exert a direct effect on the digestibility of cell-wall constituents which contain cellulose and hemicellulose. Perhaps the distribution of lignin, and the quantity and configuration of cellulose and hemicellulose, in the stem of DS, might have hindered digestion by the ruminal microbes, hence the low IVDMD compared with the stems of PM and PP. Furthermore, CP level of PM among others was higher than DS which could partly explain IVDMD as affected by CF levels.

The mean IVDMD of leaf, stem and whole-plant generally declined (r = -0.87 to -0.98; -0.85 to -0.98 and -0.93 to -0.98 respectively) with increasing grazing interval (Figure 13 and Table 25). This observation conforms with reports by other workers (Terry & Tilley, 1964; Mowat et.al, 1965; Fianu, 1977; Arroyo-Aguilu & Oporta-Tellez, 1980). The IVDMD values reported for CPS, CC and DD are fairly close to those reported by Fianu, (1977).

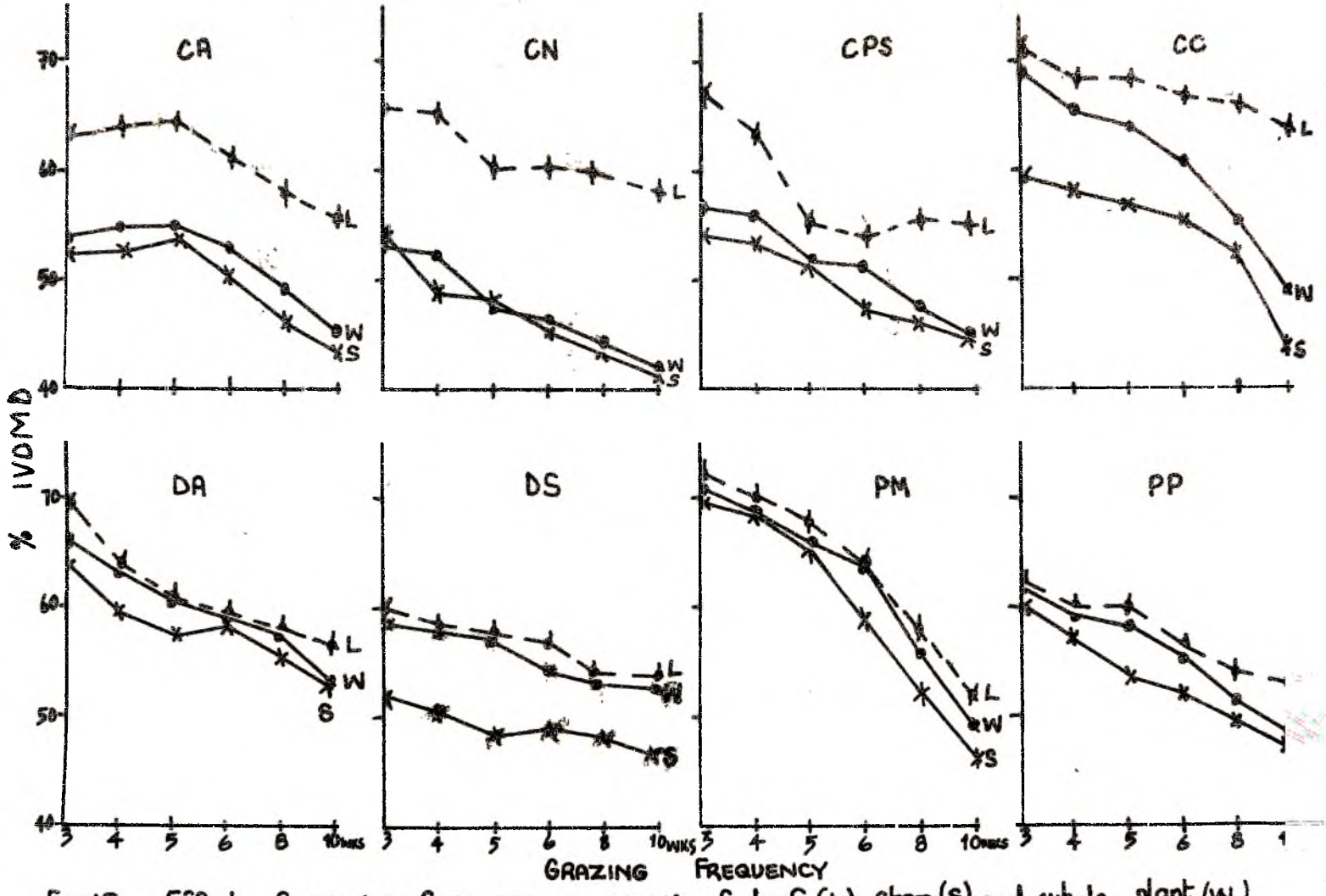

Fig:13 Effect of grazing frequency on IVDMD of leaf (L), stem (S) and whole plant (W) of each grass entry.

TABLE 25: Mean IVDMD of leaf, stem and whole-plant at six grazing frequencies.

Grazing Frequency (wks)	Percentage IVDMD		
	Leaf	Stem	Whole-plant
3	66.3a+	58.3a	61.4a
4	64.3b	56.2b	60.0b
5	61.7c	54.6c	57.5c
6	60.1d	52.3d	55.0d
8	58.2e	49.5e	51.8e
10	56.1f	45.9f	47.9f

+ Means in the same column followed by one or more common letter(s) do not differ significantly at the 5% level.

Mean leaf, stem and whole-plant IVDMD differed significantly ($P < 0.05$) among the grazing frequencies (Table 25). This is an indication of the early and progressive lignification of tropical grasses reported by French (1956).

The inverse relationship between IVDMD and advancing maturity of the whole-plant may be related to the general decline in the IVDMD of leaf and stem fractions and decreasing leaf to stem ratio. With advancing maturity the cell undergoes thickening and cell-wall increases at the expense of nitrogen-rich protoplasm. Thus the fall in IVDMD may partly be due to increasing levels of cell-wall constituents and subsequent lignification which hinders rumen microbial degradation of cellulose. Increasing levels of silica as suggested by Rangarao (1978) and the decline in CP of leaf, stem and whole-plant, and nitrogen free-extracts (Nkrumah-Antiedu, 1981) with age may partly be contributing factors.

According to Wilman et.al. (1976) dead leaves are less digestible than green leaves. With advancing maturity, the fraction of dead leaf in swards increases due to mutual shading. This may partly account for the inverse relationship between whole-

plant IVDMD and maturity.

Sward height is positively correlated to stem proportion there-in (Chin-Tain & Smith, 1972). In the present study, sward height increased with advancing maturity, implying an increase in less digestible stem proportion. Thus the decline in whole-plant IVDMD with age may partly be attributed to the increasing sward height.

The decline in leaf and stem IVDMD with age may be partly due to the increasing CF and decreasing CP content of leaf and stem factions respectively with age.

Mean IVDMD of leaf in all species at the same stage of maturity was higher than the whole-plant and stem IVDMD respectively (Figure 13, Tables 24 & 25). Findings by Terry and Tilley (1964), Mowat et.al (1965) and Fianu (1977) are similar. The relatively high CF and low CP of the stem fraction compared to the whole-plant and leaf fractions respectively may account for this observation (see Tables 14, 15, 19 and 20). High levels of cell-wall constituents in stem than whole-plant and leaf fractions respectively may also be related.

The rate of decline in IVDMD for all species except DS was slower in leaf than whole-plant and stem respectively (Tables 26, 27 & 28). The results of Terry and Tilley (1964), Mowat et.al (1965) and Fianu (1977) are similar. In DS, IVDMD declined at a faster rate, in the whole-plant than the leaf and stem respectively. The deviation exhibited by DS may be partly attributed to the high proportion of senescent leaves; the very tiny culms which were a hindrance to separation and a possible soil contamination of the whole-plant by the grazing animals due to its low growth habit.

P. maximum exhibited the highest rate of decline in leaf, stem and whole-plant IVDMD with increasing grazing interval (2.95, 3.66 & 3.29% respectively per week increase in age), while CC (0.83%) and DD (0.75 & 0.93%) had the lowest (Tables 26, 27 & 28).

The IVDMD data, and the foregoing discussion suggest that it will be possible to raise the contents of digestible dry matter in herbage plants by selection either for leafiness or for higher digestibility of the stem fraction. It must however, be realized that IVDMD values are only estimates, and the final critical evaluation with animals is still considered essential.

TABLE 26: Regression equations of form Y = a + bX for estimating percentage in vitro dry matter digestibility of leaf (Y) from age in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coefficient of correlation r
C. aethiopicus	67.87	-1.22	2.45	-0.94
C. nlemfuensis	67.87	-1.02	1.23	-0.88
C. plectostachyus	67.89	-1.56	2.22	-0.74
C. ciliaris	72.58	-0.83	0.91	-0.97
D. decumbens	71. 33	-1.64	2.00	-0.87
D. swazilandensis	61.70	-0.84	0.92	-0.97
P. maximum	81.60	-2.95	3.16	-0.98
P. plicatulum	65.95	-1.36	1.50	-0.97

+ SE : Standard error.

TABLE 27: Regression equations of form Y = a + bX for estimating percentage in vitro dry matter digestibility of stem (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coefficient of correlation r
C. aethiopicus	58.62	-1.47	1.69	-0.92
C. nlemfuensis	57.60	-1.75	1.76	-0.94
C. plectostachyus	62.37	-1.80	1.64	-0.98
C. ciliaris	66.92	-2.05	2.27	-0.96
D. decumbens	71.41	-1.29	1.62	-0.85
D. swazilandensis	53.75	-0.75	0.86	-0.93
P. maximum	82.27	-3.66	3.80	-0.98
P. plicatulum	64.90	-1.99	1.92	-0.97

+ SE : Standard error.

TABLE 28: Regression equations of form Y = a + bX for estimating percentage *in vitro* dry matter digestibility of whole-plant (Y) from age (Xwks) in eight tropical grasses.

Grass Species	Intercept a	Coefficient of regression b	SE+	Coefficient of correlation r
C. aethiopicus	59.79	-1.36	1.55	-0.94
C. nlemfuensis	57.69	-1.68	1.87	-0.96
C. plectostachyus	58.54	-1.47	2.08	-0.94
C. ciliaris	77.26	-2.74	2.91	-0.98
D. decumbens	70.03	-1.69	1.90	-.98
D. swazilandensis	61.21	-0.93	1.06	-0.94
P. maximum	82.10	-3.29	3.52	-0.93
P. plicatulum	67.44	-1.91	2.16	-0.97

+ SE : Standard error.

13. Digestible Dry Matter Yield (DDMY)

Grass species and grazing frequency effects were highly significant ($P < 0.01$). There was significant ($P < 0.01$) grass x grazing frequency interaction (Appendix B19).

P. maximum exhibited the highest DDMY (2.48 t/ha) at the 10-week grazing frequency, while CA had the lowest DDMY (1.0 t/ha) at the 3-weekly grazing (Appendix A20 & Figure 14). The increase in DDMY with increasing grazing interval is a reflection of the increasing DMY and DMC with age.

Although DDMY in all species except CC (and probably CA) increased with age, CP and IVDMD decreased, indicating a deterioration in quality. Thus there must be a reasonable compromise between yield and quality. Figure 14 seems to reveal that for CA (5- to 6-weekly grazing) and CC (3- to 9-weekly grazing) may be suitable. The increase in DDMY for the rest of the species (CN, CPS, DD, DS, PM and PP) indicates that, their optimum grazing frequency has not been exceeded, suggesting that grazing intervals of more than 10-weeks may be suitable.

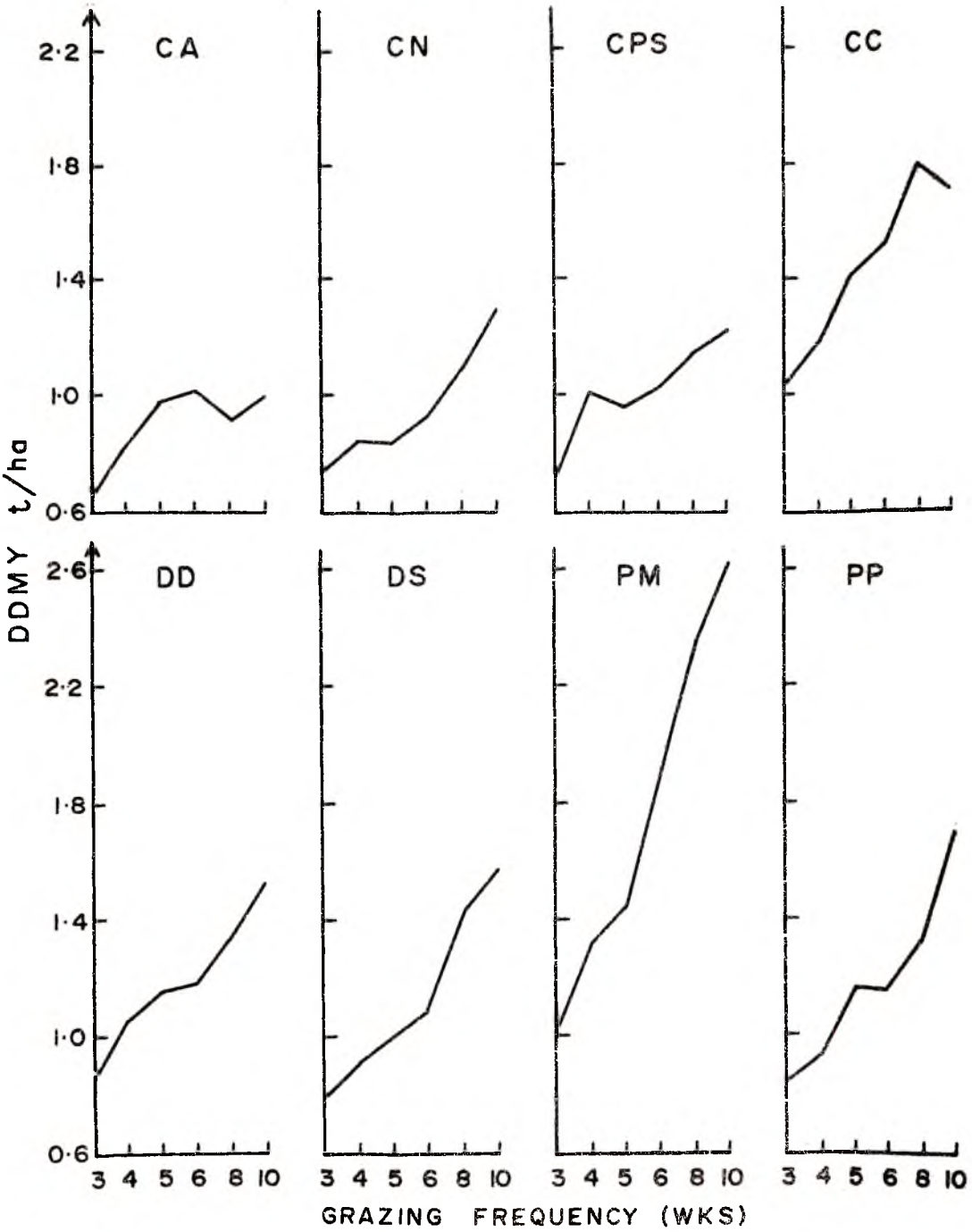

Fig.14 EFFECT OF GRAZING FREQUENCY ON DIGESTIBLE DRY MATTER YIELD OF EACH GRASS ENTRY

14. Relative Palatability

On introduction of cattle into paddocks, they moved all round the paddock and as put by Asare (1975) "tasted" the forage on each plot, before selectivity began. Field observation showed that cattle preferred PM, DD, DS and PP. These were grazed intensively at the early minutes of introduction of animals. DS suffered occasional uprooting by cattle. On the plots of CA, weeds mostly Cyperus and Chloris species provided much of the cattle's food, due to low persistency.

Ranking of grasses based on their mean percentage relative palatability (%RP) at the different grazing frequencies is presented in Figure 15. The mean %RP, correlation coefficient between grazing interval and %RP and Spearman's rank correlation (r_s) values are shown in Appendix A21.

Panicum maximum was the most palatable species at 3-, 4- and 6-weeks grazing frequency whilst DS (3- and 4-weeks) and CC (5-weeks) were the least palatable. DD was highly prefered at the (5-, 8- & 10-weeks grazing frequency), with CA (5- & 8-weeks) and DS (10-weeks) been the least prefered. The other grasses fall between these two extremes (Fig. 15).

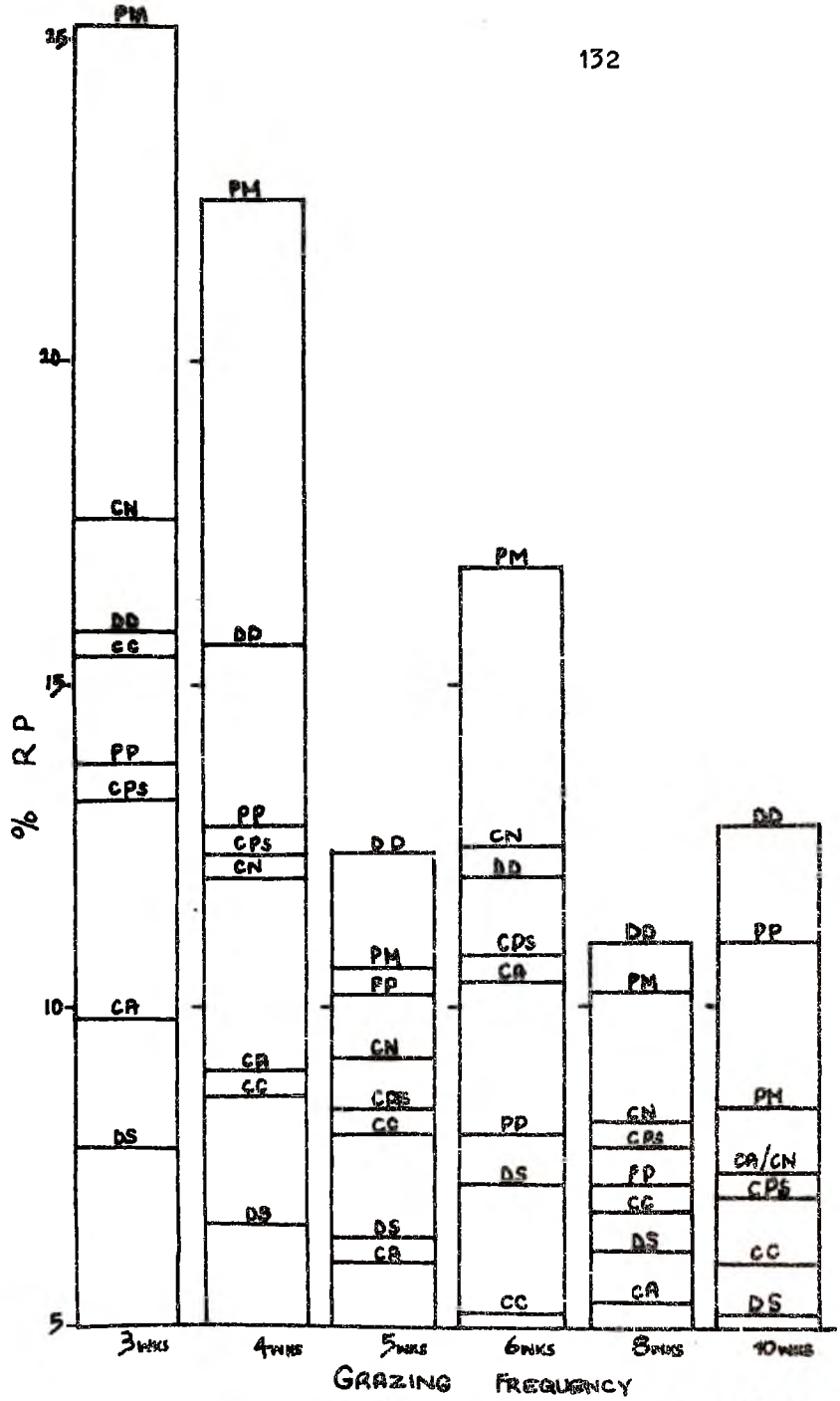

FIG: 15 Effect of grazing frequency on percentage relative palatability (% RP) of eight (8) forage grasses.

For all the grasses, %RP was negatively correlated (r = -0.87 to -0.45) to grazing frequency. The positive, but rather low rank correlation (r_s = 0.19 to 0.43) shows that ranking of replicates within a paddock showed little variation (Appendix A21).

Data presented in Figure 19 suggest that cattle prefered PM and DD, more than the other species. This observation confirms that of Tetteh (1974) who reported that PM and DD were heavily grazed by cattle whilst CC was moderately grazed. CC exhibited a marked drop in acceptability with maturity.

Tetteh (1974) postulated that cattle prefer tall grass species to shorter ones. This may partly explain the high %RP of the tall species especially PM in comparison to the very low growing DS at all grazing frequencies (Figure 15). PM was superior in green forage yield at all the grazing frequencies than the other grasses (Table 5). The relatively high %RP of PM may thus be associated with its availability as suggested by Simon (1974). The comparatively high CP and IVDMD (refer to Tables 19 & 24) of PM may also be contributing factors. Further-

more, the upright growth habit of PM might have reduced soil and excreta contamination and thus increased palatability.

At the 4-weeks grazing frequency, %RP of PM (22.5) was higher than that of CC (8.6). This differs from the findings of Asare (1975). This discrepancy might be due to the use of pure and mixed grass and legume plots in his study, variation in climatic conditions, soil fertility status and herd of cattle used.

The hairy leaves of CA might have contributed to its low %RP. (Figure 15).

Field notes indicate that DS was rapidly grazed close to the ground within some few minutes after introduction of animals into the paddocks. Thus if recordings had been confined to the initial minutes (30 to 60 mins.) of grazing, there is no doubt that DS would have been more outstanding than presented. However, the short growth habit of DS might have hindered prehension by the cows. It is also possible that the short growth habit of DS might have been a predisposing factor to intensive trampling, fouling and sand contamination (confirmed by the high total ash content). The comparatively low crude protein and IVDMD may also be contributing

factors (Tables 19 & 24). Aggregation of these factors might have been responsible for the low %RP recorded for DS in this study. On the other hand, the low palatability of DS confirms the conclusion of Gohl, (1973), who refered to DS as "not very palatable Species". According to Whyte et.al (1959) DS was used for sheep grazing. This may partly explain its low RP to cattle.

The general depression in %RP with decreasing frequency of grazing is difficult to explain. Young and actively growing herbage is said to be more palatable than herbage making little growth (Jones, 1952). Thus reduction in the rate of growth could be a contributing factor. Decline in leaf to stem ratio, digestibility, crude protein, total ash and phosphorus with corresponding increase in crude fiber components of the herbage with age could also contribute to such a trend.

Conclusions from such palatability studies may be interpreted with caution, because it is possible that:-

(a) animals might have spent considerable time carefully selecting a few succulent shoots from a plot of unpalatable species, and spend a comparatively short time intensively grazing on a plots of very palatable species,

(b) if a different herd or specie of animal had been used different results would have been obtained, since herds behave differently under grazing,

(c) the presence of "weed" which may be of variable palatability on plots of species under test can influence the time animals spend on a plot.

15. In Vivo Dry Matter Digestibility (in vivo DMD) and Dry Matter Intake (DMI)

Analysis of variance revealed significant differences between in vivo DMD at the different stages of maturity at ($P < 0.01$) for CPS and DS and ($P < 0.05$) for CN (Appendix B20).

Mean percentage in vivo DMD values ranged from (58.0 to 65.3%; 57.9 to 64.9% and 54.3 to 60.8%) for CPS, CN and DS respectively (Table 29). These ranges are similar to those reported by Milford (1960), Grieve and Osbourn (1965), Ademosun (1973) and Adu and Adamu (1982), with one or more of the grasses studied in this experiment.

in vivo DMD declined with advancing maturity ($r = -0.99$ to -0.98). The decrease for each week advance in age ranged from (2.3%) for CN to (3.25%) for DS (Table 30). This observation contradicts with the reports of Grieve and Osbourn (1965) who reported an increase in in vivo DMD with age in Brachiaria decumbens and Digitaria pentzii. Reasons for the decrease in in vivo DMD with age are similar to those given earlier (refer to earlier discussion for IVDMD).

TABLE 29: Dry Matter digestibility and intake of chopped hay of three grasses at different stages of maturity fed to sheep.

Grass Species	Maturity (weeks)	Dry matter Digestibility (%)	Dry Matter Intake (g/kgW0.75)
Cynodon plectostachyus	3	65.3a+	50.0bc
	4	63.3ab	58.0a
	5	60.3abc	55.3ab
	6	58.1c	50.4bc
Cynodon nlemfuensis	3	64.9a	52.8c
	4	61.6ab	69.2a
	5	59.6bc	52.0c
	6	57.9bc	61.6b
Digitaria swazilandensis	4	60.8a	56.7a
	5	57.0ab	50.0a
	6	54.3b	55.0a

+ Means values in the same column within each grass entry with one or more common letter(s) are not significantly different at the 5-percent level.

TABLE 30: Simple regression and correlation between dry matter intake, dry matter digestibility and maturity.

Grass Species	Variables Y	Variables X	Regression Equation	Correlation Coefficient
C. plectostachyus	DMI+	M	Y=54.1-0.15X	-0.05
	DMI	DMD	Y=46.6+0.11X	0.09
	DMD	M	Y=72.9-2.46X	-0.99
C. nlemfuensis	DMI	M	Y=54.5+0.93X	0.15
	MDI	DMD	Y=94.9-0.59X	-0.22
	DMD	M	Y=71.4-2.30X	-0.98
D. swazilandensis	DMI	M	Y=56.5-0.45X	-0.12
	DMI	DMD	Y=44.5+0.17X	0.15
	DMD	M	Y=73.7-3.25X	-0.99

+DMI = Dry Matter Intake
DMD = Dry Matter Digestibility
M = Maturity
Y = Dependent Variable
X = Independent Variable

The mean *in vivo* DMD of the 3-week regrowth differed significantly ($P < 0.05$) from the 6-week regrowth, but, *in vivo* DMD for the 4- and 5-week regrowths showed no significant difference in all the three grasses (Table 29). This is probably due to the early lignification of tropical grasses as reported by French (1956).

The design of the experiment did not allow an in-depth comparison of the three grasses. However, it is worthy to note that, DS had lower *in vivo* DMD compared with the CPS and CN. This may be explained by the fact that, DS by nature is very soft to touch, culms are less cellulolytic and lignified than CPS and CN. One could hardly separate the very tiny and leaf-like culms of DS from the leaves. These attributes of DS might have allowed thorough chopping and mixing of the hay with subsequent reduction in selectivity on the part of the sheep. Thus equal proportions of more digestible leaves and less digestible stems might have been consumed. On the other hand, the stoloniferous nature of CPS and CN might have hindered thorough chopping and mixing, predisposing the diets to

selection. Consequently, greater portion of leaves as against stems might have been consumed, hence the higher *in vivo* DMD values in comparison to DS.

Dry matter intake was significantly different among stage of maturity for CPS ($P < 0.05$) and CN ($P < 0.01$), however, maturity had no effect upon DMI in DS (Appendix B21). Slight variations in the rate of tillering, leaf to stem ratio, lignification and levels of nitrogen free extracts with advancing maturity may account for the statistically insignificant differences established between DMI values for DS at all stages of maturity.

In all the grasses DMI did not exhibit any consistent trend with advancing maturity. For example in CN, DMI rose from 52.8g for the 3-week regrowth to 69.2g for the 4-week, and decreased to 52.0g for the 5-week, only to rise again to 61.6g for the 6-week regrowth (Table 29). It is most probable that the prevailing weather conditions especially rainfall might have partly contributed to such erratic DMI trends.

This observation agrees with that of Ademosun (1973) who reported that DMI was independent of

maturity when PM and two Cynodon species were fed to sheep and goats. However, the results were at variance with findings by Minson (1971) who reported that DMI of three varieties of PM decreased with increasing maturity when fed to sheep. Grieve and Osburn (1965) in contradiction to the results reported in this study, also reported that DMI of CPS and DD increased with increasing maturity when fed to sheep.

Intake levels in the present study ranged between 50 to 58g; 52 to 69.2g and 50 to 56.7g for CPS, CN and DS respectively for the 3- and 6-week regrowth (Table 29). These DMI levels fall within the "upper" limit of 83g set by Jeffery and Holder (1971) for sheep on tropical forages. The levels were also in general agreement with those reported by Sonej et.al. (1972), More and Mott (1973), Grieve and Osbourn (1975) and Adu and Adamu (1982), but were slightly higher than those reported by Ademosun (1973).

DMI was poorly correlated with maturity (r = -0.05, -0.12 and -0.15) for CPS, DS and CN respectively. Intake decreased by 0.15g and 0.45g in CPS and DS respectively and increased by 0.93g in CN for each week advance in age (Table 30).

The data in Tables 29 and 30 seem to indicate that *in vivo* DMD *per se* was not a reliable guide to DMI in all the three grasses (r = 0.09, -0.22 and 0.15) for CPS, CN and DS respectively. This observation concurs with reports by Milford and Minson (1966) and Sonej *et.al.* (1972) on several tropical grasses. It differs however, from finding of Grieve and Osbourn (1965) who reported a higher correlation co-efficient value of 0.57. A host of factors including acceptability, rate of passage through the gut and the nutrient composition of herbage may be responsible, as suggested by Van Soest (1964).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the results it appeafs that:-

1. Frequent grazing reduced dry matter and green forage yidds of all grass entries. P. maximum, C. ciliaris and P. plicatulum occupied most of the top yield position at the six grazing frequencies.

2. Percentage dry matter content, sward height and root weight were positively correlated with increasing grazing interval.

3. Basal cover of weeds increased on all plots under grazing. Weed infestation occurred at a minimum on plots of C. decumbens and D. swazilandensis. C. aethiopicus had the highest increase of weeds.

4. Total ash and phosphorus were inversely related to increasing grazing interval. Changes in calcium and calcium to phosphorus ratio with increasing grazing interval were erratic. Calcium, phosphorus and calcium to phosphorus ratio levels of the eight grasses appeared to be nutritionally adequate for sheep and beef cattle.

5. Crude fiber of leaf, stem and whole-plant increased with increasing grazing interval. The rate of increase in crude fiber was rapid in the stem than

the whole-plant and leaf in that order. Crude fiber of leaf in all species at the same stage of maturity was lower than the whole-plant and stem in that order. The highest and lowest CF contents of leaf, stem and whole-plant were recorded for C. ciliaris and D. decumbens respectively.

6. Leaf, stem and whole-plant crude protein decreased with increasing grazing interval. The rate of decline in CP was faster in the stem than the whole-plant and leaf in that order. Crude protein content of leaf in all species at the same stage of maturity was higher than that of the whole-plant and stem. C. aethiopicus, D. decumbens and P. maximum registered the highest leaf, stem and whole-plant crude protein contents respectively. The lowest values were recorded for P. plicatulum (leaf and stem) and D. swazilandensis (whole-plant).

7. IVDMD of leaf, stem and whole-plant decreased with increasing grazing interval. The rate of decline of IVDMD was rapid in the stem than the whole-plant and leaf in that order, in all species except D. swazilandensis. IVDMD of leaf in all species at the same stage of maturity was higher than the whole-plant and stem in that order. The highest IVDMD values were

exhibited in C. ciliaris (leaf) and P. maximum (Stem and whole-plant). The lowest values were found in D. swazilandensis (leaf) and C. nlemfuensis (stem) and (whole-plant).

8. Selection of forage grasses for leafiness and low stem fraction or high stem digestibility may increase percentage crude protein and digestible dry matter. Long grazing intervals increase yield, but decrease quality of herbage.

9. In vivo dry digestibility of C. plectostachyus, C. nlemfuensis and D. swazilandensis declined with advancing maturity. Dry matter intake in all grasses was comparatively high, however, intake was poorly correlated with in vivo dry matter digestibility and maturity.

10. All the eight grass entries were relished by cattle. P. maximum and D. decumbens were the most preferred species, while C. aethiopicus and D. swazilandensis, the least preferred. Relative palatability under the reported experimental conditions decreased with increasing grazing interval.

11. Grazing frequencies of 5 to 6 weeks and 3 to 9 weeks are recommended for C. aethiopicus and C. ciliaris respectively, the other species may be grazed above 10-weeks.

12. P. maximum, D. decumbens, C. ciliaris var Biloela P. plicatulum and C. plectostachyus are recommended.

13. The experiment could be repeated over a longer study period to bring out clearly differences in performance of the different grass species.

14. The relative palatability trial could be repeated using sheep and goats for comparative studies.

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APPENDIX A1: Effect of grazing frequency on green forage yield of eight tropical grass.

Grass Species	Grazing Frequency (weeks)					
	3	4	5	6	8	10
	Green Forage Yield (kg)					
C. aethiopicus	4.8	5.5	6.1	6.7	7.1	8.0
C. nlemfuensis	5.4	5.9	6.3	6.8	8.0	9.0
C. plectostachyus	4.6	6.6	6.7	6.8	7.3	8.0
C. ciliaris	5.6	6.4	7.2	7.8	9.2	9.6
D. decumbens	6.1	7.2	7.3	8.0	8.5	9.5
D. swazilandensis	5.4	5.7	6.1	6.3	7.9	8.7
P. maximum	6.1	7.6	8.4	10.1	12.5	15.7
P. plicatulium	6.2	6.7	7.5	8.1	8.6	10.4

APPENDIX A2: Effect of grazing frequency on dry matter yield of eight tropical grasses.

Grass Species	Grazing Frequency (weeks)					
	3	4	5	6	8	10
	Dry Matter Yield (t/ha)					
C. aethiopicus	1.2	1.5	1.8	2.0	1.9	2.2
C. nlemfuensis	1.4	1.6	1.8	2.0	3.1	3.1
C. plectostachyus	1.2	1.8	1.9	2.0	2.4	2.8
C. ciliaris	1.5	1.8	2.2	2.5	3.2	3.4
D. decumbens	1.3	1.7	1.9	2.0	2.4	2.9
D. swazilandensis	1.4	1.6	1.8	2.0	2.7	3.0
P. maximum	1.5	1.9	2.2	2.9	3.9	5.1
P. plicatulium	1.4	1.6	2.0	2.2	2.6	3.5

APPENDIX A3: Effect of grazing frequency on percentage dry matter content of eight tropical grasses.

Grass Species	Grazing Frequency (wks) 3	4	5	6	8	10
	Dry Matter content (%)					
C. aethiopicus	24.8	27.9	28.8	29.6	30.5	32.4
C. mlemfuensis	26.7	26.7	28.9	29.4	33.9	
C. plectostachyus	26.9	27.8	29.3	30.1	32.7	34.6
C. ciliaris	27.1	28.7	30.5	31.7	34.4	35.5
D. decumbens	21.6	23.5	25.8	25.3	29.6	30.8
D. swazilandensis	23.8	25.6	26.3	28.8	31.2	32.5
P. maximum	26.3	27.8	28.8	31.2	34.3	34.4
P. plicatulium	22.5	23.8	26.2	27.5	30.5	33.7

APPENDIX A4: Effect of grazing frequency on sward height of eight tropical grasses.

Grass Species	Grazing Frequency (weeks) 3	4	5	6	8	10
	Sward Height (cm)					
C. aethiopicus	62.0	70.5	74.5	76.0	81.5	91.5
C. nlemfuensis	78.0	83.0	87.0	90.5	97.0	120 .0
C. plectostachyus	75.5	98.0	101.5	107.0	116.0	123.0
C. ciliaris	102.0	112.5	120.5	121.5	137.0	161.5
D. decumbens	55.0	58.0	62.0	68.5	76.0	80.5
D. swazilandensis	29.5	31.0	32.5	36.0	38.0	42.0
P. maximum	104.5	112.0	116.5	138.5	156.3	256.0
P. plicatulium	87.0	100.0	104.0	107.5	111.5	123.0

APPENDIX A5: Effect of grazing frequency on root+ weight of eight tropical grasses.

Grass Species	Grazing Frequency (wks) 3	4	5	6	8	10
	Root Weight (g)					
C. aethiopicus	50.9	51.7	55.4	61.9	76.3	75.9
C. nlemfuensis	72.9	74.0	77.3	85.2	92.1	95.1
C. plectostachyus	79.0	81.5	83.2	85.5	98.3	98.5
C. ciliaris	127.2	135.7	138.3	152.5	157.4	158.2
D. decumbens	80.3	85.7	87.9	93.3	106.4	110.1
D. swanzilandensis	139.7	140.6	143.3	144.3	150.9	153.1
P. maximum	147.2	151.8	159.5	165.4	171.5	175.2
P. plicatulium	177.4	181.7	185.6	186.9	194.5	197.7

APPENDIX A6: Increase in percentage basal cover of weeds on plots of eight tropical grasses under six grazing frequencies.

Grass Species Designation	Grazing Frequency (weeks) 3	4	5	6	8	10	Species Mean	Coefficient of Correlation
	Basal Cover of Weeds (%)							
CA	12.8	9.5	7.5	10.0	7.0	8.5	9.2a†	-0.62
CN	6.5	5.5	4.3	3.5	5.0	5.1	5.0c	-0.33
CPS	5.5	4.0	4.0	6.3	4.5	5.1	4.9c	0.08
CC	8.0	7.5	8.0	6.8	8.0	6.1	7.4b	-0.64
DD	1.0	1.0	1.3	1.8	1.8	2.0	1.5e	0.92
DS	2.8	2.0	3.3	1.3	3.5	2.0	2.5de	-0.15
PM	3.8	4.5	6.0	3.5	3.5	3.0	4.0cd	-0.60
PP	2.8	4.0	3.8	6.5	4.8	5.1	4.8c	0.59
Mean	5.4a	4.8a	4.8a	4.9a	4.8a	4.6a		

† Means in the same row or column with one or more common letter(s) are not significantly different at the 5-percent level.

APPENDIX A7: Effect of grazing frequency on percentage total ash of eight tropical grasses.

Grass Species	* Grazing Frequency (weeks)					
	3	4	5	6	8	10
	Total Ash (%)					
C. aethiopicus	8.6	8.4	7.8	7.7	7.1	6.5
C. nlemfuensis	9.8	9.7	8.9	8.3	7.7	7.6
C. plectostachyus	9.2	9.5	8.9	8.4	7.9	7.1
C. ciliaris	10.8	11.7	10.4	9.2	9.0	6.8
D. denumbens	9.3	9.5	8.8	8.8	8.5	6.7
D. swazilandensis	15.4	11.4	10.9	8.3	7.6	8.3
P. maximum	13.2	11.7	10.2	9.1	9.4	8.8
P. plicatulium	9.6	10.1	9.5	9.3	9.2	8.3

APPENDIX A8: Effect of grazing frequency on percentage Calcium of eight tropical grasses.

Grass Species	Grazing Frequency (weeks)					
	3	4	5	6	8	10
	Calcium (%)					
C. aethiopicus	0.48	0.38	0.34	0.33	0.37	0.40
C. nlemfuensis	0.47	0.37	0.40	0.42	0.51	0.50
C. plectostachyus	0.33	0.32	0.30	0.37	0.30	0.37
C. ciliaris	0.42	0.43	0.27	0.38	0.30	0.26
D. decumbens	0.66	0.56	0.42	0.32	0.30	0.37
D. swazilandensis	0.36	0.32	0.38	0.38	0.30	0.34
P. maximum	0.33	0.32	0.42	0.59	0.33	0.38
P. plicatulium	0.67	0.43	0.64	0.57	0.62	0.41

APPENDIX A9: Effect of grazing frequency on percentage phosphorus of eight tropical grasses.

Grass Species	Grazing Frequency (wks)					
	3	4	5	6	8	10
	Phosphorus (%)					
C. aethiopicus	0.31	0.30	0.25	0.23	0.23	0.22
C. nlemfuensis	0.31	0.3	0.26	0.24	0.22	0.19
C. plectostachyus	0.31	0.31	0.32	0.23	0.22	0.40
C. ciliaris	0.34	0.33	0.30	0.23	0.26	0.24
D. decumbens	0.29	0.29	0.30	0.26	0.19	0.16
D. swazilandensis	0.28	0.26	0.26	0.24	0.23	0.20
P. maximum	0.37	0.29	0.3	0.29	0.29	0.25
P. plicatulium	0.21	0.20	0.20	0.19	0.17	0.18

APPENDIX A10: Effect of grazing frequency on calcium to phosphorus ratio of eight tropical grasses.

Grass Species	Grazing Frequency (wks) 3	4	5	6	8	10
	Calcium to Phosphorus Ratio					
C. aethiopicus	1.5:1	1.3:1	1.4:1	1.4:1	1.6:1	1.8:1
C. nlemfuensis	1.5:1	1.2:1	1.5:1	1.8:1	1.3:1	1.6:1
C. plectostachyus	1.1:1	1.0:1	0.9:1	1.6:1	1.4:1	1,9:1
C. ciliaris	1.2:1	1.3:1	0.9:1	1.4:1	1.2:1	1.1:1
D. decumbens	2.3:1	1.9:1	1.4:1	1.2:1	1.6:1	2.3:1
D. swazilandensis	1.3:1	1.2:1	1.5:1	1.8:1	1.6:1	2.3:1
P. maximum	0.9:1	1.4:1	1.4:1	2.0:1	1.1:1	1.5:1
P. plicatulum	3.2:1	2.2:1	3.2:1	3.0:1	3.6:1	2.3:1

APPENDIX A11: Effect of grazing frequency on percentage Crude fiber content of leaf of eight tropical grasses.

Grass Species	Grazing Frequency (wks)					
	3	4	5	6	8	10
	Crude Fiber (%)					
C. aethiopicus	27.0	27.6	28.7	29.5	29.2	29.9
C. nlemfuensis	25.9	26.5	27.7	28.5	29.4	29.7
C. plectostachyus	26.7	27.6	28.3	29.6	30.6	31.1
C. ciliaris	30.0	31.1	32.2	33.0	34.7	34.5
D. decumbens	28.0	29.2	30.2	31.9	31.5	32.5
D. swazilandensis	25.4	26.7	27.2	28.5	29.3	30.1
P. maximum	27.9	28.9	30.7	31.9	32.1	33.3
P. plicatulum	27.0	27.6	28.3	29.5	30.1	31.0

APPENDIX A12: Effect of grazing frequencies on percentage fiber content of stem of eight tropical grasses.

Grass Species	Grazing frequency (wks) 3	4	5	6	8	10
	Crude Fiber (%)					
C. aethiopicus	33.8	35.0	35.7	36.5	37.1	41.7
C. nlemfuensis	32.0	34.1	36.2	37.5	38.3	39.1
C. plectostachyus	32.5	34.7	36.7	37.5	38.0	39.8
C. ciliaris	35.8	39.0	40.7	42.2	42.9	48.6
D. decumbens	31.5	33.5	34.3	38.7	39.0	40.3
D. swazilandensis	28.4	30.6	32.9	32.5	34.6	35.6
P. maximum	34.4	38.0	40.8	42.6	44.3	49.0
P. plicatulum	30.0	32.3	34.5	35.9	36.7	37.5

APPENDIX A13: Effect of grazing frequency on percentage crude fiber content of whole-plant of eight tropical grasses.

Grass Species	Grazing Frequency (wks)					
	3	4	5	6	8	10
	Crude Fiber (%)					
C. aethiopicus	30.1	32.1	32.3	33.4	33.5	35.0
C. nlemfuensis	31.1	32.0	32.1	33.0	34.0	36.4
C. plectostachyus	30.8	32.3	33.2	33.5	34.2	36.2
C. ciliaris	32.9	34.4	35.9	36.8	41.3	43.2
D. decumbens	28.0	30.8	32.5	33.5	34.1	34.8
D. swazilandensis	26.9	27.4	28.2	29.3	30.9	31.2
D. maximum	29.0	30.5	33.9	33.5	35.9	36.7
P. plicatulum	28.8	29.6	30.7	31.7	32.6	34.4

APPENDIX A14: Effect of grazing frequency on percentage crude protein of leaf of eight tropical grasses.

Grass Species	Grazing frequency (wks)					
	3	4	5	6	8	10
	Crude Protein (%)					
C. aethiopicus	18.4	17.7	16.0	15.4	15.1	15.0
C. nlemfuensis	15.0	14.7	14.0	12.8	12.7	11.4
C. plectostachyus	15.2	14.5	15.1	13.1	11.8	11.1
C. ciliaris	15.2	14.3	14.3	13.9	12.5	12.1
D. decumbens	15.5	15.0	14.7	13.1	12.0	11.0
D. swazilandensis	13.9	13.8	12.3	11.8	10.6	9.8
P. maximum	14.9	14.5	14.2	13.2	13.0	11.5
P. plicatulum	12.7	12.0	11.6	10.4	10.6	10.4

APPENDIX A15: Effect of grazing frequency on percentage crude protein of stem of eight tropical grasses.

Grass Species	Grazing Frequency (wks)					
	3	4	5	6	8	10
	Crude Protein (%)					
C. aethiopicus	10.2	8.4	7.2	6.6	5.8	4.2
C. nlemfuensis	10.7	8.2	7.7	6.8	6.5	4.4
C. plectostachyus	11.1	8.1	6.9	6.4	5.5	3.8
C. ciliaris	9.6	7.0	7.4	6.2	6.7	3.8
D. decumbens	11.6	10.2	8.6	6.9	5.4	4.8
D. swazilandensis	9.4	9.2	8.5	6.7	5.8	4.6
P. maximum	10.9	7.9	6.5	6.0	5.7	3.7
P. plicatulum	9.7	7.4	6.2	6.3	5.8	4.2

APPENDIX A16: Effect of grazing frequency on percentage crude protein of whole-plant of eight tropical grasses.

Grass Species	Grazing Frequency (wks)					
	3	4	5	6	8	10
	Crude Protein (%)					
C. aethiopicus	10.1	9.8	8.6	8.7	6.4	6.9
C. nlemfuensis	11.9	11.3	10.4	8.9	7.5	7.4
C. plectostachyus	12.8	12.1	10.2	9.3	8.7	7.9
C. ciliaris	12.6	12.0	11.5	10.4	8.6	8.5
D. decumbens	12.8	12,7	9.9	9.1	8.5	7.5
D. swazilandensis	9.9	8.9	8.3	6.7	6.9	6.3
P. maximum	13.1	12.7	10.6	9.9	9.7	9.4
P. plicatulum	10.8	9.2	8.6	8.1	7.6	6.4

APPENDIX A17: Effect of grazing frequency on percentage *in vitro* dry matter digestibility of leaf of eight tropical grasses.

Grass Species	Grazing Frequency (wks) 3	4	5	6	8	10
C. aethiopicus	63.4	64.0	64.5	61.6	58.2	56.2
C. nlemfuensis	65.6	65.2	60.1	61.4	60.1	58.1
C. plectostachyus	67.1	63.9	56.4	54.0	55.5	55.2
C. ciliaris	70.5	68.6	68.5	67.4	66.7	63.9
D. decumbens	69.9	64.6	60.4	59.1	58.2	56.8
D. swazilandensis	59.5	58.2	55.8	57.1	54.1	53.9
P. maximum	72.3	69.5	68.0	63.7	58.0	51.8
P. plicatulum	62.1	60.4	60.3	56.2	54.7	52.9

APPENDIX A18: Effect of grazing frequency on percentage *in vitro* dry matter digestibility of stem of eight tropical grasses.

Grass Species	Grazing Frequency (wks)					
	3	4	5	6	8	10
	IVDMD (%)					
C. aethiopicus	52.2	52.6	53.9	50.6	46.1	43.4
C. nlemfuensis	53 .5	48.9	48.3	45.2	43.4	41.6
C. plectostachyus	54.2	53.5	51.9	47.3	46.3	44.8
C. ciliaris	59.5	58.3	57.3	55.7	52.6	44.4
D. decumbens	64.4	59.1	57.7	58.6	55.5	52.5
D. swanzilandensis	52.4	50.9	48.5	49.2	48.0	46.5
P. maximum	69.8	68.7	65.7	59.3	54.1	46.0
P. plicatulum	59.9	57.3	53.7	52.1	49.9	47.1

APPENDIX A19: Effect of grazing frequency on percentage *in vitro* dry matter digestibility of whole-plant of eight tropical grasses.

Grass Species	Grazing Frequency (wks) 3	4	5	6	8	10
	IVDMD (%)					
C. aethiopicus	53.8	54.7	55.1	51.7	48.8	45.5
C. nlemfuensis	53.1	52.8	47.4	46.2	44.2	41.8
C. plectostachyus	57.8	56.0	51.5	51.2	47.8	44.0
C. ciliaris	69.1	66.2	63.7	60.7	55.6	49.8
D. decumbens	65.9	63.2	60.5	59.0	56.5	52.9
D. swazilandensis	58.5	58.0	57.3	54.0	53.4	52.6
P. maximum	71.2	69.2	65.2	63.6	55.6	48.7
P. plicatulum	61.8	59.6	58.6	53.4	51.5	48.2

APPENDIX A20: Effect of grazing frequency on digestible dry matter yield.

Grass Species Designation	Grazing Frequency (wks)						Species Mean
	3	4	5	6	8	10	
	Digestible Dry Matter Yield (t/ha)						
CA	0.65	0.82	0.99	1.03	0.93	1.00	0.90g
CN	0.74	0.85	0.85	0.92	1.11	1.30	0.96f
CPS	0.69	1.01	0.98	1.02	1.15	1.23	1.04e
CC	1.04	1.19	1.40	1.52	1.78	1.69	1.44b
DB	0.86	1.07	1.15	1.18	1.36	1.53	1.19c
DS	0.82	0.93	1.03	1.08	1.43	1.58	1.13d
PM	1.07	1.32	1.45	1.84	2.16	2.48	1.72a
PP	0.87	0.95	1.17	1.18	1.34	1.69	1.20c
Mean	0.81f	1.02e	1.13d	1.22c	1.41b	1.56a	

Means in the same row or column with one or more common letter(s) are not significantly different at the 5% level.

APPENDIXA21: Mean percentage relative palatability of eight tropical grasses at six grazing frequencies+.

Grass Species Designation	Grazing Frequency (wks) 3	4	5	6	8	10	Species Mean	Correlation Coefficient (r)
	Relative Palatability(%)							
CA	9.8	9.0	6.0	10.6	5.4	7.5	8.1	-0.45
CN	17.5	12.0	9.3	12.5	8.2	7.5	11.5	-0.82
CPS	13.3	12.4	8.3	10.8	7.8	7.0	9.9	-0.86
CC	15.5	8.6	8.0	5.2	6.8	6.0	8.4	-0.70
DD	15.8	15.6	12.4	12.1	11.0	12.8	13.3	-0.69
DS	7.8	6.7	6.5	7.3	6.1	5.2	6.6	-0.87
PM	25.1	22.5	10.7	16.7	10.3	8.5	15.6	-0.84
PP	13.7	12.6	10.5	8.1	7.1	11.0	10.5	-0.56
Mean	14.8	12.4	8.9	10.4	7.8	7.3		
Spearman's Rank Correlation (r_s^2)	0.32	0.48	0.31	0.29	0.32	0.19		

+ No analysis of variance conducted on raw data.

APPENDIX B1: Analysis of Variance for Green forage Yield

S. V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	118.25	16.89	84.46++	2.25	3.12
Grazing	5	194.97	38.99	194.97++	2.45	3.51
Grass X Grazing	35	49.83	1.42	7.11++	1.74	2.20
Error	48	9.6	0.20			
Total	95	372.64				

APPENDIX B2: Analysis of Variance for Dry Matter Yield

S. V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	10.08	1.44	9.00++	2.25	3.12
Grazing	5	37.96	7.59	49.45++	2.45	3.51
Grass X Grazing	35	6.74	0.19	1.20	1.74	2.20
Error	48	7.75	0.16			
Total	45	62.53				

\+ Significant at the 5% Level

++ Significant at the 1% Level

APPENDIX B3: Analysis of Variance for percentage dry matter content

S. V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	266.03	38.00	10.98++	2.25	3.12
Grazing	5	835.97	167.19	48.32++	2.45	3.51
Grass X Grazing	35	6.85	0.20	0.06		
Error	48	165.92	3.46			
Total	95	1274.77				

APPENDIX B4: Analysis of Variance for Sward Height

S. V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	103,796.02	14820.00	1767.34++	2.25	3.12
Grazing	5	24,904.32	4980.86	593.67++	3.45	3.51
Grass X Grazing	35	20,123.71	574.96	68.53++	1.74	2.20
Error	48	402.63	8.39			
Totals	95	149,226.68				

\+ Significant at the 5% Level

++ Significant at the 1% Level

APPENDIX B5: Analysis of Variance for Root^{+++} weight

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	167977.68	23996.81	1488.64^{++}	2.25	3.12
Grazing	5	7358.35	1471.67	91.29^{++}	2.45	3.51
Grass X Grazing	35	853.67	24.39	1.51	1.74	2.20
Error	48	773.83	16.12			
Total	95	176963.52				

APPENDIX B6: Analysis of Variance for percentage basal cover of weeds

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	522.55	74.65	17.69^{++}	2.25	3.12
Grazing	5	5.98	1.20	0.28	2.45	3.51
Grass X Grazing	35	100.15	2.86	0.68	1.74	2.20
Error	48	202.61	4.22			
Total	95	831.29				

\+ Significant at the 5% Level

++ Significant at the 1% Level

+++ Includes stubble, root, stolon or rhizome weight

APPENDIX B7: Analysis of Variance for Total Ash

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	152.18	21.74	6.20++	2.09	2.79
Grazing	5	240.39	48.08	13.70++	2.29	3.17
Grass X Grazing	35	100.18	2.86	0.82	1.55	1.86
Error	144	505.59				

APPENDIX B8: Analysis of Variance for Calcium

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	0.93	0.133	44.33++	2.09	2.79
Grazing	5	0.18	0.036	12.00++	2.29	3.17
Grass X Grazing	35	0.95	0.028	9.33++	1.55	1.86
Error	144	0.38	0.003			
Total	191	2.12				

\+ Significant at the 5% Level

++ Significant at the 1% Level

APPENDIX B9: Analysis of Variance for Phosphorus

S.V.	df	SS	MS	Observed F	Tabulated F 5%	Tabulated F 1%
Grass	7	0.167	0.024	79.33++	2.09	2.79
Grazing	5	0.229	0.046	152.73++	2.29	3.17
Grass X Grazing	35	0.067	0.002	6.33++	1.55	1.86
Error	144	0.048	0.0003			
Total	191	0.511				

APPENDIX B10: Analysis of Variance for Crude Fiber of Leaf

S.V.	df	SS	MS	Observed F	Tabulated F 5%	Tabulated F 1%
Grass	7	463.53	66.22	19.08++	2.09	2.79
Grazing	5	601.93	120.39	34.69++	2.29	3.17
Grass X Grazing	35	109.22	3.12	0.90	1.55	1.86
Error	144	499.58	3.47			
Total	191	1674.26				

\+ Significant at the 5% Level

++ Significant at the 1% Level

APPENDIX B11: Analysis of Variance for Crude Fiber of stem

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	1,013.80	144.83	43.36++	2.09	2.79
Grazing	5	1,219.29	243.86	73.01++	2.09	3.17
Grass X Grazing	35	236.24	6.75	2.02++	1.55	1.86
Error	144	481.05	3.34			
Total	191	2,950.38				

APPENDIX B12: Analysis of variance for crude fiber of whole-plant

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	765.44	109.35	29.55++	2.09	2.79
Grazing	5	885.77	177.15	47.88++	2.29	3.17
Grass X Grazing	35	229.03	6.54	1.77 +	1.55	1.86
Error	144	533.29	3.70			
Total	191	2413.53				

\+ Significant at the 5% Level

++ Significant at the 1% Level

APPENDIX B13: Analysis of Variance for Crude Protein of Leaf

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	693.47	99.07	36.29++	2.09	2.79
Grazing	5	764.75	152.95	56.03++	2.29	3.17
Grass X Grazing	35	69.36	1.98	0.73	1.55	1.86
Error	144	393.45	2.73			
Total	191	1921.53				

APPENDIX B14: Analysis of Variance for Crude Protein of Stem

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	34.30	4.90	2.92++	2.09	2.79
Grazing	5	432.59	86.52	51.50++	2.29	3.17
Grass X Grazing	35	30.06	0.86	0.51	1.55	1.86
Error	144	241.21	1.68			
Total	191	738.16				

\+ Significant at the 5% Level
++ Significant at the 1% Level

APPENDIX B15: Analysis of Variance for Crude Protein of Whole-plant

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	247.71	35.39	10.75++	2.09	2.79
Grazing	5	938.24	187.65	54.34++	2.29	3.17
Grass X Grazing	35	42.13	1.20	0.36	1.55	1.86
Error	144	473.35	3.29			
Total	191	1701.43				

APPENDIX B16: Analysis of Variance for in vitro dry matter digestibility of leaf.

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	2162.84	308.98	185.02++	2.09	2.79
Grazing	5	2308.70	461.74	276.49++	2.29	3.17
Grass X Grazing	35	841.02	24.03	14.39++	1.55	1.86
Error	144	240.91	1.67			
Total	191	5553.47				

\+ Significant at the 5% Level

++ Significant at the 1% Level

APPENDIX B17: Analysis of Variance for in vitro dry matter digestibility of Stem.

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	3265.24	466.46	210.12++	2.09	2.79
Grazing	5	3704.70	740.94	333.76++	2.29	3.17
Grass X Grazing	35	838.52	23.96	10.79++	1.55	1.86
Error	144	319.69	2.22			
Total	191	8128.15				

APPENDIX B18: Analysis of Variance for in vitro dry matter digestibility of whole-plant.

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	5688.03	812.58	314.95++	2.09	2.79
Grazing	5	3855.71	771.14	298.89++	2.29	3.17
Grass X Grazing	35	759.14	21.69	8.41++	1.55	1.86
Error	144	371.36	2.58			
Total	191	10,674.22				

\+ Significant at the 5% Level

++ Significant at the 1% Level

APPENDIX B19: Analysis of variance for digestible Dry Matter Yield

S.V.	df	SS	MS	Observed F	Tabulated F 5%	1%
Grass	7	6.13	0.88	440.0++	2.25	3.12
Grazing	5	5.41	1.08	540.0++	2.45	3.51
Grass X Grazing	35	1.62	0.05	25.0++	1.74	2.20
Error	48	0.09	0.002			
Total	95	13.25				

APPENDIX B20: Analysis of Variance for apparent Dry Matter Digestibility of the three grasses.

C. plectostachyus

Sv	df	SS	MS	Observed F	Expected F 5%	1%
Maturity	3	232.39	77.46	4.77++	2.95	4.57
Error	28	460.46	16.45			
Total	31	692.85				

C. nlemfuensis

Sv	df	SS	MS	Observed F	Expected F 5%	1%
Maturity	3	216.50	72.17	4.44+	2.95	4.57
Error	28	455.50	16.17			
Total	31	672.0				

D. swazilandensis

Sv	df	SS	MS	Observed F	Expected F 5%	1%
Maturity	2	170.42	85.21	6.44++	3.49	5.85
Error	21	277.76	13.23			
Total	23	448.18				

\+ Significant at 5 - percent level

++ Significant at 1 - percent level

APPENDIX B21: Analysis of Variance for voluntary dry matter intake of the three grasses

C. plectostachyus

Sv	df	SS	MS	Observed F value	Tabulated F 5%	1%
Maturity	3	633.30	211.10	3.94+	2.76	4.13
Error	52	2785.20	53.57			
Total	55	3418.70				

C. nlemfuensis

Sv	df	SS	MS	Observed F value	Tabulated F 5%	1%
Maturity	3	2750.89	916.96	13.05++	2.76	4.13
Error	52	3652.45	70.24			
Total	55	6403.34				

D. swazilandensis

Sv	df	SS	MS	Observed F value	Tabulated F 5%	1%
Maturity	2	663.76	331.88	2.26	3.23	5.18
Error	39	5726.72	146.84			
Total	41	6390.48				

\+ Significant at the 5 - percent level

++ Significant at the 1 - percent level