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NUTRITIVE VALUE OF RHODES GRASS AT DIFFERENT GROWTH STAGES FOR RUMINANT PRODUCTION

BY

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THIS THESIS HAS BEEN COMPILED BY MYSELF AND HAS NEVER BEEN PREVIOUSLY ADMITTED FOR A DEGREE QUALIFICATION. THE WORK OF WHICH THIS REPORT HAS BEEN DONE, WAS RECORDED BY MYSELF AND ALL OTHER SOURCES ARE ACKNOWLEDGED AS REFERENCE ONLY

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ABSTRACT

The nutritive value of Rhodes grass (chloris gayana) at different levels of growth, with minimum fertilisation was studied. Nutritive value is in reference to the chemical composition and digestibility of the grass. The grass was harvested at eight growth stages with respect to time after seedling emergence and height of plants above ground; with the first to last harvests being done at 12cm, 20cm, 30cm, 45cm, 60cm and on average >70cm for the sixth, seventh and eighth harvests.

Proximate analysis for the samples showed a steady decline in CP from 8.61% at 4 weeks old to 2.83% at 15 weeks when it was cut as hay at eighth harvest. CF increased from 32.34% at initial harvest to 42.03% during the eighth harvest. This reciprocal relationship between CF and CP agreed with previous reports. DM yield increased from 1.75tonnes per hectare at initial harvest to 14.5t/ha at eighth harvest. Invitro OMD also indicated a steady fall from 75.52% at harvest level one, to 54.1% for the eighth. The drop in CP and OMD, rise in CF were attributed to the increase in lignin content of the grass. Invivo OMD was estimated for the eighth harvest level (62.82%) and compared to the laboratory invitro method. The former was higher than the latter which contrasted with earlier reports. Invivo digestibilities for OM, DM, CF and GE were consistent with other figures reported.

The analysis helped to determine how much a ruminant animal would obtain in terms of nutrients at each harvest level. It was concluded that the optimum cutting stage would be at 45-60 CM

when CP and GE are still relatively high, and when DM yield at 6.69 t/ha and OMD at 60.14% are within levels that benefit the animals. Beyond the fourth harvest level, the increase in lignification which goes with the reproductive stage of plant growth causes a drop in digestibility and hence affects nutrient uptake.

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DEDICATION

To my late dad, who should have been around to see me through this milestone. May your soul rest in peace dear one.
To my mum, brothers Job and Masauso, sisters Rhoda, Martha and Rachel and the rest of the family, too numerous to mention. May God bless you all.

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LIST OF ABBREVIATIONS

DM	Dry Matter
CP	Crude Protein
GE	Gross Energy
CF	Crude Fibre
ADF	Acid Detergent Fibre
NDF	Neutral Detergent Fibre
EE	Ether Extract
OM	Organic Matter
OMD	Organic Matter Digestibility
GED	Gross Energy Digestibility
CFD	Crude Fibre Digestibility
DMD	Dry Matter Digestibility
CWC	Cell Wall Contents
CHOs	Carbohydrates
CPD	Crude Protein Digestibility

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CHAPTER 1

INTRODUCTION

The increase in the world population and general awareness for improved nutrition among humans has caused an increase in demand for meat and it's by-products. Meat is among other things a major source of protein and for this reason, research continues to be done on the subject of animal nutrition (Maynard 1962). Animal produts and by-products such as meat, milk, wool and hides have proved to be of nutritional and economical value to many people involved in production (Adegbola et al 1986).

One of the most important aspects of animal nutrition especially in ruminants is the provision of good quality grass (Crowder and Chheda 1982). The expansion of ruminant production in the tropics has stimulated increased interest in the quality of available sources of nutrients. Grasslands are presently the major source of these nutrients and will continue as such (Crampton, 1969).

By nutritive value is meant chemical composition of the grass, its digestibility and nature of digested products, although voluntary intake may also be used as a measure of feeding value (Bogdan 1977). Chemical composition can be determined by carrying out proximate analysis for DM, CP, CF, OM, EE, ADF, NDF and NFE. The levels of each of these components will tell the nutritive value in a feed stuff based on its chemical composition; however, they must be digested and absorbed to be of any value to the animal (McMeekan and Walshe 1963).

Digestibility is a principle measurement used to predict or ascertain the nutritive value of feeds. It is probably the most useful single measure of the nutritive value of a grassland feed (Cowlishaw and Miller 1975). It is defined as the difference in value between the feed eaten and materials voided by the animals. The digestibility value is also a measure of loss by excretion of energy, dry matter, crude fibre or any other component of nutrient material available in the feed.

The natural grasslands provide the basic diet for the vast majority of ruminant livestock in the tropics. The nutritive value of feeds for domestic livestock is expressed by the level of animal production of the desired type that is achieved and the length of the productive life. The nutritive value of feeds is generally given in terms of value per unity weight, but that of grassland herbage is viewed in its ability to meet the requirements of the animal for energy and protein (Crampton 1969).

One such grass that has been cultivated is Rhodes grass (chloris gayana). It is a perennial tropical plant that is very adaptable and has ease of establishment on newly cleared land. It is responsive to high soil fertility and has an added advantage of drought resistance, tolerance to heavy grazing and high soil salinity (Kretschner 1985), but will disappear if poorly managed. It also occurs naturally in most tropical and subtropical areas of Africa (Rotar et al 1985). Rhodes grass is one of the most satisfatory of the tropical grasses for hay, but is is not suitable for silage (Gotil 1981). Various cultivars have been developed in

Zambia, Kenya, Zimbabwe and South Africa.

Grasses are used in ruminant production solely for the reason that man does not compete for grass with the animals as is the case with grains. Grass does not have the nutrient composition that would benefit man directly, but ruminant animals derive a large proportion of nutrients from grass.

However, good quality grass is not available throughout the year in the tropics. There is a strict time for growth and maturity in the rainy season. Dry season feeding is dependent on conserved grass either as hay or silage.

The time of harvest has a pronounced effect on forage quality. One must always provide herbage which is at a stage of growth where it will do most good to livestock. Grasses generally lose their nutritive value with advancing maturity.

The notion that grasses can be supplemented with concentrate feed may be a far cry for most livestock producers of whom the majority are small scale farmers with no access to such materials as concentrate feed.

Therefore, this experiement attempts to determine the optinum cutting stage for Rhodes grass which can then be stored as hay without adversely affecting its nutritive value. The digestibility and chemical composition will be determined at different growth stages so as to establish potential for dry season feeding in ruminants.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

The nutritive value of a pasture is basically a function of the species in the pasture and the stage of growth, but may be modified by climatic factors during growth, soil factors which affect nitrogen and other mineral status, and management factors which affect pasture re-growth rate and botanical composition.

The chemical composition of a pasture is influenced by soil fertility, species composition and such factors as temperature and soil moisture (Mannetje *et al* 1976). It can be a valuable indicator of the quality of pasture in terms of protein and mineral composition and also a means of explaining animal production over the various seasons of the year (Howard *et al* 1962).

Forage quality is best defined as output per animal and is a function of voluntary intake and digestibility of nutrients when forage is fed alone and *ad libitum* to a specified animal (Moore and Mott 1973). Minson (1968) suggested that pasture quality can be expressed as quantity of milk, meat or wool produced by animals when they graze pastures with adequate available forage. However, forage quality can only be expressed in terms of output per animal only when forage availability is not limiting.

2.2 Factors Affecting Forage Quality

2.1.1 Stage of Growth and Maturity

The general effect of increasing age or stage o growth of pastures on nutritive value has bee studied before. Most forages decline in nutritiv value with age. The effect is a complex respons and is not guaranteed in all instances. First, i should be recognised that age and physiologica maturity are not identical (Van Soest 1982). Thus an old plant may have its physiological maturit delayed due to limitations in plant requirement such as moisture, nutrients and prevailing climati conditions.

With increasing age, the proportion of potentiall digestible components comprising solubl carbohydrates, proteins and other cell content tends to decline while the proportion of lignin protected cellulose and hemicellulose and othe indigestible fractions such as cuticle, silic increase. Minson (1971) has shown a linear declin in the digestibility of cellulose as the percentag of lignin in cellulose is increased.

As plants grow, there is a greater need fo: structural tissues, and therefore the structura CHOs (Cellulose and hemicellulose) and ligni: increase. This is reflected in the CF conten which in the dry matter may increase from below 20% in young plants to as much as 40% in mature crop. As the plant ages, the percentage of protein decreases; there is therefore a reciprocal relationship between CP and CF in a given species, although this can be upset by the application of nitrogen fertilisers (Greenhalgh ad MacDonald 1973).

Forages are highly digestible at young and immature stages of growth and this declines with age. The initial high digestibility is attributed to the high level of cell contents and high digestibility of the cell wall fractions. The cell wall constituents become increasingly indigestible as the plant becomes more mature, dry and fibrous (Hamilton 1970).

In an experiment with grass of Digitaria spp (Cowlishaw and Miller 1976) observed a linear increase in CF content amounting up to 1.58% per week when the grass was cut at weekly intervals for up to 8 weeks.

The greatest differences in digestibility between forages are those due to differences of stage of growth, and as the plants mature, their composition show large changes (Corbett 1969). To the animal, the most important change is the increase in structural constituents especially lignin which with a variety of other substances contribute to the CF fraction.

Even in the young plant, cellulose and hemicellulose comprise at least one-third of the dry matter, but are then highly digestible (Waite et al 1964). As their concentration in the plant increases, their digestibility decreases. This may be due in part to physico-chemical changes such as an increase in crystallinity (Halliwel and Head 1961) or degree of polymerisation of the cellulose chiefly due to lignification.

Further investigations carried out in Australia (Milford ad Mirison 1966, 1968) on the daily intake (g/kg LWT 0.75) for several forages, chloris gayana included, at various stages of growth indicated that the intake of these samples declined with increasing maturity. This was also confirmed by Crowder and Chedda (1982).

A daily decline in digestibility of 1% was observed in a trial on a commonly grown Nigerian pasture species Cynodon nemfluesis (Mohammed Saleem 1978). Another important change that occurs as pastures mature is that the proportion of stem compared with leaf increases. The stem fraction at a given stage of growth is often of lower digestibility as shown by the data of Jones (1969).

Age of regrowth (days)		56	84	112
Invitro OMD (%)	Leaf	64.8	66.4	68.5
	Stem	59.8	63.1	59.8

However, even at similar levels of digestibility, intake of leaf is up to 46 percent higher than for stem (Laredo and Minson 1973). Thus, increasing the proportion of stem in the pasture reduces the overall nutritive value of the dry matter on offer.

2.1.2 Lignification

The physico-chemical structure of the cell wall is important in determining the biodegradability of the component parts of hte structure. There are three possible modes of action of lignin upon the availability of plant carbohydrates:

- Lignin is toxic to digesting micro organisms
- Lignin physically encrusts CHOs, rendering parts of them inaccessible to digestive organisms
- Lignin is linked to CHOs by covalent and hydrogen bonds which cellulytic organisms do not possess appropriate enzymes to hydrolyse.

Of these theories, the first has been recognised, but highly ignored (Maynard and Crampton 1938). The theory of encrustation has been supported by evidence that ball milling of lignified tissue greatly increased the *in-vitro* digestibility of cellulose (Dehority *et al* 1962). As for the third theory involving lignin-CHO bonds, recent evidence shows that lignin surrounds the carbohydrates and renders them unavailable although the nature of the bonds formed is controversial (Head 1966).

However, it should be appreciated that structural carbohydrates are not completely digestible with the main factor limiting the extent of digestion being lignin. Isolated lignin had no effect on *in-vitro* cellulose digestion, but there were good relationships between increasing maturity, increasing lignifaction and decreasing digestibility of cellulose (Johnson and Dehority 1965).

Further evidence that lignin is the principle factor affecting availability of cell wall carbohydrates lies in the increase in digestibility obtained when plant fibres are delignified (Hvidsten and Simonsen 1952). The very low digestibility of wood can be increased to about 95% for ruminants by paper making processes (Saarinen *et al* 1959).

The usefulness of CF to the host animal depends initially on its digestion by the rumen or caecal microflora. The extent of microfloral activity depends in part on how adequate the ration is in Nitrogen and Phosphorous which are needed for the nourishment of microflora.

It is suggested that when nitrogen intake is below a critical level, activity of rumen micro-organisms is reduced, so that efficiency and rate of digestion of DM, and hence its intake is inhibited (Minson 1971). However, it has been shown (Egan 1977) that sheep on low nitrogen diets (1 to 1.5 g N per 100g DM), dry matter intake was increased by 15-20% when readily available soluble protein was perfused directly into the duodenum.

2.1.3 Pasture Species

The nutritive value of pasture species even at similar stages of growth varies widely, both in DMD and voluntary intake. Reviewing comparison of over 1000 tropical and temperate grass samples, Minson and Macleod (1970) showed that tropical grasses were on average 13% units lower in DMD. Most samples of temperate grasses had digestibilities above 65 per cent, but few tropical grass samples were in that category.

The tropical environment differs in that there is generally a much higher solar intensity, which, in combination with adequate moisture and high temperature results in rapid plant development and growth toward maturity. As presently grown, tropical forages are on average inferior to temperate ones (McDowell 1972; Van Soest 1982). However most of this difference could probably be corrected with better management of tropical plantings.

Minson and Macleod (1970) suggested that low DMD% values of tropical grasses may, in part, be due to higher growing temperatures, but the data of Reid and Rugerwa (1973) supports the view that for selected species of tropical grasses such as Brachiaria spp, Chloris spp, Setaria and Panicum spp, DMD values are comparable to those of similarly managed temperate grasses.

The protein content of tropical forages has been shown to be generally low, falling rapidly with growth to time of flowering. During the dry season, this drops even further to as low as 2% (French 1957; Bredon et al 1961)

A review of tropical grasses in terms of milk production showed that production per cow per day *when measured at low grazing would be about 8 -*

9Kg; contrasted to 16Kg/cow/day for cows grazing temperate grass (Greenhalgh and Stobbs 1971). The lower production per cow on tropical grasses may be explained by lower intake, primarily due to lower digestibility (Hamilton <u>et al</u> 1970) although low protein may sometimes be a factor (Hardison 1966). Tropical grasses are low in protein and energy largely as a result of their rapid growth as influenced by light and temperature (French 1967; Devendra and Gohl 1970).

2.1.4 Environmental Factors

Climate - The relative importances of temperature, light and moisture upon the nutritive value of pastures are in the order listed.

(i) Temperature - increases metabolic activity of all nonhomeothermic organisms (Van Soest 1982). This means a more rapid turnover of energy and pooled metabolites as well as more rapid synthesis of new cells and substances. Plants accumulate cell wall structures containing lignin and cellulolytic CHOs that are irretrievable by the organism and accumulation of lignin and CWC is likely to be a temperature related phenomenon because of the more rapid collection of metabollites. Increasing temperature tends to lower nutritive value at the same physiological age in grasses (Wilson 1983).

As a result of requirement for frost hardiness, forages grown in cold climates develop reserves of CHO s and proteins in leaves and stems that are of high nutritive value. Low yield and high nutritive value are characteristics of temperate grasses (Stobbs 1973).

(ii) Light - supports photosynthesis which fosters the synthesis of sugars and organic acids. Independent of temperature, this becomes a vector towards increasing digestibility of the plant. (Van Soest 1980)

(iii) Moisture The effect of moisture is more variable if moisture is limited, the plant may be prevented from developing toward maturity. However, some adapted perennial plants go into dormancy in a dry season, pulling reserves into the roots and leaving an upper part of lower value. Moisture content of pasture is of particular importance where a crop is being harvested for conservation and is high at earlier stages of growth,but falls as the plants mature. (Cowlishaw and Miller 1976)

2.1.5 Effects of fertilisation

Crude protein content as influenced by fertiliser nitrogen is the most important effect of fertilisation (Van Soest 1982). The effects of other minerals is mainly on yield and content of the in the forage. Digestibility is affected very little althogh palatability maybe.

N fertilisation of grasses increases CP content, depresses soluble CHOs in leaves and stems and promotes more rapid lignifaction.

2.2 Estimation and Prediction of Digestibility

Digestibility, expressed as DM, OM, energy or TDN is the most commonly used measure of nutritive value. It is used mostly because of the relative ease with which it can be applied as well as its reproducibility compared to consumption and efficiency which are other indices of nutritive value (Van Soest 1982). Various methods of digestibility have been described:

APPARENT DIGESTIBILITY

This is the balance of feed ingested less the matter lost in the faeces. This method assumes that whatever does not appear in the faeces has been digested and can be applied to DM, energy or any other feed component. (MacDonald *et al* 1987).

TRUE DIGESTIBILITY

This is the actual digestibility or availability of a feed, forage or nutrient as represented by the balance between intake and faecal loss of the same undigested material. True digestibility of whole rations, forage and protein is always greater than apparent digestibility because part of the faeces is of metabollic (non feed) origin (Van Soest 1982).

2.2.1 INVIVO ESTIMATION

The standard technique for estimating digestibility is based on measuring the intake and digestion of cut pasture samples fed to animals in metabolism pens (Minson 1971). This is termed *invivo* estimation. Forages to be compared must be grown under the same conditons, cut and fed at the same time.

The invivo estimation involves the determination of difference in nutrient content between feed eaten and materials voided as faeces (McDonald *et al* 1987). The nutrient being considered can be CP, DM, OM and so on.

As for DM,

$$DMD\% = \frac{\text{DM eaten} - \text{DM faeces}}{\text{DM eaten}} \times 100$$

This gives the apparent digestibility and represents the proportion that does not appear as waste in faeces.

Advantage:

- obtains results that are applicable to the animals used in the trial

Disadvantage

- requires considerable work and time, and is costly too.
- a number of animals to experiment with are needed.
- demands for a considerable amount of herbage.

Moreover, the digestibility of herbage is influenced by the type and breed of animal, its age and health. Digestibility thus obtained is not a constant characteristic of the herbage (Tilley and Terry 1973).

2.2.2 Laboratory Methods For Predicting Digestibility

Some chemical laboratory methods have been proposed for use with small pasture samples owing to the time and expense in invivo feeding trials. Some of the methods are:

(i) Nylon bag technique - in which preweighed ground samples of feed are put in small nylon bags which are placed in the rumen of a fistulated animal. After 48 hours, the material is removed and subjected to acid-pepsin digestion and weight of the DM determined.

(ii) 2-stage invitro estimation

For tropical pastures, this has become the most accurate lab method for predicting digestibility. It has given the lowest errors in prediction and is used for rapid screening of a large number of samples since it was developed by Tilley and Terry (1963).

Stage one of this method stimulates digestion of feed stuff in the rumen by action of rumen micro-organisms. The method involves a weighed quantity of ground forage placed in a test tube to which artificial saliva and rumen fluid innoculum are added. The rumen fluid can be obtained from rumen-fistulated sheep or goats, fed on a high quality grass diet.

Stage two simulates the digestion, primarily of protein and energy in the lower digestive tract using acid pepsin or neutral detergent.

Advantages

1. There are many sources of variation in the method which make it difficult to standardise and adapt to a routine economic method of testing forages.
2. This method is less useful in satisfactorily assessing feed intake or animal efficiency (Van Soest 1982)
3. It tends to yield higher values because some animal metabolic products cannot be generated invitro.

(iii) Cellulase digestion technique

This is a more recent technique which promises to be more rapid, convenient and precise than the invitro method (Jones and Hayward 1975).

In this experiment, the invivo and invitro techniques are used. A drop in digestibility as the grass matures is expected and a reciprocal relationship between CP and CF with the former falling with age.

2.3 EFFECTS OF DIGESTIBILITY ON THE ANIMAL

Low digestibility usually results from feeds of high fibre as is the case with older plants where lignification is high. In the first instance, the rate at which physical breakdown in the rumen occurs is slow (MacDonald et al 1966). This also delays enzyme access to the food constituents and results in lengthy retention in the rumen. As a result of poor digestibility therefore, uptake of nutrients by the animals is impaired with poor performance being recorded (Norris et al 1973).

2.4 ANIMAL FACTORS AFFECTING DIGESTIBILITY

The factors which may affect digestibility of feeds in the animal are such as stress on the animal and its health. A sick animal will be less inclined to ingest feedstuff and even if it ate, the digestibility is poor because of disease which is defined as a deviation from the normal physiological function of the body (Hall et al 1978). Digestive upsets in the animal can also cause low digestibility. A normally ruminating cow will defaecate 12 - 18 times a day giving at least 40Kg of moderately hard faecal material (Alexander, 1978). Below 12 defaecations is indicative of low digestibility while above 18 times indicates a stomach upset and usually results in waterly stool.

Stress is a deviation from the conditions that animal is content with. It can either be due to high temperature and humidity, or high radiation, overcrowding and intimidation. The effect of high temperature is very pronounced with food consumption and rumination practically ceasing in Bos taurus type cattle (Perry and Wainman 1961). Increasing humidity with high temperature has been seen to depress intake (Ragsdale *et al* 1953) while radiation stress has the same effect on *Bos taurus*, but nct on *Bos indicus* type cattle (Brody *et al* 1954).

CHAPTER 3

MATERIALS AND METHODS

The experiment was carried out at the University of Zambia, School of Agricultural Sciences, Field Station.

Rhodes grass (*Chloris gayana*) cultivar Katambora was broadcast on a well prepared plot (70m x 58m) and fertilisation was as prescribed in the Zamseed production manual at 500Kg/ha of D-compound fertiliser. The plot was divided into five equal sub-plots from which grass was harvested at different growth stages, meaning that each collection had five replications. The growth stages are designated 1 to 8 according to progressive growth stage as given below.

HARVEST LEVEL	AGE IN WEEKS	HEIGHT (CM)	INFLUORESCENCE
1	4 weeks after emergence	12	Nil
2	6 weeks after emergence	20	Nil
3	8 weeks after emergence	30	Nil
4	10 weeks after emergence	45	First seen
5	12 weeks after emergence	60	Increasing
6	14 weeks after emergence	70	>50%
7	15 weeks after emergence	>70	>50%
8	4 days later	>70	>50%

At each harvest level, average height was determined and the area harvesed noted too. This was done to facilitate for the estimation of DM yield per hectare. (Table 4). Each of the samples collected was oven dried at 100^{0}C for 24hours in order to determine dry matter.

The 8th sample was cut and left to dry as hay in the field for 4 days before being collected and put to safe storage. A representative sample of the hay was oven dried and DM determined too. The dried samples were then ground to pass through a 2mm and 1.5mm sieve, bulked and stored. A representative sample at each harvest level was taken for chemical analysis.

3.1 CHEMICAL ANALYSIS

Proximate chemical analysis was done for (DM, Ash, EE, CF, GE, OM and CP) for each of the samples. ADF, NDF cellulose and lignin were also determined by using the methods of Goering and Van Soest (1970).

DM was determined by drying each of the samples at 100^{o}C for 24 hours as stated. OM was calculated by subtracting the Ash content from dry matter. Ash was determined by subjecting the samples to 550^{o}C for 3 hours until they were ashed (A.O.A.C. 1970).

Gross energy was determined by using a 1241 Adiabatic Bomb Calorimeter as per instructions given in the Laboratory Analysis handbook.

All results are shown in Table 1.

3.2 ESTIMATION OF DIGESTIBILITY

Digestibility was estimated by using the 2-stage <u>invitro</u> fermentation technique (Tilley and Terry 1963). The rumen fluid was collected from a rumen-fistulated sheep that had been on a grass diet prior to collection of hte fluid. The basic steps used were as by Minson and Macleod (1972). In this experiment only CMD was estimated and results are as shown in table 2 for all the eight samples

Digestibility was calculated by looking at nutrient content in faecal material compared to that in the hay sample. For example

$$OMD(\%) = \frac{OM\ hay - OM\ faeces}{OM\ hay} \times 100$$

The same equation was used for calculating the digestibilities of CP, CF, GE and DM. Results are given in table 3.

3.3 ANALYSIS OF RESULTS

There was no statistical analysis of data apart from the comparison of the chemical composition of the different levels of harvest of the grass.

Invitro OMD at the different growth stages was also noted. *Invivo* OMD for sample number 8 was compared to the *invitro* OMD for the same sample.

Therefore, analysis of results was more descriptive than statistical with an explanation being offered for each set of results obtained as given in the discussion of results.

TABLE 1

NUTRIENT COMPOSITION OF RHODES GRASS AT DIFFERENT GROWTH STAGES

HARVEST LEVEL	1	2	3	4	5	6	7	8
DM %	34.4	36.8	44.07	51.63	64.36	68.41	69.73	72.31
OM %	29.92	32.28	38.44	45.67	53.05	60.31	64.59	65.88
EE %	2.18	2.01	1.94	1.81	1.69	1.54	1.48	1.44
GE (Kcal/g)	4.09	4.05	4.01	3.99	3.99	3.90	3.74	3.06
CP %	8.61	8.01	7.58	6.03	5.68	4.2	3.8	2.83
CF %	32.34	32.63	34.37	36.14	38.70	39.88	42.36	42.00
ADF %	22.22	26.64	29.42	35.29	34.55	36.25	37.23	34.68
NDF %	68.46	65.56	66.95	67.72	71.52	72.97	74.19	70.75
Lignin %	3.82	4.49	4.34	6.17	5.75	5.94	6.13	6.21
Cellulose %	18.42	24.42	23.63	28.42	29.12	30.26	30.48	29.92

TABLE 2. INVITRO ORGANIC MATTER DIGESTIBILITY OF GRASS SAMPLES

HARVEST LEVEL	1	2	3	4	5	6	7	8
OMD (%)	75.52	69.63	71.63	60.14	64.24	60.95	56.1	54.1

TABLE 3 INVIVO NUTRIENT DIGESTIBILITY FOR HAY SAMPLE (%)

DM	CF	GE	CP	OM
70.98	40	58.17	36.22	62.82

TABLE 4 DRY MATTER YIELD FOR THE DIFFERENT SAMPLES OF GRASS

YIELD LEVEL	1	2	3	4	5	6	7	8
DM Yield tonnes/ha	1.75	2.98	4.13	6.69	8.64	10.28	12.49	14.5

CHAPTER 4

RESULTS

Proximate chemical composition values for the different harvest levels of the grass are presented in Table 1. DM values show an increase with advancing maturity from 34.4% at first harvest, to 72.31% at the hay stage. DM is a rough estimate of the amount of nutrients, usually CHOs and a few proteins which remain the feedstuff after moisture has been removed. It may also contain some fat, ash and silica.

DM yield per hectare is given in table 4. There is a gradual increase in yield from 1.75/ha to 6.69 t/ha between the first and fourth harvest levels. After flowering at the fifth level, there is a drastic rise (8.69 t/ha) and this tendency continues up to the last harvest.

Similar patterns of increasing content are observed for CF, ADF, NDF and OM. The CF fraction contains cellulose, lignin and hemicellulose and ranges between 32.34% in the initial harvest to 42.03% in the hay. This is consistent with the observations made by Salim (1978) on plantings of Rhodes grass done in Tanzania where CF values were between 28% and 44% at 4 weeks and at time of harvest as hay. ADF divides the CHOs into those which are readily available and digestible, and those poorly available. NDF is a measure of total CWC of the sample which excludes soluble contents like sugars, starch and fats, but includes hemicelluloses, cellulose and lignin too.

Buttersworth (1967) had CF ranges of 24 - 47%, ADF and lignin ranges of 30-40% and 1-11% respectively when he experimented with chloris gayana at different growth stages, although this did not differ much with ranges for temperate grasses (Minson and Macleod 1970). Lignin in this experiment ranged between 3.82-6.21% between the initial harvest at 4 weeks and the hay at 15 weeks indicating an increase of 0.22% per week.

A reciprocal relationship is established between CF and CP with the former increasing as the latter falls. The CP levels between the first and fourth harvest stages are 8.61%m, 8.01%m, 7.58% and 6.03%. These figures are near the maintenance requirements for an average ruminant animal at 8.5% CP (NRC publication No. 4, 1970). Woodman and Fagan (1968) observed a progressive fall in protein content of various pastures as they matured, which was accompanied by an increase in fibre.

The ether extract (EE) gives a non specific energy source and contains fats, oils, waxes, organic acids, sterols and vitamins A,D,E,K. This was reducing wiht maturity and the reduction was more drastic after flowering had occured. It ranged between 2.18% in the initial harvest and 1.44% in the hay sample. Gross energy was also dropping as the plant matured although the drop is more steady.

4.1 INVITRO ORGANIC MATTER DIGESTIBILITY

The results for invitro OMD are given in table 2 for all the harvest levels which show a reduction too. Harvest level one was at 75.52% OMD while the hay was 54.1% OMD. This reduction in digestibility comes in the wake of increasing OM. This reciprocal tendency has also been observed by Johnson (1972) and Harris et al (1973).

4.2 INVITRO AND INVIVO OMD

The OMD of the hay sample as analysed both by invitro and invivo estimations (results in table 3) gave the results as 54.1% and 62.82% respectively. This contrasts with Van Soest et al (1972) who noted that invitro OMD was higher and attributed this to the fact that some of the synthetic materials used in the estimation cannot be produced in the animal and hence results in higher invitro OMD.

CHAPTER 5

DISCUSSION

An increase in DM and OM was observed as maturity set in. The reason for this is that there is an increase in percentage of cell wall contents which give the plants its structure and strength. A young plant tends to have more of water than other CWCs which explains the low DM and OM at the initial stages of growth. There is generally an increase in the structural tissues as the plants grow older.

The rate of DM accumulation is faster between the seedling emergence and flowering stage at fourth harvest level. This is during vegetative growth beyond which comes the reproductive stage when the plant devotes most of its energy to the development of flowers and seeds. This is also confirmed by the DM yield pattern.

MacDonald et al (1966) observed a similar pattern of increased DM, OM, ADF, NDF and CF in an experiment with 14 tropical pasture species and concluded that as plants grew, there was greater need for structural tissues and therefore carbohydrates like cellulose, hemicellulose adn lignin increased. This was reflected in the CF content which rose from below 200g/kg DM in a young plant to as much as 400g/Kg DM in mature plants.

The role of protein in the overall quality of tropical grasses cannot be dismissed. The level of CP below which nitrogen is the first limiting factor in tropical grass is about 7% on the

DM basis (Minson and Milford, 1967). This is approximately the minimum level required for positive nitrogen balance (Milford and Haydock 1968). Therefore, when an explanation of unexpected low production is sought, the CP percentage should be examined first, before turning to structural limitations and then to other nutrients and toxic agents (Moore et al 1969).

This means that the cutting stage for grass is when minimum CP requirement is just about met and adequate dry matter has been accumulated. The need for adequate DM is what a farmer desires that his herd eats to fill their stomachswithin minimum feeding time, but that the feed should also be digestible. After flowering, plantings tend to concentrate their reserves on the development of their reproductive system and the acquired DM begins to lignify. The 4th harvest level should meet the CP requirements and provide adequate dry matter which is fairly digestible. The grass should not be harvested at earlier stages of growth unless efficient drying equipment is available that will dry the grass without adversely affecting the availability of nutrients.

Besides, dry season feeding for which hay is essentially cut, is done for maintenance purposes and the energy for this comes from the digestion of structural carbohydrates. But these are lower at early harvest. More and more of the feed would have to be given in order to meet the intake requirements of the animals and this entails cultivation of a larger area. At the same time, very late harvest would provide a high DM supply to the animals with other nutrients deficient and less available because of poor digestibility resulting from high lignification.

A compromise has to be struck among such characteristics as energy provision, protein availability, lignification and digestibility in order to determine cutting stage. DM increases with age of plant as seen in the yield levels (Table 4), but should be given when it is moderately digestible. In this experiment OMD at the 4th harvest was 60.14%. According to Hamilton et al (1970), a digestibility of DM, OM and energy of 65% in a grass should be indicative of good nutritive value and should permit an adequate intake of digestive energy, except in lactating animals.

This is also consistent with the findings of Minson and Macleod (1970) where the frequency distribution of OMD for 592 cuts of temperate grasses and 543 cuts of tropical grasses were plotted; the highest frequency for temperate grasses was 70-75% while the tropical grasses were at 55-60%.

In this experiment, invitro OMD values were reducing as the plant matured. This can be attributed to the increasing lignin content in plants. Lignin binds most of the CWC to its own structure and hence, reduces their digestibility. This is consistent with the findings of Schank et al (1973) who observed a decrease in OMD as grass plantings of the _Hemarthria_ spp matured and attributed the drop to the lignification of the bundle sheath cells. Fagan and Woodman (1968) also observed a fall in digestibility with age in an experiment with temperate grass species and agreed that this was due to the conversion into fibre of soluble and easily digestible CHOs.

5.1 INVITRO AND INVIVO OMD RELATIONSHIP

The _invitro and invivo_ OMD results showed a higher degree of digestibility in _invivo_ estimation than in the other. The discrepancy in this experiment can be due to the different animals used in both experiments. The rumen fluid used in invitro analysis was obtained from sheep, while _invivo_ analysis was carried out in feeding trials with goats. Goats are generally known to be efficient converters into their own use of the worst kind of feed in a given circumstances; that is, they are likely to survive more than sheep in rough environments (Devendra and Leroy 1978). Therefore, the difference in ability to digest material could have been due to varying degrees of rumen fluid activity.

The difference could also have been due to experimental error when carrying out the feeding trials. Even though the goats were given 10 days in which to acclimatise to the new feed with 10% more feed being given on each subequent day, they had not stabilised in their intake and this could have affected the OMD results.

Further speculation could be that the rumen fluid used in the invitro OMD estimation was of low activity. Normally, temperate pastures on which the sheep that provided the rumen fluid was fed, are supposed to be of a higher nutritive value than tropical grasses at similar growth stages (Whiteman 1980), and hence higher rumen fluid activity. But then, poor management even in the temperate pastures can resist in loss of quality. Therefore, the low activity of rumen microbes can be attributed to poor quality herbage prior to collection. Another reason for the higher invivo OMD can be due to the slow rate of passage of the grass feed in the rumen. Although rate of passage was not measured, the highly lignified hay would have delayed in its passage through the rumen, hence allowing for greater digestibility by the rumen micro-organisms. The passage of food through the the gastral intestinal tract is influenced by a number of factors such as quality of the feed, texture of the ingredients, chemical composition and so on (Galyean et al 1987). At maturity, pasture is just a little better than straw with its low protein level and hence will stay longer in the rumen for maximum utilisation of available nutrients by the micro-organisms. However, this also depresses intake.

CHAPTER 6

CONCLUSION

The nutritive of grasses decreases with age. Nutrients that fulfil the requirements of ruminant animals tend to be more available at a young age of hte plants and yet harvest at this stage is not encouraged. Plants at this stage are more of moisture than structural tissues which will only increase with maturity. This is observed in the DM content as well as total DM yield per hectare which increases. The major DM components are CHOs and some proteins. These comprise the structural tissues which supply energy once digested in the rumen. Unfortunately, one of the structural tissues is lignin which as it increases binds the other more available nutrients to its structure and renders them indigestible and hence, poorly available for animal uptake.

Therefore in determining an optimum cutting stage of grass for hay, the factors to consider are such as amount of lignification, CP content and accumulation of dry matter which must also be reasonably digestible. Digestibility tends to fall drastically after flowering because of increased lignin. In this experiment, the fourth harvest level at 45-60cm above ground is suggested as optinum. The plants have acquired enough DM and the CP level is within acceptable limits. Lignification is not so serious as to markedly affect the digestibility of other nutrients.

FUTURE RESEARCH

There is a time when grass hay is just a little better than straw in terms of nutritive value. To improve its potential for ruminant nutrition, there is need to incorporate compatible legume forages which have been reported to be of high nutritive value. Future research should look at the nutritive value of a grass-legume fodder.

The use of similar species of animals is recommended for both invitro and invivo digestibility estimations to reduce the experimental error that goes with using different animal species. There is need for replication of results so as to allow for statistical analysis and to establish whether the observed differences are significant or not.

CHAPTER 7

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