Optimal stage of maturity for feeding napier grass (*Pennisetum purpureum*) to dairy cows in Kenya

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Abstract

Two experiments were conducted to determine the maturity at which napier grass (*Pennisetum purpureum* var. Bana) should be fed to dairy cows in Kenya. The grass was grown in two fields and irrigated to simulate precipitation in the high (1200 mm/yr) and medium (800 mm/yr) rainfall areas in Kenya. The height, chemical composition and yields (Experiment 1) and *in vivo* digestibility (Experiment 2) of the grass were determined weekly from week 3 to week 15 of growth. Optimal maturity for feeding was determined using crude protein concentration, yields of digestible organic matter and crude protein, and crude protein:digestible organic matter ratio methods. Height and yield increased and *in vivo* digestibility and nutrient ratio declined as the grass matured (P < 0.001). Although the height and yields of high-watered grass were 3 times those of low-watered grass, organic matter digestibility was higher on low-watered grass (P < 0.001). The optimal ages for feeding obtained using these methods were within the 6–10 weeks but the heights were different from the 60–100 cm ranges that are recommended in Kenya. Further, the recommended maturity was different and more specific for each watering regime. The nutrient-ratio method was preferred since it considered the interrelationship between protein and energy concentrations. This method indicates that napier grass should be fed to dairy cows at 55–60 cm (7–8 wk) and 130–140 cm (9–10 wk) in the medium and high rainfall areas in Kenya, respectively.

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Introduction

Dairy production in Kenya is concentrated mainly in the medium and high potential areas receiving annual rainfall of about 800 and 1200 mm, respectively. Napier grass (*Pennisetum purpureum* var. Bana) is the main feed resource in these areas due to its high yields of dry matter (Stotz 1981). As napier grass matures, yields of dry matter (DM) increase whereas the crude protein (CP) concentration declines (Boonman 1993). In Kenya, it is recommended that the grass be fed to dairy cows at a height of 60–100 cm or 6–10 weeks of growth (MLD 1991). This general recommendation is based on the optimal CP concentration (10–12% DM) for moderate milk production by dairy cows (ARC 1984). The average carrying capacity based on yields of DM at these levels of CP was estimated to be 3.8 cows per hectare (Snijders 1989). However, for better utilisation and performance, more precise recommendations on maturity at which to harvest the grass and the corresponding carrying capacities are required for napier grass in areas with varying levels of precipitation.

Chemical composition is a measure of the potential to supply nutrients, whereas DM yields indicate the carrying capacity of a forage. The first step in estimating the nutritive value of a feed is to measure digestibility. Most data on digestibility of napier grass have been based on *in vitro* digestibility which is a less reliable estimate of nutritive value than *in vivo* digestibility (McDonald *et al.* 1988). Available information on *in vivo* digestibility of napier grass was determined on material at limited stages of growth and at *ad libitum* feeding levels (Thomas *et al.* 1980; Anindo and Potter 1994; Muinga *et al.* 1995).

Information on changes in yields of digestible nutrients as the grass matures is scarce. Furthermore, the optimal maturity to harvest the grass in the medium and high rainfall areas, based on yields of digestible nutrients, needs to be determined.

Energy and protein concentrations of a feed influence the performance of animals, and their interrelationship is important (Tamminga 1982; Nocek 1988; Oldham 1988). The protein:energy (nutrient) ratio of the ingested diet has an influence on the nature and extent of rumen fermentation on one hand and utilisation of energy, microbial protein and undegraded protein in the small intestines on the other (Van Es 1980). The nutrient-ratio method is, therefore, closely related to utilisation of a diet and animal performance and would be a useful method for determining the optimal maturity at which napier grass should be fed to dairy cows in Kenya.

The objectives of this study were to:

- compare the estimated optimal maturities for harvesting napier grass using the optimal CP concentration, yields of digestible nutrients and nutrient-ratio methods with each other and with the current recommendations in Kenya; and
- make specific recommendations for harvesting the grass in the medium and high rainfall areas.

Materials and methods

Study site

The study was conducted from January 1994–February 1995 at the National Animal Husbandry Research Centre (0° 40' S, 36° 26' E; altitude 1940 m), Naivasha, Kenya. The mean annual rainfall of 650 mm is received mainly in late March–June and October–December for the long and short rains, respectively. Irrigation is, therefore, required for improved forage and fodder production. Although the mean temperature is 17.8°C, daily values range from 7–26°C, particularly in the dry months. The soils are dark grey-dark brown with humic top-soil, and are very deep and slightly–moderately alkaline (Jaetzold and Schmidt 1983).

Management of napier grass

Napier grass (var. Bana) was established on 2 fields (A and B) using root-splits spaced at 60 and 90 cm within and between rows, respectively. A preliminary study indicated that field A was more fertile than field B (Table 1). Compound fertiliser (N:P:K, 20:10:10) was applied to field B only at 500 kg/ha/annum and top-dressing was done using C.A.N. (26% N) at 50 kg/ha after harvesting the grass. Analyses of soil samples at 5 weeks of growth of the grass indicated that fertility status of both fields was comparable as a result of fertilising (Table 1). The grass in fields A and B was irrigated fortnightly for 24 h and 8 h, respectively. The total amount of water available was 1200 mm in field A and 800 mm in field B, which was aimed at simulating annual precipitation in high and low rainfall areas of Kenya, respectively.

Experiment 1

Each field of 1.36 ha was divided into 7 equal plots (70 m × 27.7 m) which were further subdivided into 13 equal sub-plots (10 m × 14.9 m). The grass was cut weekly from week 3 to week 15. The different harvesting ages of the grass were allocated randomly to the various sub-plots within each plot. At each stage of growth, the height of 50 randomly selected plants was measured using a 2 m stick, as the distance from ground level to the apex of the majority of the leaves. Height was considered to be a more appropriate measure than age for determining maturity of napier grass at farm level. At each maturity, the grass was harvested from the respective sub-plots, weighed and yields per hectare calculated.

Experiment 2

The harvested grass from Experiment 1 was used to determine *in vivo* digestibility. Six Dorper wethers, aged 16.2 (± 1.7, ± s.e.) months and weighing 40.4 (± 3.2) kg, were fed in metabolism cages which allowed separate watering, total faecal collection and feeding at about a maintenance level of intake. The animals were weighed on 3 consecutive days to obtain mean liveweight and drenched to control internal parasites at the start of the experiment. For each stage of growth, enough grass to feed the 6 sheep for 14-day adaptation and 5-day faecal-collection periods was harvested. The grass was chopped using a motorised chaff-cutter to a size of 2.5 cm to minimise selection by sheep, weighed into plastic bags and stored at −20°C. Prior to feeding, the grass was thawed to room temperature. At each maturity stage, *in vivo* digestibility of the high-watered grass was determined 19 days earlier than that on the low-watered grass using the same sheep. The sheep were fed 3 times per day at 08.00, 13.00 and 18.00 h. A mineral mix and clean water were available *ad libitum*.

Faeces of each sheep were weighed before feeding and representative samples (20 % of total collection) were preserved using 20 ml formalin solution (10 % V/V) and stored in plastic bottles at 3–5°C. Organic matter (OM) and CP digestibility coefficients were calculated according to procedures of Close and Menke (1986).

Sampling and chemical analyses

Soil samples were taken at random from each field at depths of 0–15 cm and 15–30 cm for top- and sub-soil, respectively. The pH and fertility status of the soil were determined using the procedures in a manual by Hinga *et al.* (1980). Representative samples of napier grass were taken before feeding to the sheep. Feed and faecal samples were bulked for the 5-day collection period. Representative sub-samples of the bulked material were taken according to procedures of Van Soest and Robertson (1985).

The DM concentrations in feed and faeces were determined by drying at 105°C for 24 h and total ash by ashing at 450°C for 6 h. Samples for chemical composition were dried at 70°C for 24 h and then ground to pass through a 1 mm screen. The CP concentration in feed was determined according to the procedures of AOAC (1990). The CP concentration in faeces was determined on fresh material as described by Van Soest and Robertson (1985).

Calculation of parameters

The yield of digestible nutrients (YDN) was calculated from the yields of nutrients (YN) in Experiment 1 and their respective digestibility (ND) coefficients in Experiment 2 as follows:

YDN (tonnes/ha) = YN (tonnes/ha) × ND (%)/100.

The CP: digestible organic matter (nutrient) ratios (NR) were calculated from yields of CP (YCP) and yields of digestible organic matter (YDOM) as follows:

NR (g CP/kg DOM) = YCP (g/ha)/ YDOM (kg/ha).

Statistical analyses

The data from Experiment 1 were analysed using a split-plot design with 7 replications. The main plots were the experimental units to determine the effect of watering regimes (2 levels) on height, chemical composition and yield of the grass whereas the sub-plots were the experimental units to determine the effect of age (13 levels) on these study parameters.

The data from Experiment 2 were analysed using a completely randomised design replicated 6 times (sheep). The watering regimes and stages of maturity of the grass were the treatments. The analysis of variance and mean separation for the determined and calculated parameters were done using the general linear model (GLM) procedures of the Statistical Analyses Systems (SAS 1988).

Results

Extractable nutrients and pH of the soil in the two fields

Before the experiment was started, the fertility status (K, P and N) of field A was superior to that of field B but after application of fertiliser to field B, the fertility of both fields was comparable (Table 1).

Height, chemical composition, yield and in vivo *digestibility*

The changes in height, chemical composition, yield and *in vivo* digestibility of napier grass with time under the 2 watering regimes are shown in Table 2. Height, DM and ash concentrations, yields of OM and CP, and OM digestibility were affected by both watering regime and age ($P < 0.001$). The CP digestibility was affected by age but not watering regime ($P < 0.001$).

The average height was about 70% greater for the high-watered grass and increased by 11.5 cm/wk compared with an increase of 6.4 cm/wk for the low-watered grass. Although the DM concentration was increasing at a similar rate (2.80 g/kg DM/wk), the average was 16% higher for the low- than the high-watered grass. Mean yields of OM and CP on the high-watered grass were 3 times those on the low-watered grass. As the grass matured, rates of increase in yields of OM were 0.91 and 0.30 t/ha/wk on the high- and low-watered grass, respectively. The yield of CP increased to a maximum (high, 1.03;

Table 1. Extractable nutrients and pH of soil in fields A and B before experiment and at 5 weeks of napier grass growth.

	Before experiment				At 5 weeks of napier growth			
	Field A		Field B		Field A		Field B	
	Top-soil	Sub-soil	Top-soil	Sub-soil	Top-soil	Sub-soil	Top-soil	Sub-soil
pH	7.73	7.89	7.59	7.69	7.82	7.78	7.61	7.66
Na[1] (me)[2]	2.37	2.63	2.47	2.58	2.29	2.51	2.46	2.39
K (me)	3.26	2.53	1.67	0.92	3.10	2.06	2.93	2.16
Ca (me)	20.50	21.52	19.67	18.97	18.41	17.32	18.91	17.34
Mg (me)	2.21	3.12	2.50	3.74	2.11	3.02	2.34	3.50
Mn (me)	0.71	0.51	0.63	0.47	0.65	0.47	0.58	0.42
P (ppm)	125.36	128.41	78.42	71.30	120.42	111.70	116.41	99.72
C (%)	3.59	2.53	1.82	1.67	3.07	2.32	2.87	2.41
N (%)	0.36	0.25	0.18	0.17	0.31	0.23	0.29	0.24

[1] Na, sodium; K, potassium; Ca, calcium; Mg, magnesium; Mn, manganese; P, phosphorus; C, organic carbon; pH, hydrogen potential.
[2] milliequivalents.

Table 2. Changes in height, chemical composition, yield and *in vivo* digestibility of napier grass from 3 to 15 weeks of growth under two watering regimes.

Watering regime	Regression equation[1]	r^2	rsd	Significance
1200 mm/yr				
	$y_1 = 23.800 + 11.531\ x$	0.982	4.439	0.001
	$y_2 = 118.951 + 2.621\ x$	0.882	3.632	0.001
	$y_3 = 242.325 - 5.212\ x$	0.954	4.282	0.001
	$y_4 = -0.785 + 0.907\ x$	0.999	0.138	0.001
	$y_5 = -0.014 + 0.158\ x - 0.006\ x^2$	0.975	0.033	0.001
	$y_6 = 74.551 - 1.508\ x$	0.909	1.947	0.001
	$y_7 = 84.135 - 2.870\ x$	0.969	2.083	0.001
800 mm/yr				
	$y_1 = 10.112 + 6.381\ x$	0.957	1.957	0.001
	$y_2 = 138.874 + 3.005\ x$	0.850	5.148	0.001
	$y_3 = 249.262 - 5.488\ x$	0.863	8.284	0.001
	$y_4 = -0.097 + 0.304\ x$	0.995	0.085	0.001
	$y_5 = 0.005 + 0.053\ x - 0.002\ x^2$	0.950	0.013	0.001
	$y_6 = 75.638 - 1.241\ x$	0.923	1.462	0.001
	$y_7 = 82.645 - 2.680\ x$	0.933	2.919	0.001

[1] y_1, height of napier (cm); y_2, dry matter concentration (g/kg); y_3, total ash concentration (g/kg DM); y_4, yield of organic matter (t/ha): y_5, yield of crude protein (t/ha); y_6, *in vivo* organic matter digestibility (%); y_7, *in vivo* crude protein digestibility (%).

low, 0.36 t/ha) at 13 weeks of grass growth for both watering regimes. The average ash concentration on the low-watered grass was slightly higher (2.3%) than that on the high-watered grass but rates of decline were similar (5.3 g/kg DM/wk). Average CP digestibility (high, 58.31; low, 58.53%) and rate of decline (high, 2.87; low, 2.68% units/wk) were similar for both watering regimes. Average OM digestibility was higher (64.47 *vs* 60.98 %) for the low- than the high-watered grass. However, the rate of decline in OM digestibility on the high-watered grass was faster (1.51 *vs* 1.24 % units/wk) than that on the low-watered grass.

Crude protein content and yield of dry matter

The influence of watering regime on yields of DM and CP concentration as napier grass matured is shown in Figure 1. Both parameters were affected significantly ($P < 0.001$) by watering regime and age of the grass. The average CP concentration was 12% higher for the high- than the low-watered grass but rates of decline were similar (high, 7.60; low, 7.44 g/kg DM/wk). The following equations describe changes in CP concentration (y, g/kg DM) with age (x, weeks) of the grass: $y = 169.516 - 7.604\ x$ ($r^2 = 0.977$; rsd $= 4.411$; $P < 0.001$), and $y = 157.187 - 7.440\ x$

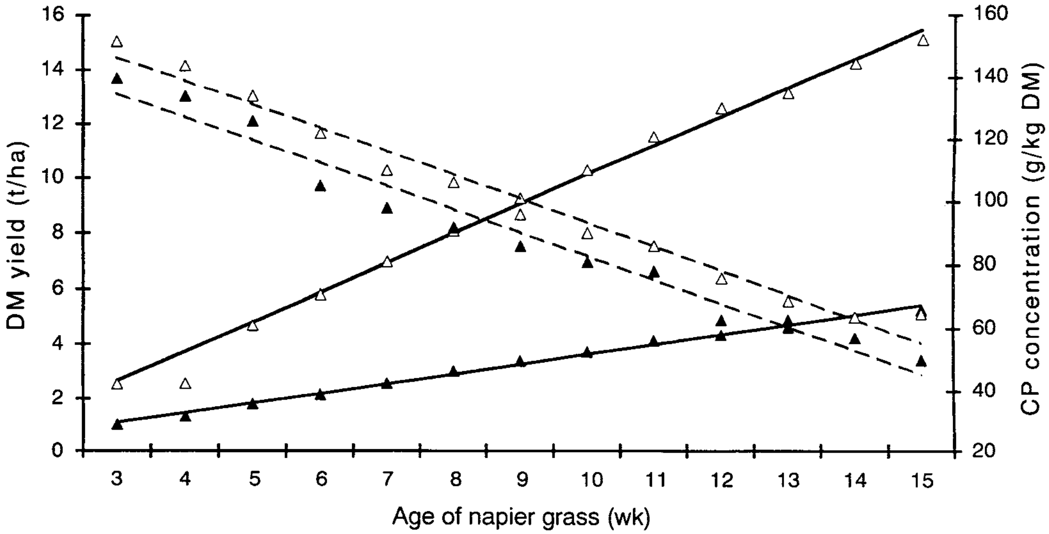

Figure 1. Yield of dry matter (–) and crude protein concentration (--) at various ages of napier grass receiving 1200 mm/yr (△) and 800 mm/yr (▲) of water.

($r^2 = 0.967$; rsd = 5.174; $P < 0.001$) for the high- and low-watered grass, respectively. The average yield of DM on the high-watered grass was about 3 times that on the low-watered grass, and changes in yields of DM (y, tonnes/ha) with age (x, weeks) of the grass are described by the following equations: $y = -0.540 + 1.069\ x$ ($r^2 = 0.997$; rsd = 0.221; $P < 0.001$), and $y = 0.013 + 0.361\ x$ ($r^2 = 0.995$; rsd = 0.105; $P < 0.001$) for the high- and low-watered grass, respectively.

Yields of digestible organic matter and digestible crude protein

The changes in yields of digestible OM and digestible CP as napier grass matured under the two watering regimes are shown in Figure 2. Yields on the high- watered grass were 3 times those on the low-watered grass. Changes in yields of digestible OM (y, tonnes/ha) with age (x, weeks) of the grass could be described using the following equations: $y = 0.233 + 0.453\ x$ ($r^2 = 0.992$; rsd = 0.163; $P < 0.001$), and $y = 0.189 + 0.162\ x$ ($r^2 = 0.962$; rsd = 0.131; $P < 0.001$) for the high- and low-watered grass, respectively. In contrast, changes in yields of digestible CP (y, tonnes/ha) with age (x, weeks) of the grass could be described using the following quadratic equations: $y = 0.066 + 0.097\ x - 0.005\ x^2$ ($r^2 = 0.859$; rsd = 0.031; $P < 0.001$), and $y = 0.024 + 0.033\ x - 0.002\ x^2$ ($r^2 = 0.815$; rsd = 0.013; $P < 0.001$) for the high- and low-watered grass, respectively.

For both watering regimes, yields of digestible CP of the grass increased to a maximum at 8–10 weeks of growth and declined thereafter. At maximum yields of digestible CP, the height was 115–140 cm and 60–75 cm for the high- and low-watered grass, respectively. Yields of DM at these stages of growth were 8.0–10.0 t/ha for high- and 3.0–3.5 t/ha for low-watered grass.

Crude protein concentration:digestible organic matter ratio

Figure 3 shows the changes in nutrient ratio for napier grass under the two watering regimes. The nutrient ratios were affected significantly ($P < 0.001$) by watering regime and age of the grass. The average nutrient ratio was about 17.5% higher for the high- than the low-watered grass although rates of decline as the grass matured were similar (high, 11.60; low, 12.47 g CP/kg DOM/wk). The following linear equations were used to describe changes in nutrient ratio (y, g CP/kg DOM) with age (x, weeks) of the grass: $y = 307.948 - 11.595\ x$ ($r^2 = 0.979$; rsd = 6.846; $P < 0.001$), and $y = 285.500 - 12.466\ x$ ($r^2 = 0.943$; rsd = 12.444; $P < 0.001$) for the high- and low-watered grass, respectively.

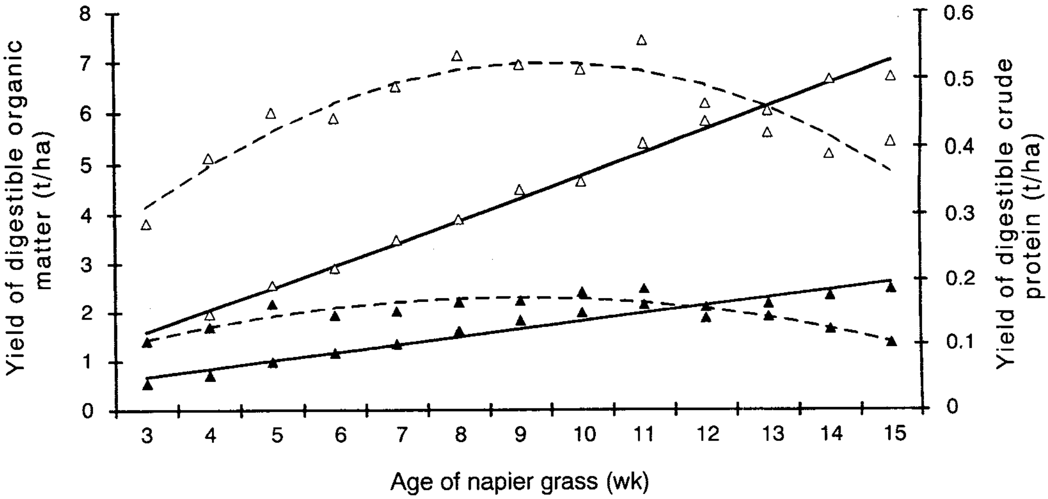

Figure 2. Yields of digestible organic matter (–) and digestible crude protein (--) at various ages of napier grass receiving 1200 mm/yr (△) and 800 mm/yr (▲) of water.

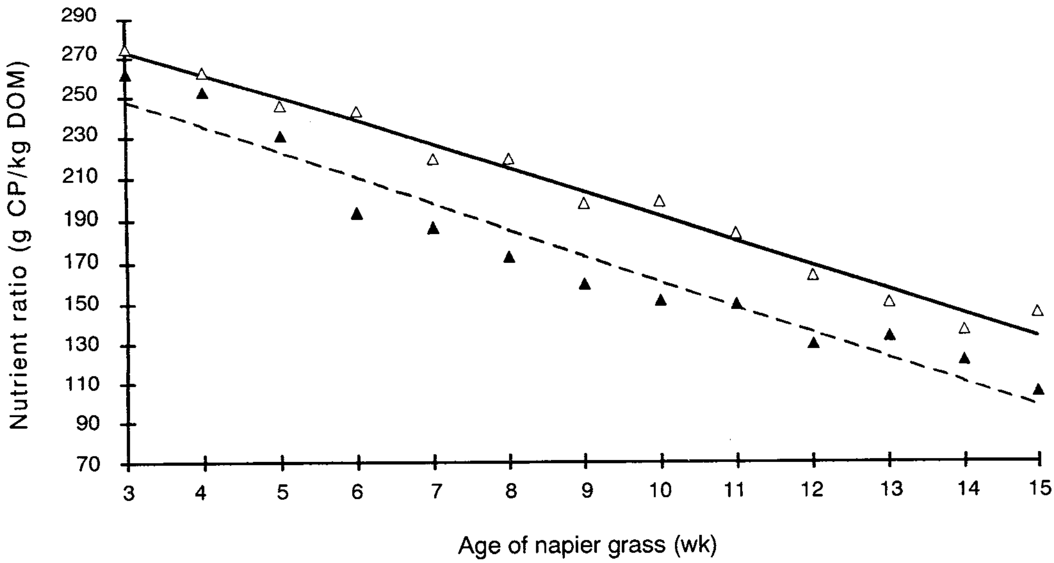

Figure 3. Crude protein:digestible organic matter ratio at various ages of napier grass receiving either 1200 mm/yr (–) or 800 mm/yr (--) of water.

Discussion

Crude protein concentration and yield of dry matter

The CP concentration for maintenance of a cow fed a medium quality forage of about 60–70 g CP/kg DM (ARC 1984) occurred at 12–13 weeks of growth of the grass for both watering regimes. In contrast, the CP concentration for moderate milk production by dairy cows is about 100–120 g/kg DM (ARC 1984). Using these levels of CP (conventional method), the current recommendation in Kenya is to feed grass at 60–100 cm or 6–10 weeks of growth (MLD 1991). We achieved these concentrations at 100–120 cm (7–9 wk) and 40–55 cm (5–7 wk) for the high- and low-watered grass, respectively. At these maturity stages, the ages were within but the heights were outside the recommended ranges.

Owing to the high yields of DM, the carrying capacity on the high-watered grass (10 cows/ha) was 2.7 times that on the low-watered grass (3.7 cows/ha). Annual yields of DM and the carrying capacity on the low-watered grass were similar to the recommended 20.0 t/ha (MLD 1991) and 3.8 cows/ha (Snijders 1989) in Kenya. However, the use of CP concentration to determine the appropriate stage for feeding the grass to dairy cows may be limited by lack of information on rumen degradability of the protein which determines its usefulness for ruminants (Ørskov 1982; ARC 1984) .

DM yields of napier grass increased over time due to accumulation of structural carbohydrates while CP concentration declined due to the dilution effects which occur as forages mature (Humphreys 1991). The higher yield on field A than field B could probably be attributed to the higher water supply since the fertility of the soil was comparable (Table 1). Water supply is highly associated with nutrient uptake and accumulation of biomass because of an accelerated maturation process when other factors such as temperature, soil fertility and light intensity are not limiting forage growth (Van Soest 1982; Humphreys 1991). Results from this study agreed with those of Anindo and Potter (1994) and Ndikumana (1996) that yields of napier grass in the tropics are closely related to amounts of rainfall. The higher rate of elongation on the high- than the low-watered grass could have also contributed to the reported high DM yields. A close association was found between height and yield of napier grass by Boonman (1993).

Yields of digestible organic matter and digestible crude protein

Yield of digestible OM increased as the grass matured because the rate of increase in yield of OM was greater than the rate of decline of OM digestibility (Table 2). Although yield of CP peaked at 13 weeks as the grass matured, yield of digestible CP increased to a maximum at a height of 115–140 cm (8–10 wk) and 60–75 cm (8–10 wk) on the high- and low-watered grass, respectively. The observed changes in yield of digestible CP as the grass matured reflect the slow rate of increase in yield of CP to the age of 13 weeks and a decline thereafter, and the faster rate of decline in CP digestibility. Maximum yields of digestible CP were obtained within the recommended ages of 6–10 weeks for the grass under both watering regimes. However, at these stages of maturity, the heights for the high-watered grass were outside the 60–100 cm range recommended in Kenya. Determining optimal stage for grazing based on supply of digestible nutrients appears superior to the conventional method, but this ignores the interrelationship of protein and energy.

Crude protein concentration:digestible organic matter ratio

The nutrient-ratio requirement for moderate milk yield by dairy cows is 194 g CP/kg DOM (Tamminga 1989). This ratio occurred at 130–140 cm (9–10 wk) and 55–60 cm (7–8 wk) for the high- and low-watered grass, respectively. At these stages of maturity, the CP concentration in the grass under both watering regimes was 90–100 g/kg. Van Vuuren *et al.* (1990) obtained an optimal protein:energy ratio at a wider range of CP (69–100 g/kg DM) concentration in fresh temperate grass than in the current study. At these stages of maturity, the ages were within but the heights were outside the recommended ranges. The obtained stages of maturity to harvest the grass were more specific and different for the two watering regimes than from the other two methods. For each watering regime, the yields of DM and carrying capacities were comparable with the values obtained using the other two methods.

The use of this method indicated that a well managed napier grass could be utilised as a maintenance diet even at advanced maturity since the 130 g CP/kg DOM ratio required for optimal rumen microbial growth (ARC 1984) was achieved at about 14–15 weeks for both watering regimes. However, the high CP concentration at young ages implied that the grass could not be utilised efficiently for milk production since the nutrient ratios were higher than the critical value of 210 g CP/kg DOM (Poppi and McLennan 1995). This critical nutrient ratio level occurred at 120 cm (8.5 wk) and 50 cm (6 wk) for the high- and low-watered grass, respectively. When nutrient ratios of fresh grass are above this critical level, losses of protein or incomplete net transfer of protein from the rumen to the intestine occur (Poppi and McLennan 1995).

Nitrogen in fresh grass is highly digestible in the rumen and results in low efficiency of microbial protein synthesis and energy utilisation (Ørskov 1982; ARC 1984). Therefore, utilisation of this grass at a maturity below 120 cm (8 wk) and 50 cm (6 wk) in the high and medium rainfall areas, respectively, should be accompanied by a readily fermentable energy source (*e.g.* molasses) to maximise rumen microbial activity and growth. This would lead to a better supply of protein of microbial origin in the small intestines. However, for high milk yields, a source of undegradable protein in the rumen (*e.g. Leucaena leucocephala*) should be incorporated in the diets (NRC 1988). Alternatively, for high milk yields, supplements high in energy and protein should be provided when the grass is fed to dairy cows at 130–140 cm (9–10 wk) and at 55–60 cm (7–8 wk) in the high and medium rainfall areas, respectively.

At the stages of maturity suitable for milk production, the average CP concentration (90–100 g/kg DM) and OM digestibility (60%) of the grass could support daily milk yields of about 10–12 kg/cow (ARC 1984). At similar CP concentrations, daily milk yields varied and were lower (5 –10 kg/cow) when dairy cows were fed a napier grass only diet (Anindo and Potter 1986; Muinga *et al.* 1992, 1995). From their reports and results obtained by Combellas and Martinez (1982), supplementing napier grass with either concentrates or fodder trees (120–140 g CP/kg DM of diet) gave lower milk yields (8–15 kg/cow) than the 15–20 kg/cow expected from similar CP concentrations (ARC 1984). Our results indicated that the critical CP concentration for milk production by dairy cows was 90 g/kg DM, a level below which the grass should be supplemented with a rumen-degradable nitrogen source.

The CP concentrations recommended for maintenance and production in ruminants by ARC (1984) are based on temperate forages and may not be appropriate when dealing with tropical forages. Tropical forages are more fibrous than temperate forages and a higher proportion of their nitrogen is not available to ruminants because it is bound within the indigestible vascular bundles (Van Soest 1982). Furthermore, the high levels of non-protein nitrogen in tropical forages is an indication that the true protein is low suggesting that the CP concentrations (N × 6.25) tend to overestimate the value of protein to ruminants (Reeves *et al.* 1996). It may be because of these characteristics that Hennessy (1980) suggested a higher critical CP concentration for tropical forages (81.3 g/kg DM) than the quoted value of 68.8 g/kg for temperate forages (ARC 1984).

The soil fertility status and management of napier grass in our study were better than for most farms in Kenya. It is, therefore, expected that, when fertility of soil is lower than in the current study, the grass should be harvested at young ages or lower heights when the quality is good (protein:energy ratio) for satisfactory milk production by dairy cows. Feeding the grass at young ages implies lower carrying capacity but higher milk yield per animal. It is only on exceptional farms that fertility of soil and management of napier grass will be better than in the current study. In such circumstances, grass should be harvested at a more advanced maturity and at a higher carrying capacity than our recommendations. In addition to soil fertility, the amount of rainfall is expected to influence harvesting stage and yields of napier grass.

The nutrient-ratio method takes into account the interactions of energy and protein which are known to have a major influence on performance of animals (Tamminga 1982; Nocek 1988; Oldham 1988). This method, therefore, has advantages over the previous two methods in determining the appropriate maturity for feeding the grass to dairy cows. However, the importance of the quality of the protein which determines the extent of degradability in the rumen and the ability to escape rumen digestion (Tamminga 1982; Nocek 1988; Oldham 1988) is one of the drawbacks in the use of this method.

Conclusion

The optimal harvesting ages determined using optimal CP concentration, yields of digestible OM and CP, and CP concentration:digestible organic matter ratio methods were within the 6–10 weeks range whereas the heights were outside the 60–100 cm range that are recommended in Kenya. The CP concentration:digestible organic matter ratio method was preferred to both the optimal CP concentration and the optimal yields of digestible nutrients methods since the interrelationship between protein and energy concentrations in the grass was considered. The use of this method indicated that grass in medium rainfall areas should be harvested earlier (55–60 cm; 7–8 wk) and that in high rainfall areas later (130–140 cm; 9–10 wk) than currently recommended.

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