

**FOLIAGE YIELD, CHEMICAL COMPOSITION AND INTAKE
CHARACTERISTICS OF THREE MUCUNA VARIETIES**

**[RENDIMIENTO, COMPOSICIÓN QUÍMICA Y CARACTERÍSTICAS DE
CONSUMO DE TRES VARIEDADES DE MUCUNA]**

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SUMMARY

The effect of variety and fertiliser on foliage yield and chemical composition of the foliage of three mucuna varieties, *Mucuna deeringeana*, *Mucuna cochinchinensis* and *Mucuna spp.* var. Ghana, was studied in an experiment in Burkina Faso in 2005 and 2007. The chemical composition and intake of hay from the same mucuna species were also studied using six Zebu cows per treatment offered 1/3 of their diet as grass hay. A completely randomised 3*2 factorial design was used, three mucuna varieties and not fertilised or fertilised with 2 kg DM/m² of cow manure. The foliages were harvested when 75% of the plants were flowering both for measuring foliage yield and for making hay. Soil characteristics before and after the experiment, dry matter yields and stem/leaf ratio of the vines were recorded and chemical composition of the foliages analysed. The mean age at harvesting was 57 d for *M. spp.* var. Ghana that was significantly shorter than for *M. deeringeana* (63 d) and *M. cochinchinensis* (81 d). Age at harvesting was not significantly affected by fertilisation. Dry matter yield was significantly lower for *M. spp.* var. Ghana, 1.71 t/ha for the unfertilised plots, compared to 3.29 and 3.07 t/ha for *M. deeringeana* and *M. cochinchinensis*, respectively. Fertilisation with manure more than doubled the yield for all varieties. There was no difference in stem/leaf ratio due to variety or fertiliser. The leaves+petiole fraction was generally heavier than the stem fraction. *M. spp.* var. Ghana had significantly higher content of crude protein than *M. deeringeana* and *M. cochinchinensis* (204, 177 and 150 g/kg DM, respectively). *M. cochinchinensis* had significantly higher ADF content than *M. spp.* var. Ghana, 474 and 369 g/kg DM, respectively. *M. spp.* var. Ghana had the highest CP content (209 g/kg DM), significantly different from *M. cochinchinensis* (165 g/kg DM) but not from *M.*

deeringeana (192 g/kg DM). *M. spp.* var. Ghana had the best intake characteristics (4659 g and 3668 g/d for cows and heifers, respectively), but significantly so only for cows. In conclusion, the high foliage yield, the possibility of increasing soil fertility through N fixation and the high nutritive value of the foliage makes mucuna an interesting feed for ruminants even in areas with low soil fertility and a short rainy season.

Key words: *Mucuna deeringeana*, *Mucuna cochinchinensis*, *Mucuna spp.* var. Ghana, foliage yield, chemical composition, intake, manure.

RESUMEN

Se estudió el efecto de la variedad y fertilizante sobre la producción y composición química del follaje de tres variedades de mucuna: *Mucuna deeringeana*, *Mucuna cochinchinensis* y *Mucuna spp.* var. Ghana, en un experimento realizado en Burkina Faso durante 2005 y 2007. La composición química y el consumo de heno de las mismas tres variedades fue estudiado en vacas Cebú alimentadas con 1/3 de su dieta como heno de pasto. Se empleó un diseño completamente al azar con arreglo factorial 3*2 (tres variedades de mucuna y fertilizado o no con 2 kg MS/m² de estiércol de vaca). Se cosechó cuando el 75% de las plantas se encontraba en floración y se midió rendimiento y preparó heno. Se registró las características del suelo antes y después del experimento, producción de materia seca y proporción hoja/tallo así como la composición química. La edad a la cosecha fue de 57d para *M. spp.* var. Ghana, significativamente menor a *M. deeringeana* (63 d) y *M. cochinchinensis* (81 d). La fertilización no influyó sobre edad a la cosecha. La producción de MS fue significativamente menor para *M. spp.* var. Ghana, 1.71 t/ha en las parcelas no fertilizadas, comparado con 3.29 y 3.07 t/ha para *M. deeringeana* y *M. cochinchinensis*, respectivamente.

La fertilización duplicó los rendimientos de todas las variedades. No se encontró efecto de variedad o fertilización en la proporción hoja tallo. *M. spp.* var. Ghana tuvo un mayor contenido de proteína cruda en comparación con *M. deeringeana* y *M. cochinchinensis* (204, 177 y 150 g/kg MS, respectivamente). Existió un mayor contenido de FDA en *M. cochinchinensis* que en *M. spp.* var. Ghana, 474 y 369 g/kg MS, respectivamente. El mayor contenido de PC se encontró en *M. spp.* var. Ghana (209 g/kg MS), significativamente diferente de *M. cochinchinensis* (165 g/kg MS) pero no de *M. deeringeana* (192 g/kg MS). Las vacas tuvieron

mayores consumos de *M. spp.* var. Ghana (4659 g y 3668 g/d para vacas y novillas, respectivamente), pero únicamente fue significativo en vacas. En conclusión, el mayor rendimiento de follaje, la posibilidad de mejorar la fertilidad del suelo y su alto valor nutritivo hacen de la mucuna un alimento importante para ruminantes aún en áreas con baja fertilidad y estaciones lluviosas cortas.

Palabras clave: *Mucuna deeringeana*, *Mucuna cochinchinensis*, *Mucuna spp.* var. Ghana, rendimiento follaje, composición química, consumo, excretas.

INTRODUCTION

Livestock systems in Sub-saharan Africa are mainly extensive and rangeland vegetation and crop residues constitute the predominating feed resources. Rainfall is unimodal and distribution varies widely from 450 mm in the Northern Sahelian zone to 1200 mm in the sub-humid zone. During the short rainy season the perennial grasses are grazed. During the dry season crop residues and some few limited shrub and tree leaves are used as supplements since the grasses available are inadequate both in quantity and quality. To reduce mortality rate in young animals and improve production, dairy farmers in urban and periurban areas provide some supplementation such as cottonseed cake and seeds, sugar cane molasses and rice bran but in insufficient amounts because of the high costs and low availability in the market during the dry season. Recent research has suggested that pasture management can include intercropping with legumes as a sustainable strategy to increase the biological activity of the soils and improve animal production (Murphy and Colucci, 1999; Nyambati and Sollenberger, 2002; Pengelly *et al.*, 2004). To overcome the ecological problems caused by degraded soils or excessive *I. cylindrica* infestation, the development project "Sassakawa Global, 2000" has, since the beginning of 1995, introduced the legume mucuna in the central plateau of Burkina Faso to rehabilitate fields previously abandoned and to improve soil fertility. Mucuna (*Mucuna pruriens*), commonly known as velvet bean or the magic bean belongs to the *Fabaceae* family, and is a vigorously growing annual plant usually with long vines (3 to 15 m). Fresh foliage production can be above 23 t/ha and dry matter (DM) yield can reach 9 t/ha under dry farming with low soil fertility. Mucuna can accumulate from 313 to 348 kg N/ha as a sole crop or about 160 kg N/ha when intercropped with maize (Sanginga *et al.*, 1996; Vanlauwe *et al.*, 2000; Sakala *et al.*, 2003; Whitbread *et al.*, 2004; Pugalenthi and Vadivel, 2007). The germination of mucuna was faster than for broad-grained vegetables and the plants were free of insect pests, although some were badly attacked

by some unidentified pests. Mucuna produced 2.7 to 8.0 t/ha of DM and the N content varied from 1.65 to 3.95 % (Segda *et al.*, 1998). Mucuna has been reported to suppress weeds and lower the population of nematodes for the following crops (Pugalenthi *et al.*, 2005).

Mucuna could be a viable protein feed supplement for ruminants and can provide good quality hay to use as a supplement to low quality grass from natural pastures. Mucuna has a high content of crude protein (CP) (150 to 340 g/kg DM) and feeding Mucuna has resulted in increased DM intake, diet digestibility, milk production and growth rate of calves (Adjorlolo *et al.*, 2001; Murungweni *et al.*, 2004; Juma *et al.*, 2006a; Sidibé-Anago *et al.*, 2006; Sidibe-Anago *et al.*, 2008). Incorporation of mucuna hay in ruminant diets led to significantly higher DM intake (Mbuthia and Gachui, 2003) and the digestibility of DM and CP ranged from 56 to 60% and 72 to 91%, respectively. Mucuna has been promoted as a feed for ruminants, especially dairy cows and beef cattle (Nyambati *et al.*, 2003; Sidibé-Anago *et al.*, 2006).

The most important cultivated varieties of mucuna are *Mucuna cochinchinensis* (white seed), *Mucuna deeringeana* (speckled black seed) and *Mucuna spp.* var. Ghana (mainly black seeds) (Lorenzetti *et al.*, 1998). This study aimed at evaluating the effect of variety and fertilization with manure on foliage yield and chemical composition of these three main mucuna varieties and to investigate the intake characteristics of these varieties by Zebu cows.

MATERIAL AND METHODS

Location and climate of the study area

The experiments were carried out at Farako-bâ (11°06'N, 04°20'W) Research Station in Bobo Dioulasso, Burkina Faso. The rainfall in this area is unimodal, peaks in August and averages about 1,100 mm/year with a cropping period of 5 months (June-

October). The experiment was conducted during the rainy season in 2005 and repeated in 2007. The rainfall in 2007 (1113 mm) was in accordance with the average rainfall in the area, but higher than that of 2005 (869 mm). However, in 2007 the rains were unevenly distributed and created some flooding. The average temperature during the experimental period ranges from 23 to 33°C (Segda et al., 1998). The soil is classified as a Ferruginous tropical soil (French classification) or Ultisol of low fertility (Bado, 2002). The characteristics of the soil at the experimental site are described in Table 1.

Experimental design and management.

The agriculture experiment. The experiment was laid out in a 4 year fallow on a flat part of the field. Seeds from three varieties of mucuna, *M. deeringeana* (Mucuna Florida or Deering velvet bean) with black seeds, *M. cochinchinensis* (Mucuna Burk, or Chinese velvet bean) with white seeds and *M. spp.* var. Ghana with dark mottled seeds, were used. The germination rate was tested with 10 seeds of each variety 5 days before the experiment started and was 90% for *M. cochinchinensis* and 100% for *M. spp.* var. Ghana and *M. deeringeana*. The 100 seeds weight was 67, 107 and 91 g for *M. spp.* var. Ghana, *M. deeringeana* and *M. cochinchinensis*, respectively. The plots were marked, cleaned and ploughed, followed by harrowing combined with hand-weeding to obtain weed-free plots two days before sowing. Dried cow manure was applied as fertilizer at a level of 2 kg DM/m² according to treatments the following day. After scarification, the seeds were manually planted at a spacing of 50 cm between rows and 50 cm between plants using a traditional hoe at 3 to 5 cm depth with two seeds per pit. A completely randomised 3*2 factorial design was used. All treatments were randomly assigned to four blocks. Three mucuna varieties were tested with fertilisation or no fertilisation with manure. The number of plots was 24 each year and the experiments were laid out at in the same field but in different areas during the two years. The size of each mucuna plot was 10 m² (5 m*2 m) and the distance between the plots and the blocks was 2 m. All plots were manually weeded once at 3 weeks after planting and forage from each plot was separately hand harvested when 75% of the mucuna plants in the plot were flowering.

Three long vines in each plot were selected and the length of the vine inside and outside the border of the plot measured and weighed fresh. The leaves and the petioles were separated from the stems and both parts were weighed fresh. The ratio of stem to leaves was determined by dividing the two variables. Foliage biomass within the plot including leaves on the soil, were cut at the border of the plot to about 5 cm height and the herbage mass was weighed. All long vines growing outside the plot were also weighed. The total

plot production was determined by adding foliage within and outside the plot and the three long vines. Samples from each plot were taken from the cut material at harvesting, dried at 55°C for 48 h, and thereafter oven-dried at 105°C to determine DM yield.

The intake experiment. The natural grass hay and the three varieties of mucuna hay for the experiment were produced in the research centre. *M. cochinchinensis*, *M. deeringeana* and *M. spp.* var. Ghana were established in June at the onset of the rainy season and were manually harvested when approximately 75% of the plants were flowering, sun-dried for 48 hours in the field and for another 5 days on concrete. Both dried mucuna and grass hay (harvested in December) were mechanically chopped, baled and stored.

Nine multiparous (4th lactation) and nine primiparous local Zebu cows in their 4th month of pregnancy weighing 272 (SD=26.9) and 212 (SD=16.4) kg, respectively, were selected from the dairy herd. All animals were treated against trypanosomiasis with 5 ml Isomethamidium/100 kg BW and were vaccinated against anthrax and pasteurellosis. Three days before the experiment, all animals were drenched against internal parasites using Ivermectin (1 ml/50 kg BW) and were sprayed with Deltametrin acaricid to control external parasites. The experiment lasted for 21 d, 14 d for adaptation and 7 d for data collection. At the start of the experiment, the animals were weighed to estimate DM intake at maintenance level (2.5% of body weight (BW)), housed and fed grass hay at a level of 1/3 of the estimated DM intake. Six animals (3 multiparous and 3 primiparous) were randomly assigned to one of the three mucuna varieties. After the adaptation period the feeding level was fixed at 5 500 g DM mucuna+2 100 g DM hay for the cows and 4 300 g mucuna +1800 g DM hay per day for the heifers, corresponding to 110% of the highest intake during the adaptation period for cows and heifers, respectively. The feeds were given in two separate feed troughs. Grass hay was offered once at 08.00h, while mucuna was fed at 08.00h and 15.30h, 50% of the offer at each occasion. Refusals were collected every day in the morning before feeding. During daytime the cows were exercised from 10.30h to 13.00h. They had free access to water and a commercial mineral lick block containing 359.6 g Na, 12.5 g Zn, 3.0 g Fe, 2.0 g Mn, 0.03 g Iodine, 0.02 g Co, 1.0 g Cu and 0.5 g Mg. The remaining content was unknown.

Sample preparation and chemical analyses

At the start of each experiment soil samples were randomly taken in 10 plots from 0 to 20 cm depth corresponding to the soil layer that was influenced by tillage and organic matter input, prior to the manure was applied and before sowing. After harvesting 2 soil

samples were taken from each of the 24 experimental plots for analyses of the soil properties. The 10 original soil samples were pooled to a general sample and two sub-samples were analysed. The two samples from each plot at the end of the experiment were pooled and analysed. Four samples of air dried manure were taken each year. Manure and soil sub-samples were sun-dried and oven-dried at 60°C for 48 hours. N_{tot} was determined with the Kjeldahl method, organic C by the Walkley-Black method (Black, 1965), P with the Bray I method using 0.025 N HCl (Bray and Kurtz, 1945) and pH in water or KCl with a pH meter (McLean, 1982).

The three long vines from each plot were sampled fresh, the leaves and petioles and the stem separately. The 6 samples from each plot were pooled to one sample of leaves+petioles and one sample of stem. The samples were weighed, sun-dried for 12 hours and then weighed again and stored. Samples from each clipping date were then taken from the cut material and dried in a forced-air oven at 55°C for 48 h.

Feed offered and refusals were weighed every morning to determine voluntary intake. Daily DM intake was calculated by the difference between DM intake and DM refused. The pre-dried samples of foliage and the feeds were analysed for DM, ash and CP (calculated as $N \times 6.25$) according to the standard methods of AOAC (1990) and NDF (Neutral Detergent Fibre) and ADF (Acid Detergent Fibre) according to Van Soest *et al.* (1991). The refusals were only analysed for DM.

Statistical analyses

Treatment effects were tested by analysis of variance (ANOVA) using the General Linear Model (GLM)

procedure of Minitab 13.31 (Minitab, 2000). The treatment means which showed significant difference at the probability level of $P < 0.05$ were compared using Tukey's pairwise comparison procedures. The model used in the agriculture experiment was: $Y_{ijk} = \mu + a_i + b_j + ab_{ij} + t_k + at_{ik} + \epsilon_{ijk}$, where Y_{ijk} =dependent variables (foliage yield, stem/leave ratio, chemical composition), μ =overall mean, a_i =effect of variety, b_j =effect of fertilizer t_k =effect of year, ab_{ij} =variety x fertilizer interaction, at_{ik} =variety x year interaction, ϵ_{ijk} =random residual error term. Interactions not statistically significant were excluded from the model. The soil and manure characteristics were analyzed by ANOVA using year and fertilizer as factors and the intake using variety and type of animal.

RESULTS

Soil characteristics

Table 1 shows the chemical composition of the manure and the characteristics of the soil in the experimental sites before and after the experiments. The content of organic carbon in the soils and the pH were higher at start in 2005 than in 2007 but the other variables analysed were similar. The manure used was alkaline with a high content of P and a moderate content of N and very high ash content, more the 500 g/kg DM. The effect of fertilization with manure on soil characteristics was not significantly different between years and there was no interaction between year and fertilization. Adding manure resulted in a higher content of P and a higher pH in the soil at the end of the experimental periods, but had no effect on the remaining variables.

Table 1. Chemical characterization of the soil at the experimental site at the start and the end of the experiment and the manure used¹

Properties	Soil			Manure			End 2005		End 2007		SE
	Start	Start		2005	2007	P	Non-fert.	Fert.	Non-fert.	Fert.	
0-20 cm											
Depth	2005	2007	P								
N	4	4		4	4		12	12	12	12	
Org. C (%)	0.28	0.25	0.04	28.4	28.4	0.11	0.28	0.29	0.26	0.27	0.01
N_{Tot} (%)	0.03	0.03	0.89	0.67	0.68	0.44	0.06	0.06	0.06	0.06	0.02
P_{Tot} (ppm)	82.0	79.0	0.42	2952	2957	0.64	91.0 ^b	100.3 ^a	90.5 ^b	99.8 ^a	2.88
pH _{H2O}	5.2	5.1	0.01	9.3	9.3	0.09	5.3 ^b	5.6 ^a	5.3 ^b	5.5 ^a	0.05
pH _{KCl}	4.0	4.0	0.18	8.8	8.8	0.10	4.1 ^b	4.2 ^a	4.0 ^b	4.2 ^a	0.02
OM %	0.47	0.43	0.06	47.6	49.0	<0.00	0.46	0.49	0.44	0.47	0.02
C/N	9.0	8.0	0.42	42.6	42.0	0.48	7.6	7.9	7.7	8.0	0.05

¹Least squares means and standard error of means (SE); Means within rows and end values with different superscripts (^{a,b}) are significantly different

Foliage production of different mucuna varieties

The foliage DM yield of the unfertilized plots (Table 2) was highest for *M. deeringeana* and *M. cochinchinensis* (3.07 and 3.27 tons DM/ha, respectively), significantly higher than for *M. spp.* var. Ghana (1.71 tons DM/ha). Fertilization with manure had a significant effect on the foliage yields, which were more than doubled when manure was applied (Table 2). There was no interaction between variety and fertilization and *M. deeringeana* and *M. cochinchinensis* also showed the highest yield in the fertilized plots (6.33 and 7.42 tons DM/ha, respectively), significantly higher than for *M. spp.* var. Ghana (3.78 tons DM/ha). There was no significant difference in foliage yield between years.

The stem/leaves ratio of the three varieties did not differ significantly (Table 2). The leaves+petiole fraction was generally larger than the stem fraction except in fertilized *M. deeringeana*, which had more stems than leaves+petioles.

The age at harvest, when 75% of the plants were flowering, varied significantly among the varieties. *Mucuna spp.* var. Ghana flowered earliest (57 to 59 days after sowing), *M. deeringeana* 63 to 65 days and *M. cochinchinensis* 81 to 85 days. Although the difference in age at harvest due to fertiliser was not statistically significant, unfertilized plots were harvested 2 or 3 days earlier than the fertilised plots.

Chemical composition of the three mucuna varieties

Chemical composition of the different plant fractions is shown in Table 3. Dry matter and ash content in the whole plant did not differ significantly between the varieties and DM varied from 230 g/kg DM for *M. deeringeana* to 236 g/kg DM for *M. cochinchinensis* and ash from 77 to 61 g/kg DM for the same species. The DM content in the leaves was high compared to the stems.

The varieties had a significantly different content of CP, ADF and NDF. *M. spp.* var. Ghana had the highest CP and NDF (204 and 545 g/kg DM, respectively), and *M. cochinchinensis* the lowest (177 and 508 g/kg DM, respectively) while *M. deeringeana* was intermediate (150 and 522 g/kg DM, respectively). *M. spp.* var. Ghana contained less ADF than *M. cochinchinensis* (369 and 474 g/kg DM, respectively) ($P<0.05$). Adding manure resulted in a significantly lower content of ADF and higher content of NDF in the foliage compared to foliage from non-fertilized mucuna. There was no interaction between variety and year or variety and fertilizer for chemical composition.

The chemical composition of the hays used in the intake experiment is shown in Table 4. *M. spp.* var. Ghana had the highest and *M. cochinchinensis* the lowest CP content ($P<0.05$) while *M. deeringeana* was intermediate and did not differ significantly from the other varieties. Fibre content was similar among the three varieties.

Table 2. Effect of mucuna variety and fertilizer on age at harvesting, annual biomass and stem/leave ratio¹

	Fresh foliage yields, ton/ha	DM yields, tons/ha	Stem/leave ratio	Harvest age, days
Not fertilized				
<i>Mucuna cochinchinensis</i>	13.10 ^a	3.07 ^a	0.93	81 ^a
<i>Mucuna deeringeana</i>	14.25 ^a	3.29 ^a	0.89	63 ^b
<i>Mucuna spp.</i> var. Ghana	7.39 ^b	1.71 ^b	0.90	57 ^c
Fertilized				
<i>Mucuna cochinchinensis</i>	26.60 ^b	6.33 ^a	0.90	85 ^a
<i>Mucuna deeringeana</i>	32.38 ^a	7.42 ^a	1.07	65 ^b
<i>Mucuna spp.</i> var. Ghana	16.11 ^c	3.78 ^b	0.90	59 ^c
SE	1.8	0.44	0.07	1.58
Level of significance				
Variety	**	**	NS	**
Fertilizer	***	***	NS	NS

¹(Least squares means and standard error of means (SE)); Means within columns and fertilization with different superscripts differ significantly $P<0.05$; **= $P<0.01$; ***= $P<0.001$.

Table 3. Chemical composition of the different fractions and the whole plant of the three *Mucuna* varieties¹.

	Fraction	DM (g/kg)	Ash	CP	ADF (g/kg DM)	NDF
<i>Mucuna cochinchinensis</i>	Leaves	248	65	168	370	423
	Stem	224	59	71	550	635
<i>Mucuna deeringeana</i>	Leaves	236	65	194	393	456
	Stem	218	82	81	582	613
<i>Mucuna spp</i> (var. Ghana)	Leaves	238	69	229	361	492
	Stem	216	81	99	572	608
<i>Mucuna cochinchinensis</i>	Whole	236	61	150 ^c	474 ^a	508 ^b
<i>Mucuna deeringeana</i>	Whole	230	77	177 ^b	434 ^{ab}	522 ^{ab}
<i>Mucuna spp</i> (var. Ghana)	Whole	234	75	204 ^a	369 ^b	545 ^a
SE		2.0	3.9	2.8	8.6	3.3
Level of significance						
Variety		NS	NS	**	*	**
Fertilizer		NS	NS	NS	*	*

¹Least squares means and standard error of means of whole mucuna (SE); n=16; ** = P<0.01; * = P<0.05; NS = not significant. Means within columns with different superscripts differ significantly P<0.05;

Table 4. Chemical composition of the hays in the intake experiment¹

	DM (g/kg)	Ash	CP	ADF (g/kg DM)	NDF
Grass hay	964 (2.6)	48 (1.1)	25 (0.1)	852 (15.7)	552 (3.7)
<i>Mucuna cochinchinensis</i>	943 ^a	82 ^a	165 ^b	502 ^b	401
<i>Mucuna deeringeana</i>	941 ^{ac}	75 ^{ab}	192 ^{ab}	542 ^a	390
<i>Mucuna spp</i> (var. Ghana)	946 ^{ab}	71 ^b	209 ^a	529 ^{ab}	373
SE	11.1	2.3	9.6	8.4	10.7

¹Means and SD for the grass hay, least square means and standard error of means (SE) for *Mucuna*; N=7; Means within columns with different superscripts (^{a,b,c}) differ significantly (P<0.05)

Intake of DM by multiparous cows from *M. spp.* var. Ghana (Table 5) was significantly higher than intake from *M. deeringeana* and *M. cochinchinensis*, which did not differ. Since intake of hay was high for the diet containing *M. spp.* var. Ghana total DM intake was also significantly higher for this diet. Multiparous cows consumed significantly more feed than the heifers. The heifers also seemed to prefer *M. spp.* var. Ghana, but the differences in intake were not

significant. The intake of hay by heifers was significantly different in all three diets, and was highest in the *M. deeringeana* diet and lowest in the *M. spp.* var. Ghana diet. Total intake of the heifers was, however, not significantly different among diets. Intake expressed as g/kg W^{0.75} was not significantly different among treatments neither for cows nor for heifers.

Table 5. Dry matter intake from diets with three different mucuna varieties¹

DM intake		<i>Mucuna cochinchinensis</i>	<i>Mucuna deeringeana</i>	<i>Mucuna spp</i> var. Ghana	SE
Grass hay (g/day)	Cows	509 ^b	925 ^a	973 ^a	74.3
	Heifers	395 ^b	627 ^a	330 ^c	
Mucuna(g/day)	Cows	4065 ^b	3943 ^b	4659 ^a	123.0
	Heifers	3286	3392	3668	
Total (g/day)	Cows	4575 ^b	4868 ^b	5633 ^a	142.5
	Heifers	3681	4019	4006	
Mucuna (g/W ^{0.75})	Cows	67.1	71.7	76.4	3.7
	Heifers	61.8	65.0	68.1	

¹ Least squares means and standard error of means (SE); Means within rows with different superscripts (^{a,b,c}) differ significantly (P< 0.05).

DISCUSSION

Changes in the chemical composition of the soil

Most soils in the Sub-saharan area of West Africa are characterized by low fertility, which has been shown in a range of previous studies on soil properties (Bado, 2002; Mando et al. 2005; Traoré and Stroosnijder, 2005; Ouattara et al. 2006). Adding manure did not change the soil nutrients to any great extent but increased the content of P_{Tot} and the pH_{H_2O} since the manure was alkaline. Harvesting was done at flowering stage, which is considered as the optimum N-fixation stage of leguminous plants (Karpenstein-Machan and Stuelpanagel, 2000; Herridge and Rose, 2000). N_{Tot} was doubled after cultivation with mucuna, but since the initial level was low the soil was still of low fertility. This suggests that most of the N fixed by the legumes as well as the N added in the manure were used for foliage production. Increasing soil fertility index when growing mucuna has been reported by Koutika et al. (2001) and Pugalenti and Vadivel (2007), and mucuna has been characterized as a green manure cover plant (Buckles, 1995). Thus the most beneficial effects of mucuna have been found to be improvement of the subsequent food crop production (Buckles and Triomphe, 1999; Tian et al., 2000; Fofana et al., 2004).

Effects of treatment and variety on foliage yields

The different varieties had very different foliage yields, ranging between 1.7 and 3.2 tons/ha DM, when cultivated without fertiliser. The earliest maturing variety had the lowest biomass yield, which is probably a logical result of shorter time for growth. A short period from germination to harvest may be advantageous in a climate with a short and sporadic rainy season but must be weighed against potential yields. Adding manure as a fertiliser doubled the foliage yield of all varieties, which showed that the manure had a positive effect on foliage production. This was due to the poor quality of the soil. The amount of manure used was high but since the ash content was also high the amount of organic matter was less than 10 tons/ha. The high ash content in the manure was due to the collection method. Increasing yields when fertilizing mucuna have been reported by Tian et al. (1998) and Carsky et al. (2001). However, in general, legume crops are not fertilized in the Sub-saharan area of West Africa. The foliage yield of all three varieties was higher than for most forage legumes commonly cultivated in the Sub-saharan area of West Africa such as *Dolichos*, *Siratro* and *Stylosanthes* (Carsky et al., 2001, Nyambati et al., 2003). The high foliage yield could encourage farmers to include mucuna in the agro-pastoral system.

Chemical composition and intake of the different varieties and the effect of fertiliser on chemical composition.

In the agriculture experiment the nutrient content of the mucuna foliages was affected by both variety (CP, NDF, ADF) and fertiliser (NDF, ADF). As expected the leaves+petioles had higher nutritive value, while the stems were more fibrous and had a lower content of CP. The values of the chemical composition of the whole plant were within the ranges reported by Maasdorp and Titterton (1997), Ibewiro et al. (2000), Adjorlolo et al. (2001), Mbuthia and Gachuiiri (2002) and Juma et al. (2006b), but the CP content of *M. cochinchinensis* was low compared the values reported by Sidibe-Anago et al. (2006). *M. spp.* var. Ghana matured earliest and had the highest CP content while *M. cochinchinensis* had the longest growth period and also the lowest CP content. If the protein yield per ha is estimated *M. spp.* var. Ghana had the lowest yield, 771 kg/ha, and *M. deeringeana* the highest yield, 1313 kg/ha while *M. cochinchinensis* was intermediate, 950 kg/ha. All the varieties contained less NDF and ADF when manure was applied, which has also been found in tropical grasses (Johnson et al., 2001).

The NDF content of the mucuna hays in the intake experiment was similar among the three varieties which could probably be expected since the biomass was harvested at the same vegetative stage. The content of CP in the hay was within the range of 150 to 340 g/kg DM reported in previous studies (Nyambati et al., 2003; Njarui et al., 2003; Murungweni et al., 2004; Juma et al., 2006b; Sidibé-Anago et al., 2006). Nyambati et al. (2003), Sidibé-Anago et al. (2006) and Juma et al. (2006a) reported higher intake levels of mucuna when included in the diet of lactating dairy cows. The lower intake level in the present study was due to the fact that requirements and intake are higher for lactating than for dry cows but the fact that the grass hay was of very low quality can also have had a negative effect on intake.

CONCLUSION

Where the cropping period is short, 2-3 months, *M. spp.* var. Ghana can be recommended in spite of having the lowest yield. *M. deeringeana* had somewhat longer growth period but the highest foliage and protein yield and can be recommended before *M. cochinchinensis*.

M. spp. var. Ghana showed better intake characteristics than *M. deeringeana* and *M. cochinchinensis*, which may have been due to the higher protein content. To decide which variety to focus on further information on agronomy, biomass production and utilization for milk producing animals is needed

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Submitted June 09, 2008 – Accepted October 20, 2008
Revised received November 26, 2008