Fodder Productivity and Growth Persistency of Three Local Cassava Varieties

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ABSTRACT : Three cassava varieties, namely MM 92 (MM), Black Twig (BT) and Local (LC), were arranged in a randomized complete block design to evaluate their dry fodder and crude protein (CP) productivity as well as growth persistency. Cassava plants grown in small plots of 5 m×10 m at a planting distance of 25 cm×25 cm were harvested every 6 weeks starting from 3 months after planting. Dry fodder yields of MM, BT and LC over the 8 harvests were 8.55, 8.01 and 6.15 t/ha, respectively. All varieties produced more leaves than stems with average leaf:stem ratios of 5, 5.9 and 4.8 for MM, BT and LC, respectively. In terms of CP production, MM was the highest yielder (272 kg/ha/harvest), followed by BT and LC (238 and 184 kg/ha/harvest, respectively). The total accumulative CP amounts over the 8 harvests were 2179, 1903 and 1474 kg/ha for MM, BT and LC, respectively. The mortality rates were 9.91, 14.01 and 13.98% for MM, BT and LC, respectively. Phosphorus content was more stable than potassium content during defoliation. MM, BT and LC had whole plant phosphorus contents of 0.41, 0.41 and 0.39%, respectively; whole plant potassium contents were 1.25, 1.38 and 1.20%. ***(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 9 : 1253-1259)***

Key Words : Cassava Varieties, Fodder Productivity, Crude Protein Production, Mortality Rate, Phosphorus and Potassium Contents

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a perennial shrub grown widely in the tropics where its starchy roots provide the staple food for over 300 million people (FAO, 1990). Its potential as a source of energy for either human consumption or animal feeding has been proven. Apart from this, the cassava plant also produces a large amount of foliage that is high in nutrients. The use of cassava foliage as a major component in the daily diet of millions of people in cassava growing areas has been reported (Mpoko, 1994). More recently, it was indicated that supplementation with cassava hay (comprising leaves and stems) significantly reduced the use of concentrates by as much as 3.1 kg/head/d in a urea-treated rice straw based diet for lactating dairy cows (Wanapat et al., 2000) without adverse effect on milk yield. This reduction appears to indicate a vast scope in cutting down imported feeds in many developing countries in Asia which face escalating costs.

Current interest in the use of cassava foliage is principally related to its protein content. Cassava leaf protein content varies greatly, ranging from 17 to 34% on a dry matter basis (Rogers and Milner, 1963). Almost 85% of the crude protein fraction is present as true protein (Eggum, 1970). Several researchers (Rogers and Milner, 1963; Ravindran and Ravindran, 1988; Wanapat, 1993) have shown that the proximate composition of cassava leaves compares favorably with the composition of other feeds such as soybean grain, alfalfa, *Leucaena, Gliricidia* and maize grain. Apparently, cassava foliage can play an important role in improving protein-deficient diets of ruminants in the tropical region. Ravindran (1991) reported that cassava leaf yield varies widely according to factors such as variety, defoliation frequency, climatic conditions and fertilizer regimes. Exploitation of local cassava varieties should, therefore, be done intensively to increase cassava fodder production as requirements for high quality feed resources are increasingly critical to meet growing animal populations.

The current experiment was carried out to determine dry matter (DM) and crude protein (CP) productivity, as well as growth persistency of three local cassava varieties fertilized with cattle manure for producing a locally available source of protein for ruminants.

MATERIALS AND METHODS

Experimental site and design

The study was conducted from October 1998 to February 2000 at the experimental farm of the Department of Animal Science, Universiti Putra Malaysia at Serdang, Selangor, Malaysia on loamy clay soil with a pH of 4.1 in a field that had been previously occupied by a variety of weeds. The climate was warm and humid with no distinct seasonal variation with April and June being the two driest months (38.7 and 48.0 mm of precipitation, respectively). The rainfall data were obtained from the meteorology station of Universiti Putra Malaysia. Three local cassava varieties, namely MM 92 (MM), Black Twig (BT) and Local (LC), were arranged in a randomized complete block design with 8 replications of each variety, viz. a total of 24 plots.

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Land preparation and planting practice

Land was first cleared to eliminate weeds, and then was ploughed by tractor to a depth of 20 to 25 cm to loosen the soil. A flat method of planting was followed. Planting materials were chosen from healthy and disease-free plants and cut into segments just before planting. Cassava stakes were treated with fungicides and insecticides to ensure good germination and vigorous growth. The stakes of 25 cm length were planted vertically at a planting distance of 25 cm×25 cm in each plot of 5 m×10 m, leaving a 1 m wide alley between plots to facilitate movement from plot to plot. Cassava plants were established within 3 months before they were topped at approximately 15 cm above the ground to start the experiment.

Fodder yield and mortality rate measurements

Cassava fodder (comprising young stems, leaves and petioles) was hand-harvested at 6-week intervals after establishment. Fodder from a 1 m×5 m central portion of each plot was weighed to estimate the yield of each plot. Fresh sub-samples (40 plants) were separated for leaf:stem ratio (LSR) determination, and were used to determine the dry matter contents and subsequently the nutrient contents.

Plant survival percentage was a measure of growth persistency for each variety. The total number of live plants after establishment was referred to as germination ability of each variety under field conditions. Dead plants were pulled out while surviving plants were counted. The mortality rate was determined after every 2 harvests until the end of the experiment.

Manure application and weed control

Dung excreted by heifers fed a ration consisting of 3.5 kg of oil palm frond pellets and 1.5 kg of cassava fodder as a protein supplement (DM basis) was collected, air-dried under shade and later hand-spread onto the cassava plots in two equal portions after each harvest. In addition, all cassava plots after establishment received an initial dressing of 2 t/ha of manure (DM) which provided of 36.4 kg N/ha, 3.4 kg P/ha and 17.3 kg K/ha.

Two rounds of hand-weeding were carried out, at four weeks after planting and 8 weeks after the last weeding (the time at which cassava was established). Thereafter, to avoid competition between cassava and weeds, hand-weeding was performed after every two harvests. No herbicide was used in weed control. No disease control was necessary throughout the experiment, but foliar spraying of 2% zinc sulphate solution was carried out when zinc deficiency symptoms appeared after starting the experiment.

Chemical analysis

The harvested materials from each plot were separated into stem and leaf fractions, sub-sampled and immediately brought to the laboratory for determination of nutrient contents. Cassava fodder samples were dried at 60°C for 24 h, ground to pass through a 2-mm screen and stored in pillboxes for further analyses. The samples were analyzed for DM, CP, P and K by standard techniques (AOAC, 1990).

Statistical analysis

The results obtained were subjected to an analysis of variance for a randomized complete block design with the aid of the Statistical Analysis System (SAS, 1998). Duncan's New Multiple Range Test was used to compare the mean values between treatments (Gomez and Gomez, 1984). Chi-Square Test was used for analyzing the mortality rate of cassava.

RESULTS

Total fresh and dry fodder productivity

Fresh and dry fodder yields of three cassava varieties are presented in table 1. MM was the highest fodder yielder either in fresh or in dry form. There were significant differences among varieties in fresh fodder production ($p<0.05$). Mean fresh fodder yields were 6.3, 5.75 and 4.16

Table 1. Fresh and dry fodder yields of three cassava varieties over 8 harvests (t/ha/harvest)

Harvest	Fresh fodder yield				Dry fodder yield			
	MM	BT	LC	SEM	MM	BT	LC	SEM
1	8.97^a	7.08^b	6.32^b	0.51	1.45^a	1.25^a	1.19^a	0.06
2	6.80^a	5.71^a	3.70^b	0.42	1.32^a	1.18^a	0.85^b	0.08
3	5.41^a	4.91^a	2.45^b	0.48	0.93^a	1.07^a	0.48^b	0.08
4	6.46^a	6.30^a	4.20^b	0.35	1.11^a	1.06^a	0.80^b	0.05
5	7.31^a	7.53^a	5.78^a	0.45	1.17^a	1.14^a	0.93^a	0.06
6	6.56^a	5.80^a	4.66^a	0.49	1.03^a	0.89^a	0.79^a	0.07
7	4.67^a	4.43^a	3.20^b	0.28	0.89^a	0.74^a	0.59^a	0.04
8	4.24^a	4.27^a	2.95^a	0.3	0.71^a	0.68^a	0.52^a	0.04
Mean	6.3^a	5.75^a	4.16^b	0.31	1.07^a	1.00^a	0.77^b	0.05
Total*	50.42^a	46.03^a	33.26^b	2.47	8.55^a	8.01^a	6.15^b	0.37

^{a,b,c}: Means with different superscripts in the same row differ significantly ($p<0.05$).

SEM=Standard error of mean, *: Total of 8 harvests (t/ha).

t/ha/harvest for MM, BT and LC, respectively. However, the dry fodder production of MM though statistically higher ($p<0.05$) than that of LC, was not different from that of BT ($p>0.05$). MM produced the highest mean dry fodder yield (1.07 t/ha/harvest), followed by BT (1.00 t/ha/harvest). Poor regrowth of LC variety resulted in the lowest mean dry fodder production (0.77 t/ha/harvest).

Leaf and stem DM yield and leaf:stem ratio

Leaf and stem DM yields and leaf:stem ratios of the three cassava varieties are shown in table 2. The mean leaf DM yield of LC variety (0.63 t/ha/harvest) was significantly lower ($p<0.05$) than those of MM and BT (0.88 and 0.85 t/ha/harvest, respectively). There were no significant differences among the three varieties in stem yield. Mean leaf:stem ratio of BT was higher ($p<0.05$) than those of MM and LC. Leaf:stem ratios were 5.0, 5.9 and 4.8 for MM, BT and LC, respectively.

Total CP production

The CP yields of the three cassava varieties are presented in table 3. MM appeared to be a promising variety as a fodder crop as it produced a larger amount of CP than the other two varieties. However, the CP amount of MM, though significantly different from that of LC ($p<0.05$), was not different from that of BT. The mean CP yields of MM, BT and LC over the 8 harvests were 272, 238 and 184 kg/ha/harvest, respectively. Crude protein production was found to be highest at the first harvest, but lowest by the end of the experiment except in LC variety for which CP production was lowest at the third harvest.

Mortality rate (%)

The mortality rates of the three cassava varieties over a period of one year are shown in table 4. The mortality rate of MM (9.91%) was seen to be significantly lower ($p<0.05$) than those of BT (14.01%) and LC (13.98%) which were similar to each other ($p>0.05$).

Phosphorus and potassium contents

The phosphorus contents of leaf, stem and whole plant of the three cassava varieties are shown in table 5. There were no significant differences among the three varieties in leaf phosphorus contents. The stem phosphorus contents of MM (0.45%) and BT (0.42%) were statistically higher than that of LC (0.37%) ($p<0.05$). The same could be said for whole plant phosphorus contents.

The potassium contents of leaf, stem and whole plant of the three cassava varieties are presented in table 6. The leaf potassium content of BT was significantly higher than those of MM and LC. The leaf potassium contents were 1.25, 1.4 and 1.23% for MM, BT and LC, respectively. There were also significant differences among the three varieties in potassium contents of stem. In the case of whole plant, the potassium content of BT was significantly higher than those of MM and LC ($p<0.05$).

DISCUSSION

Total fresh and dry fodder productivity

As shown in table 1, cassava fodder productivity was largely affected by different varieties. Gomez and Valdivieso (1984) conducted an experiment in which two cassava varieties, CMC-40 and CMC-84, were grown for leaf and root yield estimations. CMC-84 gave a much higher leaf yield than CMC-40 at 1.8 and 1.2 t/ha, respectively. Ahmad (1973), investigating the leaf DM productivity of two cultivars, Black Twig and Medan, reported yields of up to 7.3 and 4.8 t/ha, respectively. Apparently, there is a difference in fodder producing ability

Table 2. Dry matter yields of leaf, stem and leaf:stem ratio of three cassava varieties over 8 harvests

Harvest	Leaf (t/ha/harvest)				Stem (t/ha/harvest)				Leaf:stem ratio			
	MM	BT	LC	SEM	MM	BT	LC	SEM	MM	BT	LC	SEM
1	1.20^{a}	1.06^{a}	1.00^{a}	0.05	0.25^{a}	0.19^{a}	0.19^{a}	0.02	5.5^{a}	5.9^{a}	5.9^{a}	0.33
2	1.06^{a}	0.98^{a}	0.68^{b}	0.06	0.26^{a}	0.20^{a}	0.17^{a}	0.02	4.3^{a}	5.1^{a}	4.7^{a}	0.22
3	0.77^{a}	0.94^{a}	0.39^{b}	0.07	0.16^{a}	0.13^{ab}	0.09^{b}	0.01	5.2^{a}	7.6^{b}	5.6^{a}	0.43
4	0.92^{a}	0.90^{a}	0.66^{b}	0.04	0.19^{a}	0.16^{a}	0.14^{a}	0.01	4.9^{a}	5.7^{b}	4.5^{a}	0.18
5	0.96^{a}	0.95^{a}	0.75^{a}	0.05	0.21^{a}	0.19^{a}	0.18^{a}	0.02	4.7^{ab}	5.5^{b}	4.3^{a}	0.21
6	0.83^{a}	0.73^{a}	0.62^{a}	0.05	0.2^{a}	0.16^{a}	0.17^{a}	0.02	4.7^{a}	5.3^{a}	4.0^{a}	0.24
7	0.68^{a}	0.62^{ab}	0.48^{b}	0.04	0.15^{a}	0.12^{a}	0.11^{a}	0.01	5.1^{a}	5.6^{a}	4.4^{a}	0.23
8	0.59^{a}	0.58^{a}	0.43^{a}	0.04	0.12^{a}	0.10^{a}	0.09^{a}	0.01	5.2^{a}	6.3^{b}	4.7^{a}	0.19
Mean	0.88^{a}	0.85^{a}	0.63^{b}	0.04	0.19^{a}	0.16^{a}	0.14^{a}	0.01	5.0^{a}	5.9^{b}	4.8^{a}	0.14
Total*	7.01^{a}	6.76^{a}	5.01^{b}	0.3	1.54^{a}	1.25^{a}	1.14^{a}	0.08				

^{a,b,c}: Means with different superscripts in the same row differ significantly ($p<0.05$).
SEM=Standard error of mean, * : Total of 8 harvests (t/ha).

Table 3. Total crude protein production of three cassava varieties (kg/ha/harvest)

Harvest	MM	BT	LC	SEM
1	370^{a}	281^{b}	280^{b}	19.1
2	291^{a}	244^{a}	171^{b}	17.0
3	247^{a}	248^{a}	122^{b}	20.3
4	261^{a}	241^{a}	187^{b}	14.3
5	299^{a}	275^{a}	244^{a}	16.8
6	272^{a}	226^{ab}	191^{b}	14.5
7	236^{a}	200^{ab}	140^{b}	14.9
8	203^{a}	187^{a}	139^{a}	13.2
Mean	272^{a}	238^{a}	184^{b}	12.1
Total*	$2,179^{a}$	$1,903^{a}$	$1,474^{b}$	97.2

^{a,b,c}: Means with different superscripts in the same row differ significantly ($p<0.05$)
SEM=Standard error of mean, *: Total of 8 harvests (t/ha).

Table 4. Mortality percentage of three cassava varieties throughout defoliation

Week	MM	BT	LC	SEM
0*	2.30^{a}	4.08^{a}	3.24^{a}	0.30
12	0.93^{a}	1.15^{a}	1.00^{a}	0.09
24	1.54^{a}	2.41^{a}	2.48^{a}	0.41
36	3.17^{a}	5.30^{a}	5.15^{a}	0.86
48	2.39^{a}	1.87^{a}	3.12^{a}	0.26
Total	9.91^{a}	14.01^{b}	13.98^{b}	1.18

^{a,b,c} : Means with different superscripts in the same column differ significantly ($p<0.05$).
*: Three months after planting, SEM = Standard error of mean.

among cassava varieties. Conceicao (1973) pointed out that certain varieties are better forage producers than others. Hence, variety selection should be done intensively to increase fodder production, contributing not only to reduction of feed imports but also to the enhancement of livestock production in the tropics in the long run.

Results obtained in this study also showed that continuous defoliation reduced considerably the dry fodder production in all the varieties, besides factors such as fertilizer regime, weather conditions (mainly rainfall), soil nutrients and weeds. Despite the low release of manure nutrients, the fluctuation in cassava fodder production seemed not to be limited by fertilizer application in the first year of cultivation. Ahmad (1973) showed no significant differences between fertilized treatments and a non-fertilized treatment on dry leaf production over all five harvests. In addition, it was reported that DM production of cassava declined over time irrespective of defoliation frequencies practiced (Wong and Mohd. Sharudin, 1986). As cassava plants were regularly injured during cutting, regrowth ability would become lower causing low DM production.

Harvests with high DM production in all the varieties appeared to coincide with some periods of high rainfall, especially at the start of the experiment. However, DM yields of the three varieties under the same agronomic practices were not well correlated with rainfall over the duration of the experiment. The relationship between rainfall and dry fodder production of cassava is presented in figure 1. It is possible that distribution of rainfall is more important than total rainfall amount. After harvest, cassava plants need a certain amount of water for re-sprouting. The dramatic yield reduction in all three varieties at the third harvest could be explained by the occurrence of a 2 to 3 week period of drought. Although a large amount of rain fell in subsequent weeks, this did not help the cassava plants restore their retarded initial regrowth ability. In addition, it was realized that LC variety was poor in drought resistance compared to MM and BT as the latter two gave relatively higher fodder yields when rainfall was as low as 100 mm.

Observations in the field also revealed that growth of weeds partially affected fodder production, particularly at the third harvest. Weeding was not done until the third harvest because of a lack of labor. It would appear that weeding should be done every two harvests to sustain dry

Table 5. Phosphorus contents of leaf, stem and whole plant of three cassava varieties over 8 harvests (% DM)

Harvest	Leaf				Stem				Whole plant			
	MM	BT	LC	SEM	MM	BT	LC	SEM	MM	BT	LC	SEM
1	0.40^{a}	0.39^{a}	0.36^{b}	0.006	0.45^{a}	0.41^{b}	0.42^{ab}	0.008	0.41^{a}	0.4^{a}	0.37^{b}	0.006
2	0.37^{a}	0.38^{a}	0.40^{a}	0.008	0.45^{a}	0.39^{b}	0.39^{b}	0.007	0.38^{a}	0.39^{a}	0.40^{a}	0.007
3	0.39^{a}	0.38^{a}	0.42^{b}	0.005	0.46^{a}	0.42^{b}	0.40^{b}	0.007	0.40^{a}	0.39^{b}	0.42^{ab}	0.005
4	0.44^{a}	0.42^{a}	0.39^{a}	0.011	0.43^{a}	0.41^{a}	0.37^{b}	0.007	0.44^{a}	0.42^{ab}	0.38^{b}	0.010
5	0.40^{a}	0.43^{a}	0.41^{a}	0.006	0.45^{a}	0.43^{a}	0.35^{b}	0.012	0.41^{ab}	0.43^{a}	0.40^{b}	0.006
6	0.41^{a}	0.45^{b}	0.38^{c}	0.009	0.46^{a}	0.46^{a}	0.23^{b}	0.023	0.42^{a}	0.45^{b}	0.35^{c}	0.010
7	0.40^{a}	0.41^{a}	0.41^{a}	0.007	0.45^{a}	0.43^{a}	0.36^{b}	0.009	0.41^{a}	0.42^{a}	0.40^{a}	0.006
8	0.42^{a}	0.40^{a}	0.42^{a}	0.005	0.47^{a}	0.42^{b}	0.39^{c}	0.008	0.43^{a}	0.40^{a}	0.41^{a}	0.005
Mean	0.40^{a}	0.41^{a}	0.40^{a}	0.003	0.45^{a}	0.42^{a}	0.37^{b}	0.008	0.41^{a}	0.41^{a}	0.39^{b}	0.003

^{a,b,c}: Means with different superscripts in the same row differ significantly ($p<0.05$), SEM=Standard error of mean.

Table 6. Potassium contents of leaf, stem and whole plant of three cassava varieties over 8 harvests (% DM)

	Leaf				Stem				Whole plant			
	MM	BT	LC	SEM	MM	BT	LC	SEM	MM	BT	LC	SEM
1	1.36[a]	1.54[b]	1.32[a]	0.03	1.25[a]	1.43[b]	1.21[a]	0.03	1.34[a]	1.52[b]	1.30[a]	0.03
2	1.15[a]	1.45[b]	1.19[a]	0.03	1.14[a]	1.33[b]	1.14[a]	0.02	1.15[a]	1.43[b]	1.18[a]	0.03
3	1.05[a]	1.43[b]	1.13[a]	0.04	1.06[a]	1.43[b]	1.02[a]	0.04	1.06[a]	1.43[b]	1.12[a]	0.04
4	1.39[ab]	1.47[a]	1.31[b]	0.02	1.32[ab]	1.39[a]	1.16[b]	0.03	1.37[a]	1.45[a]	1.28[b]	0.03
5	1.22[a]	1.38[b]	1.16[a]	0.03	1.29[a]	1.22[a]	0.93[b]	0.04	1.23[a]	1.35[b]	1.11[c]	0.03
6	1.36[a]	1.37[a]	1.26[a]	0.02	1.35[a]	1.32[a]	1.13[b]	0.04	1.35[a]	1.36[a]	1.23[b]	0.03
7	1.26[a]	1.27[a]	1.25[a]	0.02	1.22[a]	1.21[a]	1.12[a]	0.02	1.25[a]	1.26[a]	1.22[a]	0.02
8	1.19	1.26	1.19	0.02	1.30[a]	1.28[a]	1.17[b]	0.03	1.21[a]	1.26[a]	1.19[a]	0.02
Mean	1.25[a]	1.40[b]	1.23[a]	0.02	1.24[a]	1.33[b]	1.11[c]	0.02	1.25[a]	1.38[b]	1.20[a]	0.02

[a,b,c]: Means with different superscripts in the same row differ significantly ($p<0.05$). SEM=Standard error of mean.

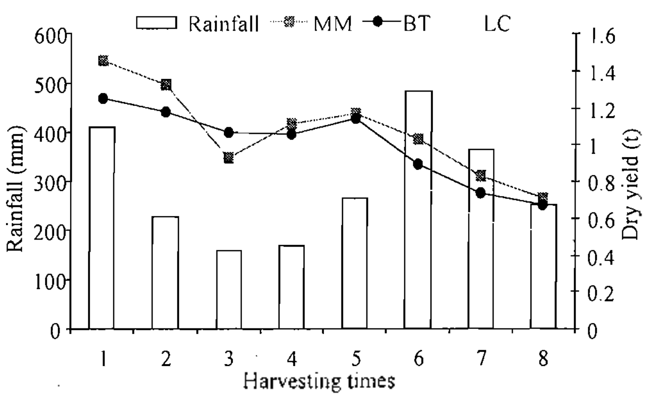

Figure 1. The relationship between rainfall and dry yields of three cassava varieties

fodder production. New cassava sprouts actually appeared from 5 to 7 days after harvest and grew quickly by the third week. When regrowth is retarded, land shaded by cassava plants reduces, and weeds take advantage of the situation to increase their population, thus further limiting the growth of cassava plants. To obtain high cassava fodder production, weed control by manual or chemical means should be considered. Local variety appeared to be more sensitive to weed growth when compared to MM and BT.

Leaf and stem DM yield and leaf:stem ratio

Growth of the cassava plants was vigorous in all varieties over the 8 harvests. Closer plant spacing than for root production and increased plant population allowed all three varieties to produce considerable leaf yields. MM and BT produced 39% and 33%, respectively, higher dry leaf production than LC. Therefore, dry fodder productivity of LC was not comparable to that of MM and BT. Leaf yields of the three varieties obtained in this study were much higher than those reported by other workers planting cassava for root harvest. Larbi et al. (1998) showed foliage yields of green mite-resistant cassava clones at 12 months ranged from 0.18 to 2.21 t DM/ha. Salces et al. (1997) also reported that foliage yields cut at 5 and 7 months and at 5 and 9 months after planting were 5.04 and 3.26 t/ha, respectively. In conclusion, both MM 92 and Black Twig yielded higher either in leaf production or in stem production than the Local variety, resulting in higher dry fodder production.

Most researchers have not considered leaf: stem ratio as one of the important factors when dry cassava fodder productivity was measured. The leaf:stem ratio is necessary to show the efficiency of a defoliation method practiced and the quality of cassava fodder obtained. Wong and Mohd. Sharudin (1986), for instance, reported that an 8-weekly harvest gave a lower total fodder production than a 12-weekly harvest, but higher leaf production was achieved with the former. Furthermore, cassava stems contain a low crude protein content (Che et al., 1999), and have a low digestibility in the rumen (Wanapat et al., 1997). The *in vivo* digestibility of cassava hay in sheep was studied by Barbosa (1972, cited by Balagopalan et al., 1988). The crude fiber digestibility was found to be reduced as the age of the leaves increased. Moreover, the concentrations of nutrients in cassava foliage decrease with aging plants (Gomez and Valdivieso, 1985; Smith, 1988).

Leaf:stem ratios in this experiment are in agreement with those obtained by Wong and Mohd. Sharudin (1986) who reported that leaf:stem ratios of the 4-weekly and the 8-weekly harvests were 7.2 and 3.6, respectively. Similar results for legume trees have also been recorded (Wong and Mohd. Sharudin, 1986). Black Twig was found to be superior in leaf:stem ratio compared to MM and LC. In general, leaves of all varieties constitute a very significant proportion of the whole plant, making cassava fodder a valuable feed material for ruminants.

Total crude protein production

Although CP content was highly stable throughout defoliation, DM yield decreased considerably, resulting in a declining trend in total CP production. Total CP yields of the three varieties at the final harvest decreased by 44%, 34% and 50% for MM, BT and LC, respectively compared to the first harvest. However, all the three varieties produced relatively high total CP yields at the defoliation frequency practiced, resulting in 2,179, 1,903 and 1,474 kg/ha/8 harvests, respectively for MM, BT and Local. Mpoko (1994) reported that cassava leaf harvests enabled a yearly yield of 490 to 1,400 kg of CP/ha which is higher than those of rice, yam and even beans. It was shown that defoliated *Leucaena* produced a CP yield of up to 1,681 kg/ha/year (Aminah et al., 1999). Cassava, which is often considered as a low protein crop when only its roots are utilized, can therefore be considered a high protein yielder if an appropriate defoliation practice is developed.

Mortality rate (%)

Generally, the low mortality rates of all three varieties at establishment indicated good germination. This played a significant role in reducing further labor costs for replanting, and allowed cassava to produce high DM yields. The higher mortality rates at the 36th week, e.g. after the 5th and 6th harvests, were probably attributed to heavy rains which flooded the cassava field for a few hours after each rain. This phenomenon occurred after the cassava harvest, causing the submerged stems to easily rot and leading to increased mortality rate. Even though the mortality rates of all the varieties increased, dry fodder yields were found to increase. Thus, the mortality rate at the levels recorded did not affect dry fodder production of these varieties. Increases in fodder production may be due to the onset of rainfall after a long drought period. In general, the persistency of the three varieties was excellent. By contrast, Wong and Mohd. Sharudin (1986) obtained the mortality rates of 23.2 and 21.4% for 8-weekly and 12-weekly defoliation frequencies, respectively.

Phosphorus and potassium contents

Phosphorus contents of the three cassava varieties seemed to be stable over 8 harvests. This ensures that cassava plants can supply a constant amount of phosphorus for certain types of animal production. Variation in phosphorus content can be large, depending on various factors such as variety, phosphorus content of soil, fertilizer and climate (Howeler, 1978). Moore (1978) showed that phosphorus contents of stem and leaf were in a range of 0.12 to 0.49 and 0.2 to 0.5%, respectively. A leaf phosphorus content of 0.58 % was also reported (Khajarern and Khajarern, 1991). Edwards (1977) reported that cassava required high P fertilizer level for maximum growth, but was able to adjust its growth rate to conditions of low P. Phosphorus contents of the three varieties obtained were appropriate implying that there was no P deficiency during the first year of manure application. However, effects of manure application on soil and plant phosphorus often take place in the long term (Gasser, 1990). Therefore, it is important to know the plant's requirements to diagnose correctly any deficiency through visual observation or soil and plant analyses over many years of cassava cultivation for fodder production. Though critical levels have not been determined and vary somewhat with the cultivar used, a phosphorus content of 0.4% is considered to be reasonable (Howeler, 1978).

Black Twig removed a higher concentration of potassium than MM and LC. This indicated that BT variety required a large amount in K for its growth. In all the three varieties K contents were slightly higher in leaf than in stem. These results agree with that (1.28% for leaf) reported by Ravindran (1991) which fell within the ranges of 0.7 to 1.74% and 1.13 to 1.92% for leaf and stem, respectively (Howeler, 1978). Potassium contents of the three varieties were more variable than phosphorus contents over harvests. It may be related to root formation and production by each variety under the defoliation practiced, beside factors such as weather, soil potassium and plant physiology. Roots are a strong sink for potassium.

CONCLUSIONS

Intensive defoliation allows cassava to produce both high dry fodder yield and crude protein production. Thus, this opens up a vast scope for better use of available forage resources to increase the effectiveness of ruminant production in the tropics. MM 92 and Black Twig were two promising varieties for defoliation. However, more evaluations should be made on varieties and different agronomic conditions in order to achieve better fodder production and higher quality fodder.

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