Effect of different harvesting intervals on foliage yield and chemical composition of cassava (*Manihot esculenta* Crantz)

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Abstract

The purpose of this study was to assess the effect of harvest interval on the production and composition of a local variety of cassava, managed as a semi-perennial forage. The experiment, which was conducted in Salao village located approximately 10 km from Pakse. the capital of Champasack province, Lao PDR, started in January and finished in August 2016. Treatments were different harvest intervals (45, 55, 65, 75 and 85 days) arranged in a randomized complete block design (RCBD) with 4 replications. Two harvests were taken for each interval.

Content of DM, crude protein (CP) and ash, and protein solubility, were higher in leaves than in petioles of the cassava foliage. Overall, the nutritional value of cassava foliage was increased with increasing harvesting interval. Predicted annual yield of DM and CP increased with a positive curvilinear trend as harvest interval was increased from 45 to 85 days. For the 85 day interval the predicted annual yields of fresh biomass, DM and CP were 43.8, 10.3 and 1.86 t/ha/year, respectively.

Key words: *biomass, crude protein, dry matter, variety*

Introduction

In Lao PDR, cassava is an important crop for industrial production of starch from the roots. It is also a main source of food for many ethnic groups living in remote mountain areas, due to its tolerance to drought and capacity to grow in less fertile soils (CIAT 2015).

Growing and using cassava as a perennial forage was first proposed by Moore (1976) based on observations at CIAT in Colombia. High yields of foliage were obtained when cassava was managed as a semi-perennial crop with repeated harvesting of the foliage at 2-3 month intervals. This idea was taken up in the Dominican Republic by Ffoulkes and Preston (1978) who showed that the fresh foliage could be used as the sole source of protein and fiber for supplementing a liquid diet of molasses-urea for fattening cattle. However, although successful at the level of the animal the system could not be sustained. Yields of foliage fell rapidly with successive harvests and were negligible by the fourth harvest, due to a lack of appreciation of the need to return to the soil the considerable amounts of nitrogen and other nutrients removed by repeated harvesting (Preston T R 1979,

unpublished observations). This appreciation of the importance appropriate fertilization was confirmed in subsequent research in Vietnam and Cambodia (Preston and RodrÃguez 2004) which demonstrated that the cassava plant could be maintained as a semi-perennial forage crop for at least 2 years, with repeated harvests every 2-3 months, provided there was heavy fertilization either with goat manure (20 tonnes manure/ha per harvest in Vietnam) or with the effluent from biodigesters charged with pig manure (100 kg N/harvest in Cambodia). Yields of fresh foliage were higher and more uniform in the system employing biodigester effluent as fertilizer, of the order of 15 tonnes/ha/harvest (Figures 1 and 2).

Figure 1. Fresh foliage yields of cassava managed as a semi-perennial forage crop in Vietnam with repeated harvests at 50 to 70 day intervals and fertilized with fresh goat manure (20 tonnes/ha/harvest) (Preston et al 2000)

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Wanapat (2002) suggested a similar system for cultivating cassava foliage to make hay; the initial harvest was recommended to be at 3 months after planting; followed by subsequent harvests at 2 month intervals. With this system the yield as hay was of the order of 20 tonnes/ha/year.

Materials and Methods

Location, climate and experiment site

The experiment was conducted in Salao village located approximately 10 km from Pakse, the capital of Champasack province, Lao PDR. The average air temperature in the region is 26.6Â°C with average annual rainfall of 2074 mm/year. The rainy season is from May to October with peak rainfall in July and August. The experiment was started in January and finished in August 2016.

Treatments and design

The treatments were five harvesting intervals of 45, 55, 65, 75 and 85 days, repeated over two successive harvests. The experiment was arranged in a Randomized Complete Block Design with 4 replications of each treatment.

Soil preparation, plot size and planting

The soil was ploughed by tractor to break down the soil structure. The area was then divided into 20 plots with the size of each plot 3 x 4 m. Cassava (local, sweet variety) was planted at the end of the dry season (February). Stem cuttings (40cm in length) were taken from a plot belonging to one household in the village. The stems were embedded in the soil at an angle of about 60Âº, with spacing of 70 cm between rows and 60 cm between plants (total of 28 stems per plot).

Fertilizing and weeding

Each plot was fertilized with goat manure corresponding to 20 tonnes/ha at planting. Water was applied every morning and evening during the first 4 months of cultivation and then was according to the rainfall. Weeds were removed by hand once a month.

Harvesting and chemical analysis

Each treatment was harvested two times, thus the overall growth periods were 90, 110, 130, 150 and 170 days for treatments 45 through 85 days. All the cassava plants in each plot were cut 20 to 30 cm above soil level (Photo 1). Four plants in each plot were separated into the three yield components (stems, leaves and petioles) which were weighed immediately after cutting. A sample of approximately 1 kg was taken of each component per plot for subsequent analysis of DM, ash and crude protein according to standard methods (AOAC 1990). Protein solubility as an indicator of tannin levels was determined from kjeldahl-N analysis of the filtrate following treatment with trichlor-acetic acid and filtering through Whatman 4 paper (Vanhnasin et al 2016).

Photo 1. Cassava stems after harvesting

Statistical analysis

The data were analyzed using the General Linear Model (GLM)option in the Analysis of variance (ANOVA) program of the Minitab (2000) software. The sources of variation in the model were: block, treatment and error.

Results and discussion

Chemical composition

The leaf had higher content of DM, CP and ash, and higher solubility of the protein, than the petiole. (Table 1). DM and CP content in leaf were increased with length of harvest interval. A similar increase of CP content in cassava leaf with harvest interval was reported by Khang et al (2005) for intervals of 45, 60 and 90 days. The higher value of CP in cassava leaves in our experiment, compared with that of Phanthavong and Wanapat (2004), might be due to the effect of the goat manure fertilizer. Khang and Preston (2005) showed that with application of effluent the percentage of CP in DM of cassava foliage increased to 20.7% (with effluent) from18.6% (without effluent).

Table 1. Chemical composition of cassava foliage harvested at different intervals over 2 harvests (H)

	NH*	Harvest interval, days				
		45	55	65	75	85
Dry matter, %						

Leaf	H1	21.3	22.0	24.8	25.3	26.
	H2	22.3	23.1	24.1	27.2	28.
	Mean	21.8	22.6	24.5	26.3	27.
Petiole	H1	16.8	17.0	16.3	16.9	17.
	H2	14.8	14.7	16.3	19.0	19.
	Mean	15.8	15.8	16.3	18.0	18.
Crude protein, % in DM						
Leaf	H1	22.6	23.3	23.3	23.9	24.
	H2	21.9	22.8	23.7	23.8	24.
	Mean	22.2	23.0	23.5	23.8	24.
Petiole	H1	6.13	6.01	6.39	6.98	6.6
	H2	7.45	7.30	6.46	6.05	5.8
	Mean	6.79	6.65	6.43	6.51	6.2
Protein solubility, %						
Leaf	H1	29.9	29.5	29.1	28.9	28.
	H2	29.5	29.7	29.7	29.2	28.
	Mean	29.7	29.6	29.4	29.1	28.

Petiole	H1	13.4	12.6	15.1	14.0	14.
	H2	16.8	13.8	12.7	14.6	15.
	Mean	15.2	13.2	13.9	14.3	14.
Ash, % in DM						
Leaf	H1	5.96	6.54	6.88	6.97	7.1
	H2	6.56	6.52	6.56	6.91	6.9
	Mean	6.26	6.53	6.72	6.94	7.0
Petiole	H1	1.14	1.13	1.15	1.16	1.1
	H2	1.03	1.13	1.12	1.16	1.1
	Mean	1.09	1.13	1.14	1.16	1.1

** NH: H_1: first harvest; H_2: second harvest*

Fresh, DM and crude protein yield

Higher foliage yield resulted from increasing the harvest interval for both leaf and petiole (Table 2). These increases are similar to those reported by Chantaprasarn and Wanapat (2003), Phanthavong and Wanapat (2004) and Khang et al (2005).

Table 2. Mean value of fresh and dry matter and crude protein yield of cassava foliage harvested at differe intervals.

	Harvest interval, days					SEM
	45	**55**	**65**	**75**	**85**	

			---------- *First harvest* ----------				
Fresh yield, t/ha							
Leaf	1.32	1.40	1.61	3.44	4.96	0.192	<
Petiole	0.83	0.81	0.84	2.40	4.08	0.145	<
Total	2.15	2.21	2.45	5.84	9.05	0.330	<
DM yield, t/ha							
Leaf	0.31	0.31	0.39	0.94	1.43	0.054	<
Petiole	0.12	0.12	0.14	0.46	0.78	0.028	<
Total	0.43	0.43	0.52	1.39	2.22	0.080	<
CP yield, t/ha							
Leaf	0.07	0.07	0.09	0.22	0.35	0.013	<
Petiole	0.01	0.01	0.01	0.03	0.05	0.002	<
Total	0.08	0.08	0.10	0.26	0.40	0.015	<
			---------- *Second harvest* ----------				
Fresh yield, t/ha							
Leaf	1.78	2.29	3.90	4.90	6.53	0.236	<
Petiole	1.34	1.72	2.99	3.61	4.82	0.184	<

Total	3.12	4.01	6.89	8.51	11.3	0.417	<
DM yield, t/ha							
Leaf	0.38	0.50	0.97	1.24	1.72	0.060	<
Petiole	0.21	0.28	0.49	0.61	0.85	0.031	<
Total	0.59	0.78	1.45	1.85	2.57	0.090	<
CP yield, t/ha							
Leaf	0.08	0.11	0.23	0.30	0.42	0.014	<
Petiole	0.02	0.02	0.03	0.04	0.05	0.002	<
Total	0.10	0.14	0.26	0.33	0.47	0.016	<
		---------Overall mean (both harvests) ---------					
Fresh yield, t/ha	2.63	3.11	4.67	7.18	10.2	0.271	<
DM yield, t/ha	0.51	0.61	0.99	1.62	2.40	0.062	<
CP yield, t/ha	0.09	0.11	0.18	0.29	0.43	0.011	<

Predicted annual yields of cassava foliage

The predicted annual yields indicate curvilinear responses in fresh biomass, DM and CP favoring the longest interval of 85 days between harvests (Table 3; Figures 3-5). However, these data should be treated with caution as being indicative of potential benefits of the extended harvest interval. Since only two harvests were taken, the effect of time of year was confounded with the treatment (eg: for the 45-day interval the growth period was from January through March, for the 55-day interval the growth period was January to mid-April, for 65-day interval it was January through to mid-May, for 75-day interval it was January through May and for 85-day interval January through to mid-June. Thus, for the 85-day interval the second harvest coincided with the start of the rainy season with expected beneficial effects on plant growth.

Table 3. Predicted annual yields of fresh and dry matter and crude protein from cassava foliage (leaf + petiole) harvested at different intervals.

	Harvest interval, days				
	45	**55**	**65**	**75**	**85**
Fresh yield, t/ha	21.4	20.6	26.2	34.9	43.8
DM yield, t/ha	4.13	4.03	5.56	7.90	10.3
CP yield, t/ha	0.71	0.71	1.01	1.43	1.86

Figure 3. Predicted annual fresh biomass yield of cassava foliage for different harvest intervals.

Figure 4. Predicted annual DM yield of cassava foliage for different harvest intervals

Figure 5. Predicted annual crude protein (CP) yield of cassava foliage for different harvesting intervals

Conclusions

- The DM and CP content of cassava foliage increased with increasing harvest interval from 45 to 85 days
- There was higher CP content in leaf than in petiole at all harvest intervals
- Predicted annual yield of DM and CP increased with positive curvilinear trends as harvest interval was increased from 45 to 85 days.

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