CASSAVA LEAVES AND FORAGE CROPS FOR RUMINANT FEED IN THE ESTABILISHMENT OF SUSTAINABLE CASSAVA FARMING SYSTEMS IN INDONESIA

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ABSTRACT

Most of the cassava production areas in Indonesia are on marginal soils, which are characterized by a low content of nutrients and organic matter, and are susceptable to erosion. Increasing the nutrients and organic matter content as well as controlling erosion is needed to maintain soil productivity. Soil erosion, the main cause of soil degradation, could be reduced effectively by such cultural practices as contour ridging, the planting of contour hedgerows of forage crops, and intercropping cassava with upland rice or peanut. The organic matter content of soil could be increased by applying organic fertilizers such as cattle manure and mulch. Contour hedgerows of forage crops planted in cassava fields will reduce erosion effectively, while the pruning of the forage crops is a potential source of feed for ruminants. Using the prunings of forages of *Gliricidia, Leucaena*, elephant grass, and the residues of food crops such as cassava leaves, cassava root skin, rice straw and maize stalks as feed of ruminants is able to increase their weight significantly. The ruminants are main organic manure producers and are used for soil preparation. Therefore, the development of this integrated crop-livestock system is advised to maintain soil fertility and increase its productivity. On the other hand, the production of cassava leaves, which is estimated to be 1.5 million tonnes per year, is an excellent protein supplement in the rations of ruminants. The main problems of cassava leaves are their low neutral-detergent fiber (NDF) and hight HCN contents. NDF can be increased by supplementing with elephant grass or napier grass, while HCN can be reduced by chopping the harvested leaves and letting them wilt for 24 hours before feeding.

INTRODUCTION

Most cassava production areas in Indonesia are located on marginal mountainous soil on Java island and undulating Ultisols of the other islands. These soils are characterized by their low contents of nutrients and organic matter; they also tend to be susceptible to erosion (Wargiono,1995). Erosion and the low contents of nutrients and organic matter are the main factors affecting the productivity of crops. Therefore, controlling erosion by growing contour hedgerows of forage crops and increasing both soil nutrients and organic matter by establishing integrated crop-livestock systems is the way to maintain the sustainability of cassava-based farming systems. Most farmers in these areas have limited capital and labor; it is estimated that they have on average 1.1 to 2.2 ruminants/household (**Table 1**).

A cheap and effective way of controlling erosion, suitable for most soils and farmers, is the planting of contour barrier strips of grasses such as elephant grass, vetiver grass, napier grass, or the planting of contour hedgerows of *Leucaena* and *Gliricidia*. Another advantage of these practices is that grasses and prunings of *Leucaena* and *Gliricidia* can be used for either ruminant feeding or for mulch, which is able to supply aditional N to the crops and inprove the soil organic matter content as well as their physical characteristics (Wargiono, 1995).

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Table 1. Ruminant population and amount of cassava leaves used for feed per farmer household[1)] in several regions of Indonesia.

Regions	Ruminant [2)] population (animal/family)	Cassava leaf production (kg/family)
Sumatera	1.4	114
Java	1.1	98
Bali + Nusa Tenggara	2.2	158
Kalimantan	0.3	61
Sulawesi	1.5	89
Maluku & Irian	1.0	151

[1)]Farmer households are asumed to be 60% of all households
[2)]Consists of cattle, buffalo, goat and sheep
Source: *CBS, 2000.*

Ruminants are useful as producers of manure, they also function as a household bank and some are used for soil preparation. Ruminants fed with elephant grass, napier grass, prunings of *Leucaena* and *Gliricidia* as well as cassava leaves increased their daily weight gain (Budiman and Djamal, 1994; Ludgate and Scholz, 1992). Increasing the daily weight gain of ruminants depends on the year-round availability of forage crops. The better the availability of the feed, the greater the weight gain. The higher the weight gain of the ruminants, the greater the production of manure and therefore, the more manure can be applied to cassava. By applying this manure annually, it is possible to maintain a low external input integrated cassava-livestock farming system.

Applying ruminant manure increases the yield of cassava leaves and thus the amount of protein supplement in the ration of ruminant feed, as the protein content of cassava leaves is higher than that of other forage crops (Ludgate and Scholz, 1992). More than 70% of cassava leaves are used for ruminant feeding in Indonesia (Sudaryanto, 1992). Cassava fresh leaf production, estimated at 5.7 million tonnes/year in Indonesia (BPS, 2000), will be a potentially important protein source for ruminants in the next decade.

Cassava Leaves as a Protein Feed Supplement for Ruminants

1. Potential and Production of Cassava Leaves

The actual yield of cassava leaves depends on the way these leaves are harvested. Maximum stem growth is at six months after planting, after which DM accumulation is redirected from growing stems and leaves to that of roots (Wargiono, 1986). As a new leaf is initiated every two days, therefore, four leaf blades/plant can be harvested a week during 3 to 4 months when plants are 3 to 7 months old, without any reduction in root yield (Sugito, 1990; Sudaryanto, 1992). By estimating an average plant population of 8,000 plants/ha, a harvested area of 1.275 million ha and a weight of each four leaf blades of 15 grams (harvested at weekly intervals for 4 months between 3 and 7 months old of 10 varieties at Bogor, W. Java), about 2.4 million tonnes of cassava leaves can be harvested during that period. Stem and leaf production decreases steadily after the seventh month (Hozyo, 1984); so, harvesting four leaf blades weekly after 7 months is not recommended, because it can reduce root yields.

The population of large ruminants in Indonesia (cows, buffaloes and horses) is about 15 million, while that of small ruminants (goats and sheep) is about 16.3 million

(BPS, 2000). Based on that ruminant population and estimating that farmers' households comprise about 60% of the total number of households, indicates that each farmers' household has between 1.0 to 2.2 ruminants. **Table 1** shows that cassava leaf production is not in line with the number of ruminants per farmer's household. Demand for cassava leaves is generally higher than production, so we have to find a way to increase cassava production or substitute cassava leaves with other forage crops.

Harvesting leaves + young stems for ruminant feeding at nine months after planting or later yielded about 20.2% of root yield weight. Using this ratio the estimated amount of harvested leaves will be 3.5 million tonnes, with the availability of those leaves per household varying from 13 to 223 kg in the various provinces. It means that production of cassava leaves should be increased as demand increases, or other forage crops that can be used as potential protein supplements, such as *Leucaena, Sesbania, Calliandra* and peanut, should be established.

2. Nutritive Value of Cassava Leaves

The protein content of cassava leaves is affected by the variety used and its age (**Table 2**). The protein content of young leaves (five blades starting from the top) varied from 24.7% to 35.5%, while for older leaves this varied from 20.2% to 30.8% (Ludgate and Scholz,1992). The protein content of leaves + petiole + young stem of Adira-1 was 23.4% (Sudaryanto, 1992). This protein content is lower than the average protein content of old and young leaves as reported by Ludgate and Scholz (1992).

Table 2. Protein content of young and old cassava leaves, Bogor 2002.

	Crude protein content (%)	
Varieties	Young leaves	Old leaves
Adira-1	35.86	30.79
Adira-4	32.12	30.23
No.50.2	32.86	23.88
No.39.1.1	33.12	27.17
No.40.3.3	24.68	20.16
BIC 319	33.09	26.53
BIC 317	33.35	29.14
BIC 323	32.20	28.68
BIC 109	32.69	27.07
BIC 137	35.49	28.61

Source: *Ludgate and Scholz, 1992*. Harvesting leaves at 8 months old.

The main problem of cassava leaves used for ruminant feed is their low level of neutral-detergent fiber (NDF) and high HCN. Therefore, the daily weight gain of ruminants fed only with cassava leaves is lower as compared to that of cassava leaves supplemented with high NDF feed. Supplementing cassava leaves with high NDF feed such as native grass, elephant grass and rice straw is one way to increase the NDF content in the ration. **Table 3** shows that supplementing cassava leaves with other feed of high NDF content, and using cassava leaves as a supplement to increase the protein intake, increased the ruminant weight effectively.

Table 3. The effect of using cassava leaves as main feed or as suppliment on the daily weight gain of sheep in Indonesia.

Ration	Daily weight gain(g)
Native grass	4
Cassava leaves	-8
Native grass + cassava leaves	31
Elephant grass + cassava leaves	67
Rice straw + cassava leaves	92

Source: *Ludgate and Scholz, 1992.*

Ruminants are more prone to HCN poisoning than non-ruminants because rumen microbes produce enzymes that hydrolyze cyanogenic-glycosides and release HCN into the bloodstream (Ludgate and Scholz, 1992). In addition to accute poisoning, chronic poisoning can occur from continuous intake of small amounts of cyanic acid over long periods of time. The lethal dose of HCN was found to be 3 mg/kg body weight (Ludgate and Scholz, 1992), but supplementing small ruminant feed with cassava leaves, where the HCN intake was 15 mg/kg body weight, had no significant effect on dry matter intake and average daily weight gain (**Table 4**) This difference may be because of characteristics of certain animals (some are more tolerant to HCN than others). A practical technology to reduce the HCN content is by chopping the leaves and young stems and letting these wilt for 12-24 hours before feeding.

Table 4. Dry matter and HCN intake, the digestibility of feed components and the average daily weight gain at three levels of cassava leaf meal in the ration of sheep.

	Level of cassava leaf meal		
	0%	20%	30%
Intake			
Dry matter (g/day)	751	716	735
HCN (mg/kg body weight)	-	9.4[a]	15[b]
Digestibility (%)			
Dry matter	55	50	56
Crude protein	49	38	45
Organic matter	59	54	59
Energy	52	45	52
Neutral detergent fiber	60[a]	54[b]	53[b]
Average daily weight gain (g/day)	112	87	109

Source: *Sudaryanto, 1992.*
Note: Means in the same row with different superscript are significantly different

Forage Crops for Erosion Control and Ruminant Feeding

Since most cassava is grown on soils that are susceptible to erosion, and cassava leaf production is generally less than demand, planting contour hedgerows of forage crops that effectively help to control erosion is a way to meet the additional demand for feed. (Sudaryanto, 1992; Wargiono, 1995).

Common forage crops used for erosion control in cassava production areas are elephant grass, *Sesbania*, *Gliricidia* and *Leucena* as well as interplanted crops under intercropping systems with cassava, such as rice, maize and peanut.

1. Forage Crops for Erosion Control

Most cassava production areas are located in mountainous and undulating areas where erosion can be quite severe. Erosion can be reduced substantially by terracing, minimum tillage and mulching. Erosion control by terracing is very expensive, minimum tillage is not often practiced by farmers because it makes weed control more difficult, while mulch is seldom available as crop residues are mostly used for ruminant feeding. Rice straw can be used either as animal feed during the dry season by farmers having ruminants, or used as mulch for cassava to reduce erosion, control weeds and to maintain soil humidity when it is not used to feed ruminants. For most farmers, ruminants are very useful as manure producers, they function as a family bank and are used for soil preparation. Therefore, a cheaper way to control erosion and which has a double function as ruminant feed, is urgently needed.

One way to control erosion, which is very effective and also produces ruminant feed, is the planting of contour hedgerows of forage crops such as elephant grass, *Sesbania* and *Gliricidia*, or intercropping systems of cassava with maize, rice and peanut (Wargiono, 1995). Contour hedgerows of elephant grass reduced soil losses by erosion at Jatikerto, Malang, E. Java by 31% compared to that without contour hedgerows, while contour hedgerows of *Gliricidia* and *Leucaena* with the pruned leaves used as mulch reduced erosion by 60% and 41%, respectively. Intercropping systems of cassava with rice or peanut reduced erosion about 20% compared to monoculture cassava (Wargiono, 1995).

Returning organic matter into the soil as mulch or as ruminant manure increased both the soil organic matter content and improved the physical characteristics of the soil, thus increasing the productivity of crops. Feeding ruminants with the prunings of forage crops such as *Gliricidia* and *Leucaena* or with straw of interplanted crops increased the daily weight gain of ruminants (Ludgate and Scholz, 1992). Therefore, the more feed is available the more manure is produced and can be applied for cassava, and the higher the productivity of both leaves for feed and roots for food. It means that contour hedgerows of forage crops and the use of intercropping systems can be applied by farmers who have or do not have ruminants.

Table 5 shows the nutrient contents of eroded soil with and without contour strips of grasses and both in monoculture and intercropping systems. The nutrient contents of eroded soil at one month after planting (1/3 of N and K applied) were generally lower than in eroded soil collected at four months (2/3 of N and K applied). This is an indication that the nutrient loss by erosion is relatively higher after fertilizers are applied. It means that using forage crops for erosion control on mountainous and undulating cassava production areas is important for maintaining low external input sustainable agriculture.

Table 5. Nutrient content of eroded soil using different erosion control practices, at 1 and 4 months after planting in Tamanbogo, Lampung in 1999.

Cultural practices[1)]	Eroded soil (t/ha/4 months)	Total nutrients content in eroded soil (%)					
		N		P		K	
		1[2)]	2[2)]	1	2	1	2
Cassava monoculture (CM)	8.86	0.146	0.163	0.008	0.014	0.020	0.018
CM + Vetiver grass (Vg) hedgerows	8.49	0.173	0.169	0.017	0.018	0.013	0.018
CM + Contour strip Vg	8.57	0.171	0.156	0.015	0.022	0.019	0.014
Cassava + Rice + Contour strip Vg	7.84	0.174	0.179	0.012	0.019	0.020	0.020
Cassava + Rice + Contour strip Eg	7.21	0.171	0.178	0.015	0.024	0.022	0.019
Cassava + Peanut + Contour strip Eg	6.68	0.162	0.206	0.020	0.023	0.019	0.019

[1)] Vg= vetiver grass
Eg = elephant grass
[2)] 1= a month after P + 1/3 NK applied (1 MAP)
2= a month after 2/3 NK applied (4 MAP)

2. Forage Crops for Ruminants Feed

Table 1 shows that the average ruminant population per household varied from 1.0 to 2.2 animals depending on the province. Ruminants produce manure, they can be sold when the family needs cash, and cattle and buffalos are used for soil preparation. Therefore, farmers need a year-round supply of forage crops or food crop residues to feed their ruminants.

Table 6 shows the effect of various rations on the daily weight gain of goats and cattle. Utilization of native grass, elephant grass, leguminous leaves, *Gliricidia* leaves, and food crop residues to feed ruminants on the outer islands is 40%, 4%, 16%, 21% and 19%, respectively (Sudaryanto, 1992). Native grass used as the main feed should be supplemented with cassava leaves to increase the NDF, or native grass need to be supplemented with *Leucaena* or *Gliricidia* to increase the protein in the ration.

Table 6. Effect of feed ration on the daily weight gain of small and large ruminants.

Ration		Ruminants weight gain (gram/day)	
Main feed	Supplement	Goats	Cattle
Native grass	-	4	-
Native grass	cassava leaves	31	-
Gliricidia	-	80	451
Gliricidia	elephant grass	111	-
Leucaena	-	44	-
Leucaena	native grass	69	470
Leucaena	elephant grass	50	570
Elephant grass	-	53	-
Elephant grass	*Gliricidia*	67	-
Elephant grass	cassava leaves	21	-
Rice straw	*Gliricidia*	-	400
Rice straw	elephant grass	67	470

Source: *Ketaren et al., 1993; Budiman and Djamal, 1994; Ludgate and Scholz, 1992.*

Using *Gliricidia* as the main feed resulted in a daily weight gain of 80 and 451 grams for goats and cattle, respectively. The daily weight gain increased 39% when *Gliricidia* was supplemented with elephant grass. Establishing two contour hedgerows of 50 meter length is enough for farmers having two cows, where *Gliricidia* is the supplement (40%) of elephant grass or rice straw. *Gliricidia* can be harvested every three months. The hedgerow should be maintained at about 0.5 meter height to minimize the shading of cassava planted between hedgerows (Wargiono, 1995).

Leucaena has a high protein content (about 24% on DM basis); therefore, this species is suitable both as a main feed and as a supplement. *Leucaena* use as main feed and supplemented with native grass resulted in a daily weight gain of goats and cows of 69 and 470 grams, respectively. An increase in daily weight gain of cattle of 21% was obtained when *Leucaena* was supplemented with elephant grass. *Leucaena* is mostly planted along the border of their land.

Elephant grass is the most common among these forage crops, especially in Java island. The problem of elephant grass is its low protein content and its strong competitive effect on cassava. Elephant grass as the main feed resulted in daily weight gain of goats of 53 grams, and this increased 26% when the grass was supplemented with *Gliricidia*. Intercrops having by-products that can be used as feed and which also reduce erosion effectively, are rice and peanut. Rice straw as the main feed and supplemented with elephant grass resulted in a daily weight gain of goats and cattle of 67 and 470 grams, respectively. Therefore, rice straw can be used as animal feed during the dry season or it can be used as mulch when not used as feed.

The advantages of planting contour hedgerows of *Gliricidia*, *Leucaena* and elephant grass as well as intercropping cassava with other food crops in an integrated cassava-based crop/livestock farming system are shown in **Figure 1**.

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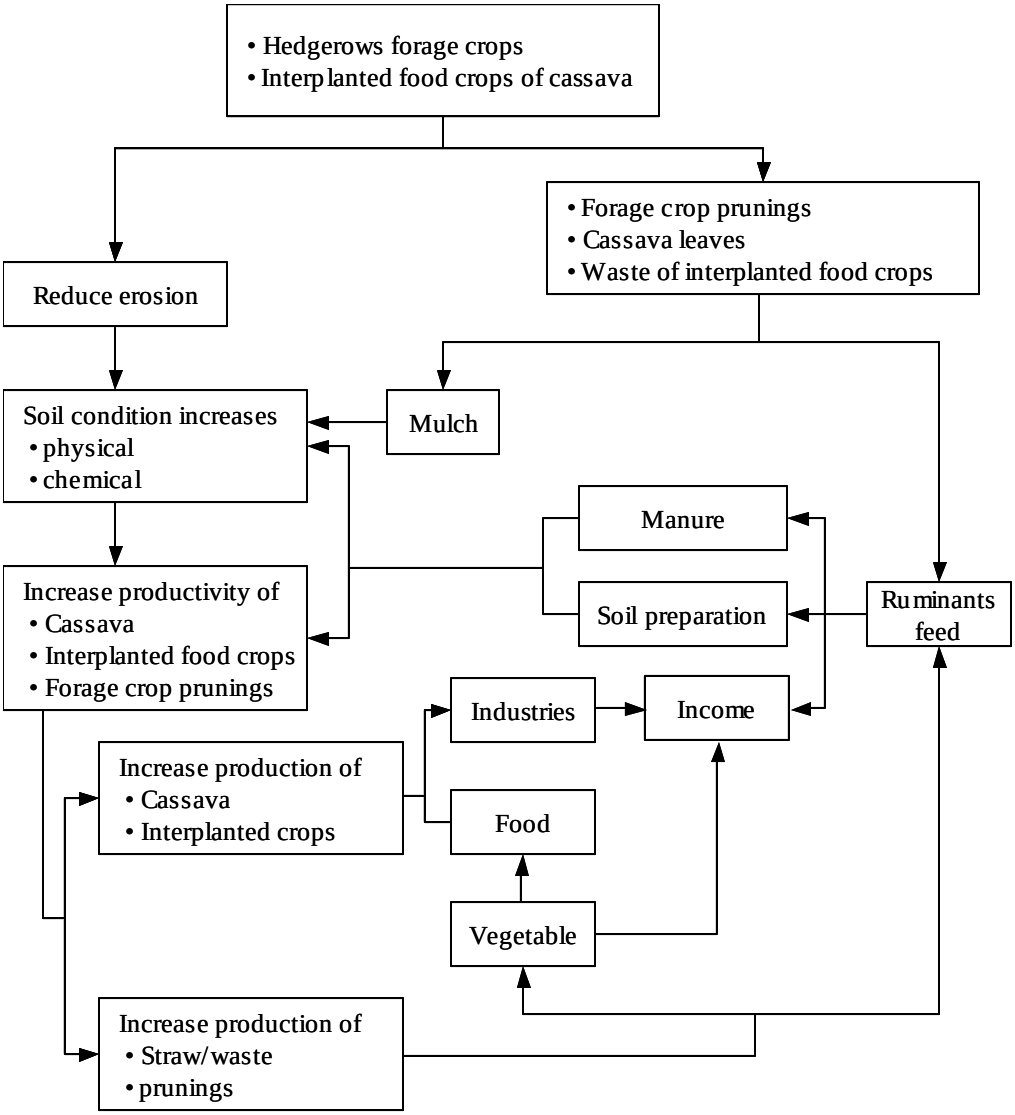

Figure 1. Diagram showing how farmers' income can be increased by an integrated cassava-based crop/livestock farming system.