# Cassava Forages Production for Animal Feeds in Cassava Based Intercropping System

T. Islami[1], Marjuki[1], and R. H. Howeler[2]
[1]Research Centre for Tuber and Root Crops, Brawijaya University, Malang, Indonesia
[2]CIAT Emeritus, Cali, Columbia
Email: {wanihadi, marjuki}@ub.ac.id, r.howeler@cgiar.org

***Abstract*—Two years consecutive field experiment was conducted to study the feasibility of cassava forage production in a cassava-maize intercropping system. Three cassava varieties were planted at two different plant spacings and were intercropped with maize. Three methods of cassava pruning were employed to produce cassava forage as animal feed, i.e. (1) no pruning; as control treatment, (2) top pruning, and (3) leaf pruning. These treatment combinations were arranged in a Randomized Block Design of three replications. The first pruning was done soon after harvesting the intercropped maize; the second and third pruning were done on 30 and 60 days after the first pruning; and the final pruning was done at the time of cassava root harvest. Top pruning was done by cutting the stems with leaves and petioles at a height of 20cm from the ground. Leaf pruning was done by harvesting all mature leaves and petioles; at the final pruning the top green stem with leaves were harvested. For the control treatment (no pruning), the forage composed of the top green stems with leaves was harvested at the time of cassava root harvest. It was shown that planting cassava for forage production in a cassava+maize intercropping system resulted in a similar gross income as planting cassava for root production only. The earlier system could be an alternative to overcome the problem of unstable prices of cassava roots. However, the system is not recommended to be continuously applied on the same field, as this will accelerate soil degradation by nutrient depletion.**

***Index Terms*—cassava, defoliation, pruning, cassava hay, animal feed, protein, farm income**

## I. Introduction

Cassava is one of the most important crops in Indonesian upland agricuture [1]. If the root price is reasonably high, the economics of planting cassava is actually comparable with that of other cash crops, such as sugarcane. With a cassava root yield of 40 t/ha and a fresh root price of Indonesian Rupiah (IDR) 7.00.000/ton, for example, the farmer would have an economic advantage of about IDR 18.000.000/ha. This is comparable with sugarcane at a yield level of 100 t/ha. However, cassava prices in Indonesia vary greatly. This depends mainly on the supply and market demand at the time of harvest. Thus, planting cassava often results in an economic disadvantage. Therefore, any additional use of cassava could increase demand and price, and hence, increase farmers' income.

So far, cassava farmers in Indonesia only harvest the roots. In addition to roots, cassava produces a high yield of leaves. It has been widely known that cassava leaves have a high protein content [2]. For that reason, cassava leaves could be used as a valuable and cheap resource for animal feeding. Actually, during the root harvest, some Indonesian farmers have used cassava leaves for feeding their livestock. However, the amount of cassava leaves at harvest is relatively little, so this does not increase much the income of the cassava farmers.

During the growth cycle, cassava continues to form new leaves while the older leaves fall off. Therefore, it was thought that pruning cassava leaves, to some extent would not have much influence on the root yield. At the same time, these pruned leaves can be used as animal feed. The possibility of planting cassava to produce forage has drawn the attention of some researchers. Reference [3] showed the use of cassava hay as a new strategic feed for ruminants during the dry season, and Reference [4] used cassava leaves as a protein source for pigs in farms in Central Vietnam.

Some studies [5], [6] have shown the positive prospects of planting cassava for leaf production. The experiments, however, were done in a cassava monoculture system. In Indonesia, most cassava famers plant their cassava in intercropping systems with short-maturity food crops such as maize, soybean and peanuts.

The objective of the current research was to study the effect of various methods of pruning on the root and forage yields of three cassava varieties planted in an intercropping system with maize. In addition, the effect of plant spacing on the yield of cassava roots and forage and on the yield of intercropped maize would also be examined.

## II. Material and Method

The experiment was conducted for two consecutive years at the experimental station of Brawijaya University in Jatikerto, Malang, East Java, Indonesia. The soil is classified as an Alfisol and has a clay loam texture, pH 6.95, 2.79% soil organic matter and 0.18% total nitrogen. The location has a distinct wet and dry season with an average annual rainfall of about 2000mm, with the rainy

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season starting in about November and ending in March of the following year.

The experimental treatments included three cassava varieties (UB 4772; UB1/2; and Faroka), two cassava plant spacings (1.0×0.8m and 1.0×0.4m) and three different pruning methods (no pruning; leaf pruning; top pruning). Those 18 treatments were arranged in a Randomized Block Design with three replications.

Cassava was intercropped with maize in plots of 6.0×4.0m. Cassava and maize were planted on the same day. Cassava was planted at two plant spacing treatments: 1.0×0.8m and at 1.0×0.4m, and maize was planted along the cassava rows at a spacing of 1.0×0.25m, 1 plant/hole.

The crops were fertilized with 180kg N/ha, 100kg $P_2O_5$/ha and 100kg $K_2O$/ha. All the P and K, and 1/4 dosage of the N fertilizer were applied at planting. The rest of the N fertilizer was applied at 30 days after planting (1/4 dosage), at the harvest of maize (1/4 dosage), and at the second cassava leaf pruning (1/4 dosage). Crop management included weeding and ridging.

To obtain cassava leaf forage, the plants were pruned four times during the crop cycle. The first pruning was done soon after harvesting the maize intercrop (around 100 days after planting), the second and third pruning were done at 3 and at 6 months after the first prunning. The fourth pruning was done at the time of the cassava root harvest (315 days after planting for the first year cassava, and 325 days after planting for the second year cassava). Top pruning was done by cutting the plant tops at a height of 20 cm from the ground. Leaf pruning was done by harvesting only the mature leaves without stems, while in the no-pruning treatment the upper green part of the stems with leaves were harvested only at the time of the root harvest.

Data were collected on the grain and biomass yield of maize, the root and total forage yield of cassava, as well as the protein content of the cassava forage. The protein content was measured by determining the total nitrogen content of the cassava leaves using the Kjeldhal method of [7], and the protein content was calculated as total nitrogen content × 6.25.

## III. Results and Discussion

### A. Cassava

The results presented in Table I show that the method of top pruning resulted in significantly higher forage yields than other methods, and produced consistently the highest amounts of forage in all cassava varieties and at both plant spacings. This is to be expected because in top pruning all parts of the plant (including stems and petioles) were harvested.

Comparing cassava cultivars, Table I shows that the variety Faroka produced a lower forage yield compared to the other two cassava varieties. The highest forage production for Faroka (top pruning at plant spacing of 1.0×0.4m) was 4.98t dry forage/ha, whereas the forage produced by the other two varieties at the same pruning method and plant spacing was more than 6t dry forage/ha.

TABLE I. Effect of Pruning on Total Forage Yield of Three Cassava Varieties Planted at Two Different Plant Spacing

| Cassava Varieties | Plant Spacing (m×m) | Pruning method | Total Forage Yield (ton/ha) | | | |
|---|---|---|---|---|---|---|
| | | | First year | | Second year | |
| | | | Fresh | Dry Matter | Fresh | Dry Matter |
| UB4772 | 1.0×0.8 | None | 10.05 f | 2.19 d | 7.49 f | 1.71 c |
| | | Top | 26.25 bc | 5.10 ab | 20.37 ab | 4.08 a |
| | | Leaf | 15.23 e | 3.17 bcd | 12.87 de | 2.69 abc |
| | 1.0×0.4 | None | 12.24 f | 2.58 cd | 8.60 f | 1.86 bc |
| | | Top | 32.87 a | 6.44 a | 20.42 ab | 4.09 a |
| | | Leaf | 19.50 de | 4.11 bcd | 15.38 cd | 3.37 ab |
| UB ½ | 1.0×0.8 | None | 10.78 f | 2.30 cd | 8.70 f | 2.05 bc |
| | | Top | 25.57 bc | 4.31 bc | 19.45 ab | 3.87 a |
| | | Leaf | 16.42 de | 3.54 bcd | 12.36 de | 2.56 ab |
| | 1.0×0.4 | None | 12.25 f | 2.69 cd | 9.98 ef | 2.00 bc |
| | | Top | 29.78 ab | 6.42 a | 21.76 a | 4.05 a |
| | | Leaf | 20.45 d | 4.21 bcd | 14.58 cd | 3.06 ab |
| Faroka | 1.0×0.8 | None | 9.10 f | 2.05 d | 7.45 f | 1.70 c |
| | | Top | 24.42 cd | 4.48 abc | 17.45 bc | 3.36 ab |
| | | Leaf | 15.35 e | 3.10 bcd | 10.28 ef | 2.16 bc |
| | 1.0×0.4 | None | 11.25 f | 2.50 cd | 8.46 f | 1.77 bcc |
| | | Top | 26.46 bc | 4.98 ab | 20.80 a | 4.02 a |
| | | Leaf | 17.35 de | 3.84 bcd | 12.65 de | 2.54 ab |

*) value means followed by the same letters in the same column are not significantly different ($P$>0.05)

In the no-pruning treatment (young stems and leaves harvested only at the time of root harvest) the forage yields obtained varied from 2.05 to 2.69 t dry forage/ha. When pruning was done by harvesting leaves (plus petioles) only, the forage yield varied from 3.10 t/ha (Faroka 1.0×0.8m spacing) to 4.21 t/ha (UB 1/2 1.0×04m spacing). Ref. [8] reported dry forage yields of 2.0 to 3.0t/ha when cassava was managed as a perennial crop with repeated harvesting of the foliage at eight week intervals.

The effect of pruning on root yield is presented in Table II. Pruning significantly decreased root yields in both years of planting. The yield of the no-pruning treatment in the first year crop varied between 37.39t/ha and 46.14 t/ha, whereas the root yield of the pruned cassava varied between 13.77t/ha to 28.07t/ha. Pruning of cassava leaves (and young stems) reduced the major photosynthesis parts of the plants, and as a result cassava root production decreased. Ref. [9] reported that defoliating cassava leaves in the second, fourth and sixth months after planting was harmful to the plants.

The results presented in Table II show that the second year root yield of both non-pruned and pruned cassava was lower compared to the yields obtained in the first year. It has been shown elsewhere that planting cassava continuously on the same soil resulted in a decrease of root yield [10], [11]. The results in Table II also show that harvesting cassava forage further increased the decline of cassava root yield in the second compared to the first year. This is reasonable because with harvesting cassava forage there would be an increase in nutrient removal from the soil. With harvesting 3.10-6.44t/ha dry

cassava forage (see Table I), with a nitrogen content of about 4% (Table III) there was an additional soil nitrogen removal of about 120-250kg N/ha.

TABLE II. EFFECT OF PRUNING ON TUBER YIELD OF THREE CASSAVA VARIETIES PLANTED AT TWO PLANT SPACING

| Cassava Varieties | Plant Spacing (m ×m) | Pruning method | Fresh tuber yield | |
|---|---|---|---|---|
| | | | First year | Second year |
| | | | (ton/ha) | (ton/ha) |
| UB4772 | 1.0 ×0.8 | None | 42.32 abc | 36.47 a |
| | | Top | 13.77 f | 8.20 ef |
| | | Leaf | 28.07 d | 22.78 c |
| | 1.0 ×0.4 | None | 40.72 bc | 33.26 ab |
| | | Top | 15.58 f | 9.42 ef |
| | | Leaf | 23.02 e | 22.76 c |
| UB ½ | 1.0 ×0.8 | None | 42.79 ab | 35.37 ab |
| | | Top | 17.71f | 7.24 ef |
| | | Leaf | 21.49 e | 18.38 c |
| | 1.0 ×0.4 | None | 40.88 bc | 35.25 a |
| | | Top | 15.09 f | 11.33 de |
| | | Leaf | 27.14 de | 23.45 c |
| Faroka | 1.0 ×0.8 | None | 37.39 c | 34.56ab |
| | | Top | 16.77 f | 6.25 f |
| | | Leaf | 25.10 de | 21.46c |
| | 1.0 ×0.4 | None | 46.14 a | 36.74 a |
| | | Top | 19.94 e | 14.35d |
| | | Leaf | 23.80 e | 22.40c |

*) value means followed by the same letters in the same column are not significantly different ($P$>0.05)

TABLE III. EFFECT OF PLANT SPACING AND CASSAVA VARIETIES ON MAIZE YIELD IN CASSAVA + MAIZE INTERCROPPING SYSTEM

| Treatment | | Grain yield (t/ha) | |
|---|---|---|---|
| Cassava varieties | Spacing of cassava (m ×m) | First year | Second year |
| UB4772 | 1.0 ×0.8 | 4.41 a | 3.41 a |
| | 1.0 ×0.4 | 3.89 b | 2.20 b |
| UB ½ | 1.0 ×0.8 | 4.40 a | 3.45 a |
| | 1.0 ×0.4 | 3.87 b | 2.28 b |
| Faroka | 1.0 ×0.8 | 4.55 a | 3.37 a |
| | 1.0 ×0.4 | 4.53 a | 3.30 a |

*) means followed by the same letter in the same column are not significantly different (p=0.05)

TABLE IV. EFFECT OF PLANT SPACING AND PRUNING METHODS ON PROTEIN CONTENT OF CASSAVA FORAGE PLANTED IN CASSAVA + MAIZE INTERCROPPING SYSTEM

| Treatment | | Protein content (% of dry forage) | |
|---|---|---|---|
| Plant spacing (m ×m) | Pruning methods | First year | Second year |
| 1.0 ×0.8 | None | 31.25 a | 26.26 |
| | Top | 28.56 ab | 25.37 |
| | Leaf | 32.42 a | 27.36 |
| 1.0 ×0.4 | None | 29.45 ab | 26.30 |
| | Top | 27.16 b | 25.26 |
| | Leaf | 30.35 ab | 27.50 |

*) value means followed by the same letters in the same column are not significantly different ($P$>0.05)

The protein content of the cassava forage was significantly influenced by plant spacing and pruning method (Table IV), but this occurred only for the first year cassava. Cassava forage protein content of the second year crops were not significantly different between treatments. There was a tendency that the protein content of forages obtained from the leaf pruning treatment was the highest, followed by that obtained from the non-pruned treatment, and the lowest from the top pruned treatment. The protein content of the top pruned forage was the lowest because it included both leaves and young stems.

It seems that there was a decrease in soil nitrogen content, so that the protein content of the forage during the second year was lower than in the first year, and was not significantly different between treatments. The decrease of soil nitrogen with continuous planting of cassava on the same field has been shown by Reference [12]. Planting cassava for forage production accelerated the decrease of soil nitrogen content [13].

### *B. Maize*

The intercropped maize was harvested before the first pruning of cassava, so the experimental results presented in Table III only show the effect of cassava varieties and spacing on the yield of maize.

The yield of maize planted with Faroka variety was not significantly influenced by cassava spacing. However, the yield of maize planted with UB 4772 and UB1/2 decreased with decreasing plant spacing. These results were consistent between the first and second year maize. The yield decrease with decreasing cassava spacing is to be expected because decreasing plant spacing would increase the cassava population, and hence increase the competition from cassava.

The results presented in Table III also show that in all cassava varieties, the yield of the second year maize was lower than that of the first year maize. This was probably due to the decrease in soil fertility because of the removal of plant nutrients by the first year crops. It seems that the rate of fertilizer given was not enough to satisfy the crops' nutritional requirements, as there was a considerable depletion of soil nitrogen [13]. This phenomenon resulted in a decrease of the second year maize yield.

### *C. Farmer's Income*

The aim of introducing forage production in cassava planting is to increase, or at least to stabilize, farmers' income. If we used the Faroka variety at a standard plant spacing (1.0 ×0.8m) as an example, farmers using the non-pruning method would obtain: 37.39t/ha (cassava roots) × IDR 700,000.-/t+4.55 t/ha (maize yield) × IDR 2,500,000.-/t = IDR 37,423,000.-/ha

If farmers practiced leaf pruning they would obtain: 25.77t/ha (cassava roots) × IDR 700,000.-/t + 4.55t/ha (maize yield) × IDR 2,500,000./t + 15.37t/ha (forage yield) × IDR 600,000./t = IDR 38,636,000.-/ha.

Based on those calculations, it can be concluded that planting cassava for forage production is comparable with planting cassava for root yield only. As discussed before, the cassava root price is very unstable. Therefore, if the cassava root price is very low, planting cassava for forage production could be a reasonable alternative system.

## IV. Conclusions

The results of the experiments show that planting cassava for forage production could be practiced in a cassava + maize intercropping system. From an economic point of view, this system can produce a comparable gross income as that obtained by planting cassava for root production only, mainly as an alternative to overcome the problem of major fluctuations in the cassava root price. However, it is not recommended to practice this system continuously on the same field, because it will accelerate soil degradation by nutrient (especially nitrogen) depletion

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**Titiek Islami** is lecturer at University of Brawijaya, Malang, Indonesia. She got her Agricultural engineer degree from University of Brawijaya, Malang, Indonesia in 1977, Master of Science from the Gajah Mada University, Yogyakarta Indonesia in 198 and PhD from University of Brawijaya Malang Indonesia in 2011.

Her interest is in Agronomy, especially soy bean and cassava farming in upland area of Indonesia. Lately her works focused on the agriculture management in the dry land of Indonesia, especially the farming of cassava to improve farmer's income.

**Marjuki** is lecturer at the Faculty of Animal Husbandry, University of Brawijaya, Malang, Indonesia. He received his Agriculture engineering degree in Animal Nutrition from the University of Brawijaya, Malang Indonesia in 1988.

He graduated from Wageningen Agriculture University-The Netherland, with a Master Degree in Ruminant Nutrition. He finished his PhD from The University of Brawijaya, Malang Indonesia in 2007. Research interest includes: Animal Nutrition, Ruminant Nutrition. Lately his research focused on the use of cassava for forages.

**Reinhardt Howeler** was born in Indonesia but grew up in the Netherlands. After completing his undergraduate degree in Tropical Agriculture he immigrated to the US, where he continued his study, obtaining a PhD degree in soil chemistry from Cornell University.

He joined CIAT in Cali, Colombia in 1970, and the newly formed cassava program in 1972, conducting numerous greenhouse and field experiments to determine the nutritional requirements of the crop, and how to manage cassava without causing serious erosion. In 1986 he moved to the CIAT office in Bangkok, Thailand, where, during the following 23 years he worked closely with researchers, extension workers and farmers in practically all cassava growing countries in the region, to develop better soil and crop management practices, and enhance their adoption by using a Farmer Participatory Research (FPR) methodology.