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Full Length Research Paper

Impact of Harvesting Management on Cassava Foliage and Tuber Yield and Nutritive Values

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The purpose of the experiment was to ascertain how various harvesting times affected the chemical makeup and productivity of cassava (foliage and tuber). For the IH3 + FH and IH5 + FH treatments, two distinct ages of cassava leaf at the time of initial harvesting—three and five months, respectively—were used. Over the course of seven months, the final harvests of these two treatments were completed, including the tuber. As a control treatment, cassava leaves were collected once during the seven-month root harvest (FH). In both cassava foliage and tuber, the control treatment had the lowest hydrocyanic acid potential (HCNp) concentration, whereas the IH3 + FH treatment had the greatest HCNp content. The leaves had higher levels of HCNp and crude protein (CP) than the petiole and stem of the foliage, while the cortex of the cassava tuber had higher levels of these components than the parenchyma. Crude fiber (CF) contents showed the reverse tendency, with the petiole and stem having higher CF levels than the leaves. In comparison to IH3 + FH and FH, the IH5 + FH treatment produced the most total foliage and protein production. In this trial, the FH treatment yielded the most tubers (15268 kg/ha), followed by IH5 + FH (11567 kg/ha). Gross energy content in the leaves and tuber is 4709 kcal/kg on average (range: 4608-4783 kcal/kg) and 3857 kcal/kg on average (range: 3842-3881 kcal/kg), respectively. The IH5 + FH treatment produces the best foliage yield, high CP, and low fiber content throughout both harvest dates when considering both yield and proximate analytical data.

Key words: Cassava, Crude protein, Energy, Cyanide, Yield.

INTRODUCTION

The amount of cassava foliage available after root harvesting is equal to roughly 30% of the tuber yield (Ravindran, 1993), and it has been observed that the foliage has an excellent amino acid content that is comparable to soybean meal (Eggum, 1970). These days, cassava is utilized for both tuber and leaf production, making it a crucial animal feed and industrial raw resource. The use of cassava leaves as feed for cattle (Moore and Cock, 1985), goats (Seng and Rodriguez, 2001), pigs (Ravindran et al., 1987), and poultry (Ravindran et al., 1986) has been the subject of numerous research. However, the majority of the cassava leaves assessed in the prior studies came from the plant after the tubers were harvested, and because of their maturity, these leaves most likely contain more fiber. For the industry as well as the farmer who depends on this crop, using its byproducts in animal feed may be an option. It is also anticipated that with appropriate management techniques, the system's sustainability would improve and both tuber and leaf yields will rise.

Few studies have been published to date that describe how various cutting stages and subsequent harvesting intervals affect nutritional status behavior. They also discuss how these factors relate to foliage yield (Hong et al., 2003) and how the nutritional makeup of leaves changes as they mature (Ravindran and Ravindran, 1988). There was no information provided regarding the nutritional quality and HCNp content in relation to the harvesting period and how it affected the development of leaves and tubers. Therefore, it was thought to be interesting to concentrate on tubers and leaves picked at a younger stage with the right nutrient inputs in this investigation.

MATERIALS AND METHODS

The experiment was conducted at the University of the Ryukyus in Okinawa, Japan, between April and October of 2013. Figure 1, which was acquired from the Japan Meteorological Agency, displays the climate data that was recorded during the trial period. Additionally, it displays a mean annual temperature of 23.6˚C and an average yearly rainfall of 2071 mm throughout the trial period. Table 1 displays the results of the chemical analysis of soil samples prior to the experiment's setup. Gray soil, known locally as Jagaru, is the type of soil found in the experimental area. The effects of various harvestings on the chemical compositions and yields of cassava tuber and foliage were investigated using a randomized complete design (RCD) with three replications. The experiment comprised of 3 treatments:

- IH3 + FH; Top harvesting in the 3 months and final harvest
- IH5 + FH; Top harvesting in the 5 months and final harvest

Because of the red color of the petiole, a local species of cassava known as Red cassava was chosen in this experiment. To create a plant population of 7500 stands/ha, old cassava stems that had been cut into around 20 cm pieces were planted in continuous rows with 1 m separating each row and 1 m separating each plant. As a base fertilizer, 50, 50, and 100 kilogram of nitrogen, phosphorus, and potassium (N-P2O5-K2O) were sprayed per hectare. One month after plating, this fertilizer was administered when the first leaf developed on the cassava stand. Cassava leaf harvesting was carried out in accordance with procedures. Seven months after planting, the cassava tuber was harvested, marking the final harvest of cassava leaves for all treatments. According to Wanapat et al. (1997), 27 plants were randomly chosen for each treatment in the corresponding harvests, and cassava foliage was taken by breaking the stem between the green and brown parts. Fresh cassava leaf plots were weighed individually. Samples of cassava leaves, petioles, and stems were taken at random and split into two sections: one for the analysis of other chemicals and another for the measurement of HCNp content. Seven months after planting, cassava tuber was harvested, and yielding was calculated by weighing the soil-free tuber in each plot. After being divided into cortex and parenchyma, cassava tubers were chemically analyzed.

Table 1: Soil nutrient composition in the 0-20 cm layer of the soil at the experimental site

Parameters	Values
pH (H_2O)	7.86±0.01
Total N (%)	0.14±0.01
Available P (mg $100g^{-1}$)	15.04±3.71
Exchangeable K (meq $100g^{-1}$)	1.11±0.14
Na (meq $100g^{-1}$)	0.74±0.15
Ca (meq $100g^{-1}$)	59.87±2.15
Mg (meq $100g^{-1}$)	2.39±0.14

Values are expressed as the mean± SD.

Chemical Analysis

Inductively Coupled Plasma atomic Emission spectroscopy (ICPE-9000, Shimadzu, Japan) was used to determine the total N, the available P by Truog (1930), and exchangeable K, sodium (Na), calcium (Ca), and magnesium (Mg). The Auto-calculating Bomb Calorimeter (CA-4AJ, Shimadzu Co. Ltd., Japan) was used to calculate the gross energy. By oven drying the experimental material to a constant weight at 70˚C, the dry matter (DM) content was ascertained. The methods outlined by AOAC (1985) were used to determine CP and CF. The acid hydrolysis method was used to measure the HCNp contents of cassava tuber and leaf components (Bradbury et al., 1991; Haque and Bradbury, 2002).

Statistical Analysis

Using SPSS 16.0 software, the data collected at each stage of the study was statistically analyzed using ANOVA in line with the General Linear Model. Significant differences between treatments were evaluated using the Duncan new multiple range test.

RESULTS

Table 2 displays the average HCNp concentrations in the various cassava leaf sections for each harvesting method. The first harvest of IH3 + FH treatment, at 3 months of age, had the significantly highest ($P<0.05$) HCNp level. Up until the last harvest at seven months with this treatment, there was a steady decline in the contents from this point on. The HCNp level of IH5 + FH-treated cassava leaves, however, tended to rise from the first harvest (152.18 mg/kg) to the second harvest (188.44 mg/kg). The control treatment had the lowest HCNp concentration in cassava leaves. In all harvesting techniques, the HCNp contents in cassava leaves fell within the range of leave>petiole>stem. De Bruijn (1973) has documented similar observations. The petiole and stem had higher CF concentrations than the leaves, indicating the opposite trend (Table 2). In all treatments, comparable CF concentrations across the petiole and stem ranged from 19.97 to 28.01%. In all harvesting treatments, the HCNp concentration in the cortex was significantly higher (P<0.05) than that of the parenchyma, but there was no significant difference (P>0.05) between treatments (Table 3). Because the cortex had larger fiber contents than the parenchyma, there was a significant difference (P<0.05) in the CF contents of the various cassava tuber portions.

The CP concentration in cassava foliage was considerably higher during the first harvest of the IH3 + FH treatment, as seen in Table 4, and subsequently decreased during the subsequent foliage harvest. Additionally, cassava leaves had more CP than the petiole and stem. The cortical region of the cassava tuber has much greater (P<0.05) CP contents than the parenchyma. Table 5 displayed the leaf, petiole, and stem ratios of the cassava foliage for each harvest. Of the entire harvest, leaves made up a larger percentage than petioles and stems. The percentage of leaf, petiole, and stem varied significantly between treatments. Out of all the final harvest period treatments, the 7-month harvest of IH5 + FH had the lowest petiole to stem ratio.

Additionally, Figure 2a showed the cassava's total leaf production and protein yield. In comparison to IH3 + FH (3209.48 kg/ha) and FH (3426.90 kg/ha), IH5 + FH had the significantly greatest (P<0.05) total foliage yield (3721.73 kg/ha). As a result, the IH5 + FH treatment yielded the highest CP yields, measuring 1878.54 kg/ha, whilst the IH3 + FH and FH treatments yielded 1733.92 kg/ha and 803.61 kg/ha, respectively. Figure 2b also displayed the DM yields of tuberous roots for each of the three treatments. The DM tuber yield in these treatments was lowest in the IH3 + FH treatment (8823 kg/ha) and greatest in the control treatment (15268 kg/ha). The CP yield in this experiment was found to follow the same trends as the tuber yields. Table 6 also showed the impact of various harvesting times on the gross energy values of cassava tuber and foliage.

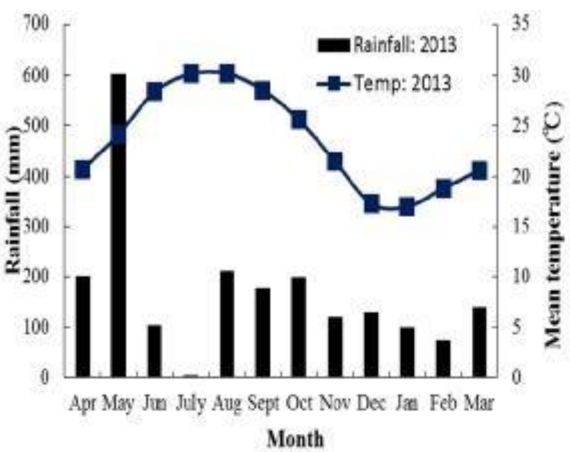

Figure 1: Average environmental temperature and rainfall in Okinawa (Naha) in 2013

DISCUSSION

In The amount of HCNp in the leaves analyzed in this study varied significantly depending on the harvesting method. According to Sundaresan et al. (1987), when leaves mature, the concentration of HCNp and the bitterness linked to high cyanogenic glycoside levels in leaves decrease.

As a result, at the last harvest, the HCNp concentration in the IH3 + FH treatment was trending downward. The IH5 + FH treatment's higher HCNp content, however, demonstrated that if a brief regrowth period was permitted, significant levels of HCNp might be formed in the foliage. Presumably, the IH3 + FH treatment had a 4-month regrowth period following the initial harvest, which gave the leaf time to reach its mature form. However, with IH5 + FH, the harvest interval was only 2 months for regrowth, which would result in a younger state of the leaves with a greater HCNp concentration. Additionally, the study's findings (Table 2) supported those of Etonihu et al. (2011) by demonstrating that leaves had greater HCNp concentrations than other portions of the cassava crop. Furthermore, the hydroxynitrile lyase enzyme, which catalyzes the hydrolysis of acetone cyanohydrin to yield HCN and acetone, was also found in the leaves (Siritunga et al., 2004).

The amount of HCNp in cassava tubers varied somewhat depending on when the leaves were harvested. Vetter (2000) states that cyanogenic glycosides are mostly produced in the early green leaves of mature plants or in the cotyledons of etiolated seedlings before being transported to other plant parts like tuberous roots. Transporting a higher concentration of HCNp from the foliage to the tuber than the control treatment may be the reason for the increased HCNp concentrations in the foliage of the IH3 + FH and IH5 + FH treatments. Consequently, the tuber receiving the control treatment had the lowest overall HCNp content. Despite linamarin's translocation from leaves to tuber, there doesn't seem to be any increasing buildup of linamarin in the tuber, suggesting that linamarin is metabolized and used rather than passively held there (Makame et al., 1987).

The cortex of the tuber is the outermost layer that is mostly exposed to various biochemical nutrients in the soil, according to Etonihu et al. (2011). Therefore, exposure to hydrocyanide in the soil may cause a region of the plant to contain a higher amount of cyanide. Thus, the HCNp concentration profile in this study demonstrated that tubers (parenchyma) are a lower cyanide storage portion of cassava than cortex, which explains why humans and animals use this portion more frequently.

Across all treatments, the average CF content in the leaves of the final harvest ranged from 9.67 to 11.84% (Table 2). The study's fiber values were less than those published by IITA (1990). The findings are similarly consistent with Phengvilaysouk and Wanapat (2008), suggesting that the variations may have resulted from variations in harvesting times. Additionally, compared to other harvest treatments, the IH5 + FH treatment had a reduced fiber content.Because high dietary fiber might result in intestinal irritation, poor digestibility, and overall decreased nutrient utilization, feed with a lower CF percentage is regarded as being of higher quality (Almodares et al., 2009). Furthermore, compared to the other treatments, the control treatment's cortical section of the cassava tuber displayed a higher fiber content. As a result, the fiber content of the tuber was marginally impacted by the subsequent leaf harvesting. Tewe (2004) noted that because of its high fiber content and HCNp, which are detrimental to non-ruminant animals' growth and development, the use of cassava peel as feed is restricted. According to the findings, new leaves often had a greater CP content than old ones. As the biomass ages, the two chemical components that are most impacted by plant age are CP and fiber content, with CP declining and fiber content rising (Gomez and Valdivieso, 1985). Additionally, according to reports, cassava leaves have a higher protein content than stems and petioles (Borin, 2005). As a result, cassava leaves are better suited for monogastric animals like pigs and poultry, but ruminants are better off with stem plus petioles or the entire plant.

Wanapat (2002) revealed that the total DM yield of cassava foliage can vary from 1814 to 7257 kg/ha, and the current study's total DM yield of cassava foliage (3209 to 3721 kg/ha) was within this range.

The potential production of cassava leaves or foliage varies significantly depending on the type, age of the plants, plant density, soil quality, frequency of harvest, and climate, according to Gomez and Valdivieso (1984). According to Khajarern & Khajarern (1992), harvesting leaves 4–5 months after planting doesn't negatively impact tuber output. The fact that the yield at the five-month harvest was the largest and that it occurred following a time of rapid leaf and stem growth supports this hypothesis. Since leaves in cassava have the largest quantities of amino acids, the leaf stem ratio is significant when examining the protein content of the plant's aboveground portions (Normanha, 1966 cited in De Pinho et al., 2004). The study's findings also demonstrated that, of the entire crop, leaves made up a larger percentage than petiole and stem. Although there was a large range, ranging from 54 to 88%, the mean dry leaf proportion of the foliage was high (65%) (Table 4).

Wanapat's (2002) research, which discovered that 62% of the cassava hay harvested four months after planting, corroborated these findings. The mean value, however, was somewhat greater than the findings of Meyrelles et al. (1977), who found that the leaf proportion of cassava leaves on a DM basis was nearly 52%. Cassava leaves typically make up a large amount of the entire plant, which makes cassava fodder an excellent source of feed for animals.

In cassava, tuberization, which is caused by the fibrous roots swelling, can start in 30 to 60 days (Cock et al., 1979). Leaf harvesting must not significantly impair tuber yield if the cassava is grown primarily for its tubers. Jalloh (1998) demonstrated that the plant can pass the most crucial stage for its tuberous root output if the first foliage collection is postponed until the fourth month. As a result, Lockard et al. (1985) suggested that leaf collecting on cassava might begin as early as four months after planting because it had minimal impact on the weight of the tuberous roots and the total weight of the leaves. We found that the average gross energy values for leaves and tubers were 4709 kcal/kg and 3857 kcal/kg, respectively. According to Okeke (1980), cassava is a plant that produces a lot of energy and is always available. Moreover, cassava can provide almost 13 times as much energy per hectare as maize or guinea corn (Sorghum) (Oyenuga 1961). Accordingly, Tewe (1997) said that using cassava as a substitute for traditional energy feedstuffs like maize might lower feed costs and lessen the issue of direct competition between humans and animals for maize. The current findings suggest that the cassava crop may be grown for its leaves, but at the loss of its tuber yield, making it unable to produce both at the same time.

CONCLUSION

According to the study, the biggest benefit of harvesting twice (IH5 + FH) is that forage may be produced with the highest leaf production while maintaining a satisfactory level of tuber yield. Since enough protein source, including young leaves, was collected, it is advised to harvest at the initial harvesting at five months and the final harvest method.

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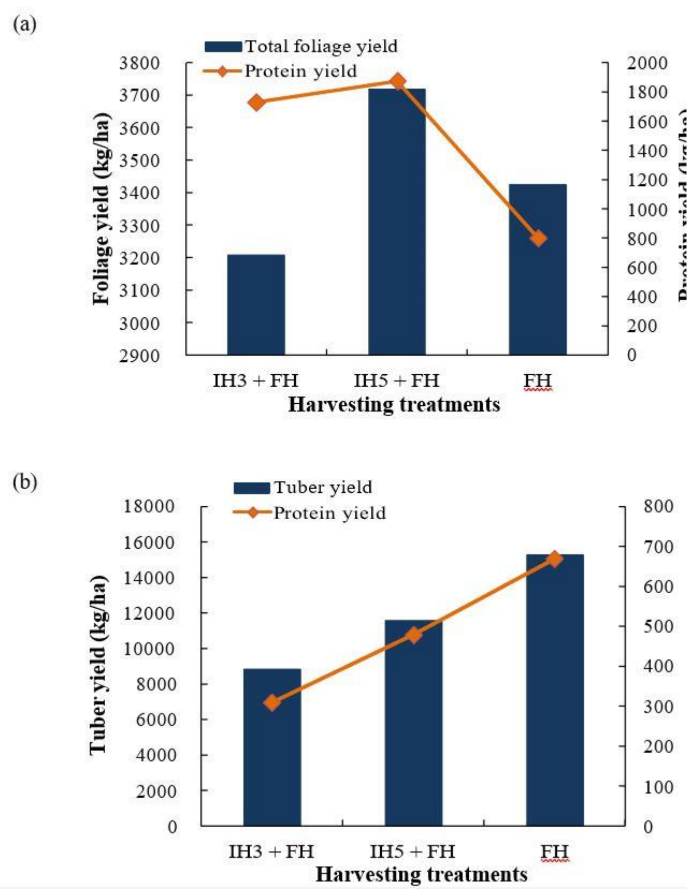

Figure 2. Effect of harvesting period on DM yield and protein yield of cassava foliage (a) and cassava tuber (b).
IH3 + FH, IH5 + FH and FH referred to Table 2.