Tropical Animal Production 1984 9:239-250

FOLIAGE AND ROOT YIELDS OF CASSAVA (*Manihot esculenta*, Crantz) UNDER DIFFERENT PLANTING DENSITIES AND FREQUENCIES OF CUTTING

D Pezo, J Benavides y A Ruiz

Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica

This study was carried out on a Typic Dystropepts soil in the humid tropics, at an altitude of 600 m above sea level and with a mean annual rainfall of 2600 mm. The effect of plant density and frequency of foliage cutting on the yield of roots and foliage was estimated in two varieties of cassava. Four plant densities (6667, 10000, 40000 y 111111 plants/ha) and four frequencies of foliage cutting (every 1,2,3 and 4 months) were considered using the variety (var.) Valencia. In the second experiment, the var. Japonesa was used with three cutting frequencies (every 1.5, 3 and 4.5 months) and an uniform density of 6667 plants/ha. In both experiments, control plots were maintained without cutting. In the treatments which infolved foliage cutting, this was done for the first time when the plant was 4 months old.
In the var. Valencia (Experiment 1), the yields of roots and foliage tended to increase as plant population rose. However, the percentage of commercial roots produced tended to fall. Cutting increased foliage yield ($P \leq 0.05$), but no difference was observed due to cutting frequency. Root yield and the percentage of commercial roots was only affected negatively ($P \leq 0.05$) when cutting was done monthly.
In the var. Japonesa (Experiment 2), cutting reduced ($P \leq 0.05$) total and commercial root yeild, and the effect became more pronounced as cutting frequency increased. Although cutting in this variety increased foliage production ($P \leq 0.05$), yield was highest at the lowest cutting frequency ($P \leq 0.05$). On the other hand, at the same plant density (6667 plants/ha), the var. Japonesa showed a higher potential for foliage production than the var. Valencia.
The crude protein content (CP) in the foliage w s 18.3 and 20.4% in the varieties Valencia and Japonesa, respectively. The corresponding values for the in vitro dry matter digestibilities (IVDMD) were 54.8 and 46.6%. The CP and IVDMD values were higher in leaves than in stems. Furthermore, cutting monthly or every 1.5 months produced the highest CP and IVDMD values.
In view of the potential of cassava for the production of protein in the foliage and energy in the roots, it is concluded that this species offers advantages for the development of mixed crop-animal production systems. However, the purpose for which the plant is grown (foliage, roots or both) will depend on the genotype available. For example, the var. Valencia can be used for the simultaneous production of foliage and roots while the var. Japonesa seems better adapted to the production of either foliage or roots alone.

Key words: Cassava, root yield, foliage yield, cutting frequency

Cassava is the crop which is second in importance in the low, humid tropics, in terms of area cultivated and total yield (Montaldo 1977). Traditionally, the plant has been used chiefly for human or animal consumption or for the industrial production of starch and alcohol. Rencently, however, attention has been given to cassava foliage as a source of forage for ruminants (Devendra 1977; Meyreles et al 1977; Ffoulkes et al 1978; Godoy and Elliott 1981; Teeluck et al 1981) as well as a protein supplement and source of pigment for poultry (Montilla 1977).

Generally, higher plant densities lead to a higher production of foliage (Montaldo and Montilla 1976; Meyreles et al 1977; Vries 1979), but also to a lower output of roots per plant (Enyi 1972; Hunt et al 1977; Godfrey-Sam-Aggrey 1978). The effect of plant density on root production per hectare appears to vary with the plant genotype (Enyi 1973; Cock et al 1977) as well as with age at which the plant is harvested (Williams 1972; Cock et al 1977).

Foliage cutting is a common practice among traditional farmers (Montaldo 1979), and may actually be beneficial when the crop is grown in association with grain legumes (Gerodetti 1979; Castellanos 1981). Factors such as the time of year, intensity and frequency of pruning or defoliation determine the effect which this practice has on root yield. Thus, when is carried out late in the growing season (Correa et al 1973; Castellanos 1981) or lightly (Schoonhoven et al 1974; Gerodetti 1979) root production is not affected. However, early, intensive or frequent cutting favours the production of foliage and has a detrimental effect, in consequence, on the output of roots (Ahmad 1973; Correa et al 1973; Montaldo and Montilla 1976;Gerodetii 1979; Castellanos 1981).

Existing evidence suggests that cassava may be treated as a root crop or a foliage crop, or both at the same time (Nestel and Graham 1977). However, information concerning this last option is scarce. Therefore, the present study, which consists of two experiments, was carried out to determine the effect of plant density and foliage cutting frequency on the yields of roots and foliage, as well as on the nutritive value of the foliage in two varieties of cassava.

Materials and Methods

Environmental conditions: The study was carried out at Turrialba, in a humid tropical area at 600 m above sea level. The mean annual temperature is 22°C, annual mean rainfall 2600 mm and the mean relative humidity 90%. The area is flat with moderate to poor drainage. The soils are typic dystropepts of pH 5.3 and low contents of phosphorous, potassium, sulphur and boron.

Crop management: The soil was broken up by ploughing once and ranking twice. The cassava cuttings were planted in a sloping position without making furrows. In Experiment 1, the planting density was variable, depending on the treatment, while in Experiment 2, the plants were sown at 1.5m between rows and 1.0 m between plants within rows. Maize was sown at a distance of 0.75 m away from the rows of cassava in Experiment 2, using initially 4 seeds and then thinning to two plants per hole. In the first experiment, the cassava was sown in April, while in the second , the cassava was sown in December and the maize in January. In Experiment 1, 40 kg of nitrogen, 90 kg of P_2O_5 and 24 kg of K_2O were applied in equal doses, one 15 days before sowing and the other 12 weeks after sowing. In Experiment 2, 125 kg of nitrogen, 130 kg of P_2O_5 and 48 kg of K_2O were applied in equal fractions at two and four months, respectively, after planting. Weeding was carried out by hand in both experiments. The cassava was harvested 13 months after sowing and the maize sown in the second experiment was harvested as grain 5 months after planting.

Varieties used: In Experiment 1, the variety (var.) Valencia was used which is of medium size and produces an adequate yield of roots with a moderate content of HCN. In Experiment 2, the var. Japonesa was planted which is a tall variety with a high yield of roots and a low HCN content. The Var. Japonesa is a less erect, more branched variety than Valencia and has a higher yield of foliage (CATIE 1980). Both varieties are in common use in Costa Rica.

Treatments and experimental design: The variables studied in Experiment 1 were the density of planting and frequency of foliage cutting. The densities were 6667 (1.0 x 1.5 m), 10000 (1.0 x 1.0 m), 4000 (0.5 x 0.5 m) and 111111 (0.3 x 0.3 m) plants per hectare, and cutting was carried out every 1, 2, 3 or 4 months. In Experiment 2, only cutting frequency was considered and was carried out every 1.5, 3.0 or 4.5 months. In both experiments a control plot was maintained in which the foliage was not subjected to cutting.

In Experiment 1, a split-plot design was used in two blocks, with planting densities in plots and cutting frequencies in sub-plots. In Experiment 2, a randomised block design with four repetitions was used. The experimental plots were of 6 x 5 and 9 x 6 m in Experiments 1 and 2, respectively.

Harvesting methods and parameters measured: In the plots which were subjected to foliage cutting, the first cutting was carried out four months after planting by removing the foliage with a machete at 40 cm above the green stems and leaves. Plants in the outside rows, as well as the first and last plants in each row were discarded from all measurements made, in order to eliminate border effects.

The yields of forage biomass, total and commercial roots were measured in each experiment. Commercial roots were defined as those exceeding 4 cm in diameter in the middle and more than 10 cm in length. In Experiment 1, the proportion of commercial roots was measured in terms of numbers, while in Experiment 2, it was measured in terms of weight.

At each harvesting forage samples of approximately 1 kg in weight were taken for the determination of air dry matter, crude protein and dry matter digestibility in vitro. In Experiment 1, separate samples were also taken of leaves and stems and subjected to the same analysis.

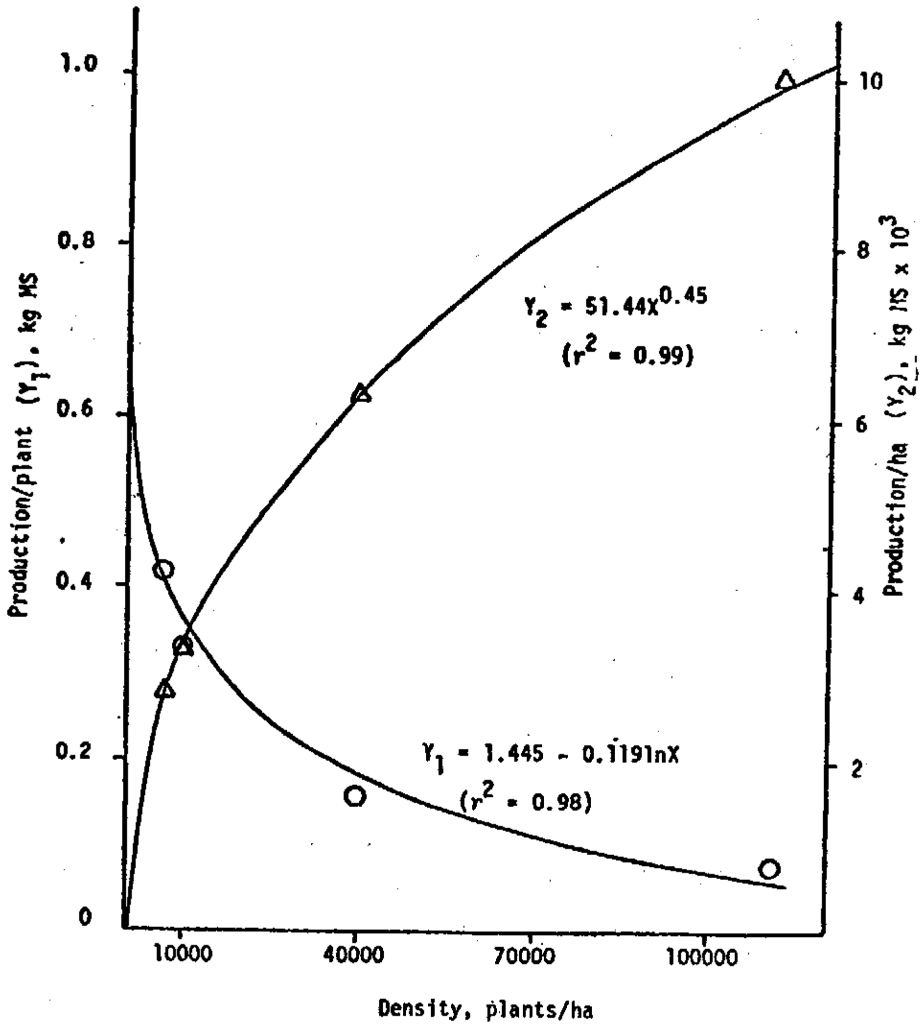
Results

The effect of plant density (X) on the foliage production of var. Valencia is shown in Figure 1. The output of foliage per plant (Y_1) tended to fall as density rose but the output per hectare (Y_2) showed the apposite tendency. The functions which describe these relationships are:

$$Y_1 = 1.445 - 0119 \ln X \quad (r^2 = 0.98;\ P < 0.01)$$
$$Y_2 = 51.445\ X^{0.453} \quad (r^2 = 0.99;\ P < 0.01)$$

Table 1 shows that the yield of foliage per plant and per hectare was significantly higher ($P < 0.05$) in the cassava subjected to foliage cutting. However, the frequency of cutting had no effect on yield.

Figure 1:
Effect of density on foliage production of cassava variety Valencia



The yield of roots (kg/ha) tended to increase as plant density rose, but at a decreasing rate so that no significant difference was detected between the two highest densities (40000 and 111111 plants/ha). However, at the highest densities individual plant yield and yield of commercial

Table 1:

Foliage production in cassava variety Valencia with different frequencies of cutting

Cutting frequency	Foliage yield	
	kg DM/plant	kg DM/ha
Monthly	0.304 a[1]	6506 a
Every two months	0.248 a	5420 a
Every three months	0.343 a	7320 a
Every four months	0.245 a	5414 a
Only at final harvesting	0.093 b	1947 b

[1] Means accompanied by different letters are different ($P \leq 0.05$), according to the Least Significant Difference test

roots was lowest, as may be seen in Table 2. On the other hand, only the highest cutting frequency (monthly) affected the total root yield and the proportion of commercial roots.

Table 2:

Effects of planting density and foliage cutting frequency on the root production of cassava variety Valencia

Variable	Root yield		% Commercial roots
	kg DM/plant	kg DM/ha	
Density:plants/ha			
6667	0.639 a[1]	5322 b	67.4 a
10000	0.881 a	6836 ab	72.1 a
40000	0.158 b	9070 a	42.2 b
111111	0.195 b	9962 a	28.9 b
Cutting frequency			
Monthly	0.384 ab	5673 c	30.5 b
Every 2 months	0.325 b	6618 bc	50.9 a
Every 3 months	0.540 a	9125 a	60.4 a
Every 4 months	0.585 a	9475 a	62.3 a
Only at final harvesting	0.507 ab	8097 ab	59.1 a

[1] Means accompanied by different letters are different ($P \leq 0.05$), according to the Least Significant Difference test

Table 3 shows the crude protein content (CP) and the apparent digestibility in vitro of the dry matter (IVDDM) of the var. Valencia, according to plant density and cutting frequency. The level of statistical significance is not indicated because the data were not subjected to an analysis of variance since combined samples were taken in the field for laboratory analysis using material from both repetitions..

Table 3:

Effect of plant density and cutting frequency on crude protein content and in vitro dry matter digestibility of foliage from the cassava variety Valencia

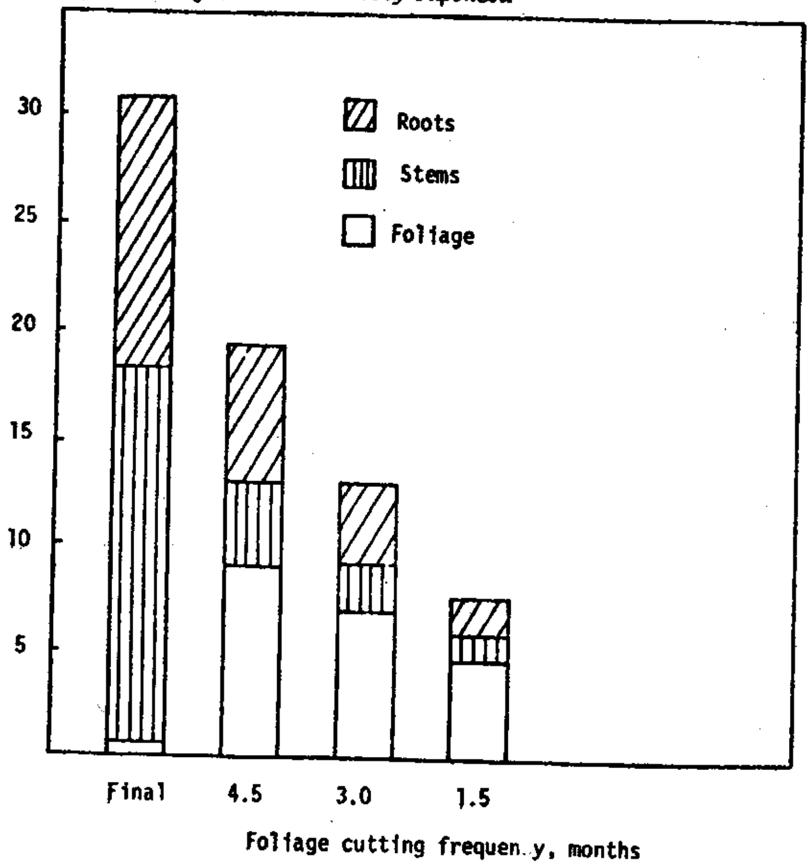
Variable	Crude protein %			In vitro dry matter digestibility %		
	Leaves	Stems	Total foliage	Leaves	Stems	Total foliage
Density, plants/ha						
6667	27.7	10.3	18.4	58.9	42.5	54.7
10000	28.3	11.2	18.8	60.5	43.0	55.9
40000	27.5	10.6	18.3	59.1	43.7	54.5
111111	24.7	8.6	17.8	61.5	42.1	54.2
Cutting frequency						
Monthly	31.4	12.9	21.2	61.1	46.4	56.9
Every 2 months	24.9	6.9	18.2	58.7	41.3	54.5
Every 3 months	25.9	7.4	18.6	59.4	43.3	55.3
Every 4 months	24.9	8.8	17.7	61.6	41.4	54.5
Only at final harvesting	25.9	6.0	16.0	60.2	41.2	52.9

On average, the content of CP in the leaves, stems and total foliage was 27.0, 10.2 and 18.3%, respectively. The corresponding values for IVDMD were 60.0, 42.8 and 54.8%. The highest plant density (111111 plants/ha) produced the lowest values of CP (24.7, 8.6 and 17.8% for leaves, stems and total foliage, respectively). However, the IVDDM was apparently unaffected by plant density. On the other hand, monthly cutting led to the highest values of CP in leaves, stems and whole plants (31.4, 12.9 and 21.2%, respectivamente) as well as of IVDDM in stems and total foliage (46.4 and 56.9%)

Experiment 2: Figure 2 shows the yield of total biomass and of its components in the var. Japonesa subjected to different cutting frequencies. Cutting had a negative effect ($P \leq 0.05$) on production of total biomass and of roots, and the effect was more pronounced as cutting frequency increased. The opposite was true in the case of foliage production. As was to be expected, the production of non-edible, woody stems was lower ($P \leq 0.05$) when cutting was carried out more frequently.

Figure 2:

Effect of cutting frequency on total production of biomass and its components of cassava variety Japonesa



The yields and nutritive value of var. Japonesa are shown in Table 4 according to cutting frequency. The highest yields of foliage dry matter ($P \leq 0.05$) were obtained when cutting was carried out every 4.5 months. However, when the results were expressed in terms of CP yields, higher output was obtained in the plots subjected to cutting, compared with the control, but no difference due to cutting frequency was observed. As in Experiment 1, the highest values of CP and IVDDM were found in the treatment subjected most frequently to cutting.

Table 5 shows that the yield of fresh roots and the proportion of commercial roots was affected ($P \leq 0.05$) by cutting, and the negative effect was more marked as cutting frequency increased. Thus, a reduction of 86 and 78% in the yield of total and commercial roots was observed when cutting was carried out every 1.5 months.

Table 4:

Effect of cutting frequency on the yield, crude protein content and digestibility digestibility of the foliage of cassava variety Japonesa

Cutting frequency	PC %	DIVMS %	Producción de follaje kg/MS/ha	Producción de Proteína cruda kg/ha
Cada 1.5 meses	25.2±3.8	53.6±6.6	4696 b[1/]	928 a
Cada 3.0 meses	17.9±3.1	41.2±10.3	6928 ab	1080 a
Cada 4.5 meses	17.5±5.6	42.1±8.5	8931 a	1219 a
Sólo a la cosecha	21.1±1.3	49.3±6.8	611 c	107 b

Means accompanied by different letters are different ($P \leq 0.05$), according to the Least Significant Difference test

Table 5:

Root yields of cassava variety Japonesa, according to foliage cutting frequency

Frecuencia de poda	Producción de raíz kg/ha	Raíces comerciales %
Cada 1.5 meses	4680 c[1]	20.4 d
Cada 3.0 meses	9870 c	55.4 c
Cada 4.5 meses	16665 b	76.7 b
Sólo a la cosecha	33202 a	91.0 a

[1] Means accompanied by different letters are different ($P \leq 0.05$), according to the Least Significant Difference test

Discussion

The optimum plant density for the production of roots in cassava has generally varied between 5000 and 20000 plants/ha (Enyi 1972; Williams 1973; Enyi 1973; Cock et al 1977; Godfrey-Sam-Aggrey et al 1978; Cock et al 1979) depending on the plant genotype used and the age at harvesting. The results obtained in Experiment 1 seem to show that a density of 10000 plants/ha is suitable for the var. Valencia, both from the point of view of the total yield of roots as well as the proportion of commercial roots obtained. If the objective is to produce roots for industrial purposes or for animal feed,it would be possible to increase the plant density since this leads to an increase in production and it is of no importance whether the roots are of the dimensions required for human consumption. However, if the cassava is to be used for forage production only, higher densities are to be recommended (Montaldo and Montilla 1976; Meyreles et al 1977; Vries 1979) since foliage yield per ha rises even up to a plant density of 111111 per ha. Nevertheless, in taking the decision as to the optimum plant density to use for the production of foliage only, it should be noted that the use of 111111 plants/ha increases the costs of establishment, mainly as a result of high labour requirements and the greater number of cuttings required. However, it would seem that densities above 111111 plants/ha are not reasonable from the practical point of view, even with erect varieties like Valencia. An additional advantage observed with high planting densities is reduced weed growth (Cock et al 1977).

The reduction in the weight of roots produced per plant obtained at densities above 10000 plants/ha was to be expected. According to Hunt et al (1977), at high densities, part of the energy which might otherwise be stored in the root as starch is used for the synthesis of the aerial parts of the plant, since with high densities the inter-nodes become elongated and the plant grows higher because of the competition for light. On the other hand, the reduced quantity of foliage harvested at high plant densities was due both to greater leaf fall as well as to the effect of shading (Cock et al 1979) and the production of thinner stems.

Cutting frequency: The effect of foliage cutting on root production was different in the two varieties. The var. Valencia was unaffected by three-or four-monthly defoliation and showed no reduction either in the yield of commercial or total roots. In contrast, the var.Japonesa produced lower yields of roots, even when cutting was carried out only every 4.5 months. With this cutting frequency, total root yield was reduced by half and the proportion of commercial roots fell by 16%. The possible causes of this difference between varieties are various, but among them may be mentioned that since Valencia is a variety with lower foliage production potential, it may tolerate certain foliage reduction without affecting root yield (Gerodetti 1979). The reserves present in the remaining stems are probably sufficient to form new shoots until these become photosynthetically active and only when defoliation is as frequent as every one or two months, is energy stored in the roots required to form the new shoots (Ahmad 1973). Logically, with its greater potential for foliage production, the var. Japonesa has greater energy requirements for the new shoots and thus the depressive effect on root production is more pronounced. On the other hand, the fact that the var. Japonesa was planted at the end of the rainy season, (December) may have resulted in a reduced development of the roots by the time that the foliage was cut for the first time (Montaldo and Montilla, 1976; Hunt et al 1977) and, subsequently, competition occurred between the formation of roots and new shoots.

The lower foliage production of the plants which were not subjected to cutting was to be expected (Correa et al 1973; Castellanos 1981), since it is recognised that this species considerably reduces its foliage area in advanced stages of growth. Obviously, in the treatments which involved cutting, leaves were collected which would otherwise have fallen. This loss of leaves in the un-cut cassava was apparently more marked in the var. Japonesa, since this was harvested in the dry season of the year (Hunt et al 1977; Gerodetti 1979).

The effect of cutting frequency on foliage production has not previously been determined, since in other studies it has been maintained constant. Thus, Ahmad (1973) and Meyreles et al (1977) used fixed cutting frequencies of 1.5 and 4 months, respectively. In the present case, the two varieties responded differently to cutting frequency. While with the var. Valencia no difference in yield due to frequency was abserved, highest yields were obtained from the var. Japonesa when cutting was carried out at intervals of 4.5 months. Although no information is available concerning the critical foliage area nor of the mean life of leaves in the two varieties, it is likely there was a smaller loss of leaves due to shading (Cock et al 1979) in the var. Japonesa due to its branching habit, even when the regrowth was 4.5 months old.

Another aspect which deserves mention is that the highest frequency of cutting (every 1.5 months) had a greater effect on the capacity of the var. Japonesa to produce new growth, than on the var. Valencia. The reduction in foliage production after the first cut at 4 months of age was 58% in the var. Japonesa, while in the var. Valencia it was less than the 20% assumed by Meyreles et al (1977).

Protein content and in vitro digestibility of the foliage: The CP levels found in the leaves and stems of the var. Valencia are similar to those reported by Devendra (1977), Meyreles et al (1977) and Araujo and Languidey (1982). Similarly, the values obtained in the foliage of both the varieties Valencia and Japonesa do not differ from those given by Montaldo (1977) and Reed et al (1982).

The apparent digestibility in vitro of the dry matter obtained in this study is lower than that reported by Reed et al (1982). However, it must be taken into account that these authors expressed their results as true digestibility values. The IVDDM figures obtained in the present study are also slightly lower than those obtained by Ffoulkes et al (1978) in an in vivo trial. This may have been due to the fact that in "enclosed" systems like in vitro ones, the detrimental effects of the tannins contained in the cassava foliage on the digestibility (Reed et al 1982) are more evident. The differences may also be due to the genotypes used, since in the present study a slight advantage in IVDDM was noted in favour of the var. Valencia compared with Japonesa.

Frequency of cutting was the factor which most influenced CP and IVDDM, among those studied. When cutting was carried out most frequently, a higher proportion of young leaves was found, with a higher nutritive value. On the other hand, the high values of CP and IVDDM obtained in the final harvest of foliage in the case of the var. Japonesa supports the hypothesis that a considerable proportion of leaf was lost at that moment and that the foliage collected during the harvesting of the roots contained a high proportion of young leaves.

Conclusions

The potential of cassava for protein production form the foliage and energy production from the roots makes it an attractive species for the development of mixed crop-animal production systems. Depending on the genotype available, cassava may be managed in such a way as to produce both roots and foliage simultaneously, as in the case of the var. Valencia, or the production of roots of foliage alone, as in the case of the var. Japonesa.

If the objective of cultivating the var. Valencia is for the exclusive production of roots for humen consumption, it would seem advisable to plant the crop at a density of 10000 plants/ha, and either cut the foliage every 3 to 4 months or not cut it at all. On the other hand, if the objective, using the same variety, is to produce roots for purposes other than human consumption and to produce foliage for animal feed, it is advisable to sow the crop at 40000 plants/ha and cut the foliage every 3 to 4 months. In the case of the var. Japonesa, foliage cutting is not recommended if the crop is to be used for root production, while cutting at intervals of 4.5 months may be carried out if the crop is grown for the production of foliage.

Acknowledgements

The authors wish to express their gratitude to the International Development Research Center of Canada and to the Regional Office for Central America and Panama of the United States Agency for International Development (AID-ROCAP), for their contribution to the financing of this study.

Referencias

Ahmad M J 1973 Potential fodder and tuber yields of two varieties of tapioca. Malaysian Agricultural Journal 49:166-174

Araujo E C de & Languidey P H 1982 Composicao química, consumo voluntario e digestibilidade aparente de fenos de rama mandioca. Pesquisa Agropecuaria Brasileira 17:1679-1684

Castellanos V H 1981 Comportamiento de la yuca (*Manihot esculenta* Crantz) sometido a una poda racial y cultivada en asociación con frijol arbustivo y voluble (*Phaseolus vulgaris* L.). Tesis Mag Sc UCR/CATIE 102p

Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Unidad de Recursos Genéticos 1980 Catálogo de la colección de yuca (*Manihot esculenta* Crantz) del CATIE. Boletín Técnico No.2 40p

Correa H, Oliviera J C E, Starling S & Ribeiro F 1973 Efeito da poda de ramas de mandioca no producao de ramas e raíces. Revista Ceres 20:148-157

Cock J H, Wholey D & Gutiérrez O 1977 Effects of spacing on cassava (*Manihot esculenta*). Experimental Agriculture 13:289-299

Cock J H, Franklin D, Sandoval G & Juri P 1979 The ideal cassava plant for maximum yield. Crop Science 19:271-279

Devendra C 1977 Cassava as a feed source for ruminants En Cassava as Animal Feed (Ed B Nestel & M Graham) IDRC & University of Guelph: Ottawa

Enyi B A C 1972 The effects of spacing and growth, development and yield of single and multi-shoot plants of cassava (*Manihot esculenta* Crantz) I. Root tuber yields and attributes. East African Agricultural & Forestry Journal 38:23-26

Enyi B A C 1973 Growth rates of three cassava varieties (*Manihot esculenta* Crantz.) under varying population densities. Journal of Agricultural Science, Cambridge 81:15-28

Ffoulkes D, Doñé F & Preston T R 1978 Forraje de yuca como alimento para el ganado: Digestibilidad y consumo del forraje integral. Producción Animal Tropical 3:234-236

Gerodetti M B 1979 Efectos de la poda y laboreo del suelo sobre el crecimiento y rendimiento de yuca (*Manihot esculenta* Crantz) asociada con maíz (*Zea Mays* L.) y vainita (*Phaseolus vulgaris* L.) Tesis Mag Sc UCR/CATIE 93p

Godfrey-Sam-Aggrey W 1978 Effects of plant population on sole-crop cassava in Sierra Leone. Experimental Agriculture 14:239-244

Godoy R & Elliott R 1981 Efecto de cinco forrajes tropicales sobre algunos parámetros de la función ruminal y flujo de nutrientes al duodeno de bovinos alimentados a base de melaza/urea. Producción Animal Tropical 6:177-184

Hunt L A, Wholey D W & Cock J H 1977 Growth physiology of cassava (*Manihot esculenta* Crantz). Field Crop Abstracts 30:77-91

Meyreles Luz, MacLeod N A & Preston T R 1977 Forraje de yuca como fuente proteica: Efecto de la densidad de población y edad al corte. Producción Animal Tropical 2:18-26
Montaldo A 1977 Whole plant utilization of cassava for animal fed. En Cassava as Animal Feed (Ed B Nestel & M Graham) IDRC & University of Guelph: Ottawa
Montaldo A 1979 La yuca o mendioca IICA, San José, Costa Rica
Montaldo A & Montilla J J 1976 Producción de follajė de yuca. Revista de la Facultad de Agronomía (Maracay) Alcance 24:35-51
Montilla J J 1977 Cassava in the nutrition of broilers En Cassava as Animal Feed (Ed B Nestel & M Graham) IDRC & University of Guelph: Ottawa
Nestel B & Graham M 1977 Cassava as animal feed: Proceedings of a workshop. IDRC & University of Guelph: Ottawa
Reed J D, McDowell R E, Van Soest P J & Horvath P J 1982 Condensed tannins: A factor limiting the use of cassava forage. Journal of the Science of Food & Agriculture 33: 213-220
Schoonhoven A V, Pérez A M & Penar J E 1974 Influencia de la defoliación artificial en la producción de raíces de yuca y su correlación con el daño causado por *Erynnis ello* L. En 2° Congreso de la Sociedad Colombiana de Entomología Colciencias: Bogotá
Teeluck J P, Nicolin R, Hulman B & Preston T R 1981 Apuntes sobre el uso de la yuca (*Manihot esculenta*) como fuente combinada de proteínas y forraje para el crecimiento de becerros alimentados con dietas de melaza/urea. Producción Animal Tropical 6:90-93
Vries C A de 1979 New developments in production and utilization of cassava. Abstracts on Tropical Agriculture 4:9-24
Williams C N 1972 Growth and productivity of tapioca (*Manihot utilissima*) III. Crop ratio, spacing and yield. Experimental Agriculture 8:15-23

Received November 18, 1983

Translated from Spanish