RESEARCH ON CASSAVA FOLIAGE PRODUCTION IN COLOMBIA

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ABSTRACT

Cassava cultivation in Colombia has been increasing recently due to its multiplicity of uses and markets. One of the most important uses for the crop is the foliage in animal feeding, as a source of protein in balanced feeds for monogastrics and ruminants. In Colombia, the animal production sector is growing very fast and domestic production of cereals such us maize and soybean that are used in balanced feeds is not sufficient to meet the increased demand. To meet this demand, the country has been importing cereals at levels that by the end of 2002 will be over 2 million tonnes of maize per year.

With the objective of identifying alternative sources of raw material for animal feeding, CLAYUCA has been conducting adaptative research on the potential of intensive cassava foliage production systems. The results obtained so far indicate that the development of parameters such us variety, plant population and harvesting period are very important as well as the climatic conditions of the region in which the foliage is produced. A comparison was made of three different regions of Colombia, using different varieties and different plant populations. The best results were obtained using a plant spacing of 30 x 30 cm which gives a plant population of around 111,000 plants/ha. The total yield obtained after 12 months was 91 t/ha of fresh cassava foliage. These results were obtained in the region Ayapel, Cordoba, a dry savanna characterized by a dry season of four months. During the dry season, with zero rainfall, cassava plants were able to survive, and with the onset of the rains they recovered normally and produced acceptable yields. The plants tops were harvested every three months.

A similar experiment was conducted in Caicedonia, Valle, a region characterized by a better rainfall distribution and soil fertility status. In this region, although the crop was maintained for two years and the plants were harvested six times, the yields obtained were lower, around 81 t/ha of fresh foliage. These differences in yield could be explained by the physical characteristics of the soils, which makes crop management more difficult. Additionally, with the aim of facilitating the management of the crop in activities such us planting, weeding, fertilization and harvesting, CLAYUCA has conducted some work with different plant spacing, using raised beds separated 70 cm and with 30 cm distance between plants. This arrangement gives a plant population of 48,000 plants per hectare. This experiment is being conducted in the Valle region, with harvest at 3, 7 and 9 months. Yields obtained in those three harvests was 98 t/ha of fresh foliage. This arrangement looks very promising for reducing labor requirements for cassava foliage production.

Another important aspect of cassava foliage production systems is the management of soil fertility. These systems extract more nutrients than normal root production systems. Data obtained by CLAYUCA indicates that with a planting density of 48,000 plants per hectare and with three harvests in a nine month period, each tonne of fresh cassava foliage harvested represents an extraction of 9.26 kg of N. This amount is considerably higher that the 4.42 kg N extracted per tonne of fresh cassava roots (including foliage) in the root production system.

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CLAYUCA is also looking at the viability of using mechanical harvesters to reduce the cost of labor in the intensive cassava foliage production systems. Some prototypes have been identified and are currently under evaluation.

INTRODUCTION

The use of cassava in animal feeding in Colombia is generally restricted to the roots that are used as a source of energy. The top part of the cassava plant has had very limited use. The importance and value that the use of cassava leaves, petioles and stems can have in animal feeding has not received adequate recognition.

During the last five years, cassava cultivation in Colombia has been expanding rapidly, due to its specific characteristics that allows the crop to be used in different markets. One of these markets, perhaps the one with the greatest potential, is the use of cassava in animal feeding, as a source of energy (the roots) and as a source of protein (the leaves). Casava leaves can be used with excellent results in the feeding of monogastrics (poultry and swine) and ruminants (cattle).

The high nutritional value of cassava leaves and the great adaptation of the crop to different types of soils and climates make it a very feasible option for animal nutrition programs.

In many regions of the world, Colombia among them, animal production has increased considerably in recent years and this growth has created an increased demand for raw materials for the elaborations of animal balanced concentrates, most of which have to be imported (maize, sorghum, soybean). This dependency on imported raw materials has increased the cost of animal production. This growing demand for raw materials opens up an opportunity for the use of cassava foliage as a protein supplement in nutrition programs for different types of animals.

CLAYUCA has conducted during the past three years some adaptative research aimed at promoting a more intensive use of cassava leaves in animal feeding programs in Latin America and the Caribbean region. This paper presents a brief summary of this work.

Nutritional Quality of Cassava Foliage

The nutritional composition of cassava foliage is affected by factors such us varieties, soil types and climatic conditions, especially rainfall, age of plant, period of harvest and proportion of stem, petioles and leaves. With older plants, the protein content is lower and the fiber and dry matter contents are higher. The protein and fiber contents determine the nutritional quality of the cassava foliage in animal feeding, specially for monogastrics.

Cassava roots contain on average 2.0% crude protein whereas cassava foliage can have protein contents between 20 to 26% (**Table 1**). Also, when compared with some grains, the nutritional value of cassava foliage in terms of protein content and digestible energy content are higher, thus making it a very attractive option for animal feeding (**Table 2**).

Table 1. Average content of dry matter, crude protein and digestible energy of some foliage crops.

	Dry matter		Crude protein		Digestible energy	
Legumes	%	t/ha/year	%	kg/ha/year	Mcal/kg	Mcal/ha/year
Kudzú	24	10.0	21.0	2,100	2.20	22,000
Desmodium ovalifolium	21	4.5	15.0	675	1.90	8,550
Gliricidia sepium	25	12.0	21.2	2,544	2.10	25,200
Leucaena leucocephala	35	15.2	25.7	3,906	1.90	28,880
Hay	26	24.0	22.5	5,400	1.47	35,280
Cassava foliage	25	25.0	22.0	5,500	1.70	42,500

Source: *Adapted from Chamorro et al., 1998; Gonzalez et al., 1969.*

Table 2. Average contents of dry matter, crude protein and digestible energy of some foliage crops.

	Dry matter		Crude protein		Digestible energy	
Grains	%	t/ha/year	%	kg/ha/year	Mcal/kg	Mcal/ha/year
Imperial grass	22	19.8	8.0	1,584	2.36	46,728
King grass	22	30.8	6.0	1,848	2.09	64,372
Elefant grass	22	26.4	7.0	1,848	1.98	52,272
Guinea grass	20	18.5	9.8	1,813	2.00	37,000
Star grass	20	20.0	10.5	2,100	2.20	44,000
Brachiaria decumbens	20	12.0	8.5	1,020	2.00	24,000
Sorghum	33	12.3	10.9	1,345	2.96	36,408
Maize (whole plant) (100 days)	32	14.5	8.8	1,268	3.22	46,690
Cassava foliage[1)]	25	25.0	22.0	5,500	1.70	42,500

[1)] assuming an annual production of fresh cassava foliage of 100 t/ha.
Source: *Adapted from Chamorro et al., 1998*

Buitrago (1990) considers fiber, protein, fat and ash as the principal elements in the composition of cassava foliage for preparation of balanced animal feeding diets (**Tables 3 and 4**).

Table 3. Nutritional composition of some foliage raw materials used in animal feeding (dry matter basis).

Component	*Manihot esculenta*	*Zea mays*	*Medicago sativa*	*Pueraria phaseoloides*
Crude protein %	18.1	7.3	20.2	16.3
Ether extract %	3.7	2.2	3.0	3.9
Ash %	11.2	6.7	11.7	8.0
Crude fiber %	21.0	33.9	25.9	37.1

Source: *McDowell et al., 1974, reported by Rosero, 2002.*

MATERIALS AND METHODS

The technology adaptation work that CLAYUCA has done during the last four years, has been implemented in three different regions of Colombia. **Table 5** describes the types of soils and the varieties used in each region. Different planting distances and plant densities were tested, ranging from 48,000 to 112,000 plants per ha with periodical harvests every three monts. Parameters evaluated included fresh and dry foliage weight, as well as crude protein, crude fiber, fat and ash contents.

Table 4. Nutritional quality of cassava foliage.

Component	Leaves	Leaves and petioles	Leaves, petioles and stems
Crude protein %	22.7	21.6	20.2
Ash %	10.9	9.8	8.5
Ether extract %	6.3	6.3	5.3
Crude fiber %	11.0	11.6	15.2
Calcium %	1.68	1.70	1.68
Phosphorus %	0.29	0.24	0.28
Potassium %	0.69	0.60	1.09

Source: *Van Poppel, 2001, reported by Buitrago et al., 2001.*

Table 5. Type of soils, and cassava varieties and plant population used in the cassava foliage technology adaptation research conducted in three regions of Colombia.

Region	Type of soil	Varieties used	Plant population (plants/ha)	Period (months)
Santander de Quilichao (Cauca)	clay	CMC-92	62,500	24
Ayapel (Cordoba)	sandy clays	CMC 4843-1	112,000	12
Buga (Valle)	calcareous clay	CM 2758	112,000	24
Buga (Valle)	calcareous clay	CM 523-7	112,000	24
Caicedonia (Valle)	sandy clays	CM 2737	112,000	24
Candelaria (Valle)	-	HMC-1	48,000	11

RESULTS

CIAT (1985) and Cadavid (2002), working under conditions of clay type soils in Colombia, and using plant densities ranging from 20,000 to 62,000 plants/ha reported yields of dry foliage of around 24 t/ha, with seven periodic harvests, every three months, over a 2-year period (**Table 6**).

Table 6. Production of fresh cassava foliage (t/ha) with the cultivar CMC 92 (Algodona) in soils of Santander de Quilichao, Cauca, Colombia with a planting density of 62,500 plants/ha , during a 2-year growing cycle.

	Age (months) at cutting							Total yield (t/ha)
	3	6	9	12	15	18	24	
Fresh foliage (t/ha)	24.5	5.0	15.0	6.0	8.6	16.8	8.7	84.6
Crude protein (%)		24.8	13.6	22.7	20.2	17.4	14.8	
Crude fiber (%)		20.8	34.4	16.1	22.9	31.6	32.7	
Ash (%)		6.4	4.8	4.3	5.3	3.2	3.8	

Source: *Cadavid, L., personal communication, 2002.*

Climatological factors are very important, especially rainfall. When the cassava plant tops are harvested, the growth of the plant suffers a stress period and the availability or lack of a following rainfall period determines to a large extent the recovery of the plant and the subsequent production of acceptable foliage yields. This effect of rainfall was demontrated recently in a trial conducted in the region of Ayapel, Cordoba, Colombia, in a sandy clay soil, with average temperature of 27 ^{0} C and average annual rainfall of 2,600 mm (**Figure 1**). It can be seen that during the dry months, the growth of the plant almost stopped, but the plants did not die. When it started to rain again, the plants recovered and achieved again acceptable yields. The time of planting and of the successive harvests, in relation with the rainfall distribution, becomes a critical factor in the yields obtained in cassava leaf production systems.

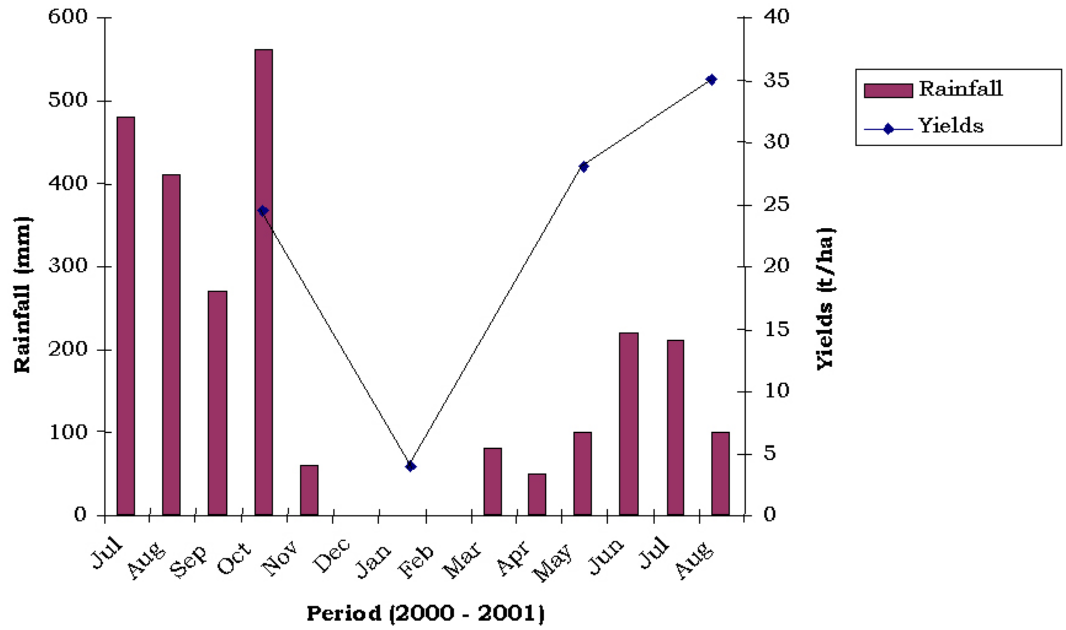

Figure 1. Effect of precipitation on the yield of fresh cassava foliage of cv CM 4843-1 in Ayapel, Córdoba in 2001/02.

In other trials conducted by CLAYUCA in various regions of Colombia, the varietal effect as well as the effect of plant age at harvest were analyzed. The results are presented in **Tables 7, 8, 9** and **10**. In general, it can be observed that in some regions, leaving the crop for two consecutive years in the field, is not a very good option. The yields obtained were the same as those obtained in another location in just one cropping cycle. The low yields obtained could be due to the fact that the varieties used were not adapted very well to consecutive harvests and high planting densities.

Using high planting densities (112,000 plants/ha) makes the leaf harvest very difficult and the plants are damaged by the workers that have to enter the plots to harvest. Seeking an alternative planting arrangement, another trial was conducted using a different planting density, in a region with better climatic conditions. **Table 11** presents the results obtained in Candelaria, Valle de Cauca. It can be observed that with only 11 months of growing period and three harvests, almost 100 t/ha of fresh cassava foliage were obtained. The planting density used was low (48,000 plants/ha), which facilitates the mechanization of the harvest operation, thus reducing the total cost of cassava foliage production.

Table 7. Production of fresh cassava foliage of cv CM 4843-1 in sandy clay soils of

Ayapel, Córdoba, Colombia, with a planting density of 11,2000 plants/ha and a growing cycle of 12 months.

	Age (months) at cutting				
	3	6	9	12	**Total**
Fresh foliage (t/ha)	24.45	4.80	27.20	34.96	**91.4**
Crude protein (%)		18.6	22.2	11.8	

Source: *Adapted from Rosero, 2002.*

Table 8. Production of fresh cassava foliage of cv CM 2758 (Parrita) in calcareous clay soils of Buga, Valle, Colombia, with a planting density of 112,000 plants/ha and a growing cycle of 24 months.

	Age (month) at cutting							**Total**
	3	6	9	12	18	21	24	
Fresh foliage (t/ha)	8.87	25.60	12.99	10.02	8.95	8.82	7.76	**83.01**
Crude protein (%)	16.4	14.6	12.0	8.9	14.6	12.1		
Crude fiber (%)	21.5	27.4	26.3	21.9	20.3	26.0		

Source: *Completed and adapted from Rosero, 2002.*

Table 9. Production of fresh cassava foliage of cv CM 523-7 (Catumare) in calcareous clay soils of Buga, Valle, Colombia, with a planting density of 112,000 plants/ha and a growing cycle of 24 months.

	Age (months) at cutting							
	3	6	9	12	18	21	24	**Total**
Fresh foliage (t/ha)	7.31	21.88	14.12	9.44	12.37	12.11	9.58	**86.81**
Crude protein (%)	17.5	17.0	12.0	11.9	14.2	10.6		
Crude fiber (%)	25.1	25.9	28.1	19.2	22.2	23.1		

Source: *Adapted from Rosero, 2002.*

Table 10. Production of fresh cassava foliage of cv MCol 2737 (Brasilera) in calcareous sandy clay soils of Caicedonia, Valle, Colombia, with a planting density of 112,000 plants/ha and a growing cycle of 24 months.

	Age (months) at cutting							
	3	6	9	12	18	21	24	**Total**
Fresh foliage (t/ha)	16.7	23.1	11.7	5.1	11.1	15.3	19.9	**102.9**
Crude protein (%)	14.2	12.6	10.5	13.6	18.5	17.5		
Crude fiber (%)	35.2	35.5	35.5	24.6	27.6	25.1		

Source: *Adapted from Rosero, 2002.*

Table 11. Production of fresh cassava foliage of cv HMC 1 in Candelaria, Valle,

Colombia, with a planting density of 48,000 plants/ha and a growing cycle of 11 months.

	Age (months) at cutting			
	3	7	9	**Total**
Fresh foliage (t/ha)	18.0	53.5	26.7	**98.2**
Crude protein (%)	26.7	18.3	20.5	
Crude fiber (%)	29.6	32.0	25.9	
Fat (%)	5.5	4.8	4.3	

Source: *CLAYUCA, 2002. (unpublished data)*

The results obtained in this trial conducted in a region with good quality soils and a good rainfall distribution give an idea of the potential that this type of arrangement can have for a sustainable, profitable production of cassava foliage. Fresh foliage yields of almost 100 t/ha per season are excellent. This particular trial was planted with a plant spacing of 70 cm between rows and 30 cm between plants, an arrangement that facilitates mechanization of the harvest operations. Another important result of this trial was the reduction of the number of stakes to be planted, a time and money consuming operation, with a consequent reduction in total production costs.

A topic that has to be considered with extreme caution in the promotion of intensive cassava leaf production systems is the fertility management of the soils. This factor is critical, especially in soils that are not very fertile. It is a well-known fact that high yields of cassava foliage result in a high nutrient extraction from the soil, especially nitrogen, potassium and calcium (Cadavid, 2002). It is therefore necessary to make specific adjustments to the fertilization of the soils when the area is used for intensive cassava leaf production. These adjustments can not be the same ones that are used for production of cassava roots.

In the trial conducted in Candelaria, Valle, Colombia (**Table 11**), the amount of nutrients extracted after each cutting was determined. **Table 12** indicates that for each tonne of fresh cassava foliage harvested, 8.42 kg of N were removed, whereas in the case of cassava root production, the removal is around 4.42 kg of N (Cadavid, 2002).

This information is important for the determination of fertility management practices in intensive cassava foliage production systems; if not properly managed, the high extraction of nutrients in several succesive leaf harvests could make the production system unsustainable.

Another important aspect in the establishment of intensive cassava foliage production systems is the cost of labor. If the harvest is done using manual labor, the costs of cassava foliage per tonne could be very high. Almost 25 man-days are required per hectare for each cutting. One option is the mechanization of the harvests. There are various types of mechanical cutters that can be used for this purpose. CLAYUCA has tested some of these machines and the best results have been obtained with a mechanical slicer (**Photos 1** and **2**), that can be attached to a tractor and allows regulation of the cutting height. Also, the foliage is cut, chopped and discharged into a trailer in one single operation.

Table 12. Concentration and content of nutrients in the harvest of three cuts of foliage of variety HMC-1 grown in Candelaria, Valle, Colombia were planted at 48,000 plans/ha.

	Nutrient concentration (%)						Nutrients removed (kg/ha)					
Age at cutting	N	P	K	Ca	Mg	S	N	P	K	Ca	Mg	S
3 months	4.27	0.32	2.28	1.70	0.47	0.29	230.6	17.3	123.1	91.8	25.4	15.7
7 months	2.92	0.36	1.99	1.25	0.42	0.24	307.5	37.9	209.5	131.6	44.2	25.3
9 months	3.28	0.36	1/82	1.40	0.54	0.24	178.8	19.8	100.1	77.0	29.7	13.2
Total							716.9	75.0	432.7	300.4	99.3	54.2
Mean extraction per tonne fresh forage harvested							**8.42**	**0.80**	**4.83**	**3.48**	**1.12**	**0.61**

Source: *CLAYUCA, 2002*

CONCLUSIONS

1. Cassava foliage is a good alternative resource for balanced animal feeds, due to its high content of crude protein.
2. High planting densities (between 50,000 to 112,000 plants/ha) could be employed for intensive cassava foliage production systems, depending on factors such as plant type, fertility of the soils, and the rainfall pattern.
3. Fresh cassava foliage yields could be as high as 100 tonne per ha per year depending on the fertility of the soil and rainfall.
4. Harvest intervals could be reduced to 45-60 days after the first cut, which is made when the plants are three months old.
5. High removal of nutrients in the foliage harvests, especially N and K, makes it necessary to increase the application of these nutrients in intensive cassava foliage production systems.

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Photo 1. Mechanized harvesting of cassava foliage.

*Photo 2. Cassava field after the mechanical harvest,
Candelaria, Valle, Colombia.*