ROLE OF SMALL-SCALE CASSAVA DRYING PLANTS IN IMPROVING EQUITABLE RURAL ECONOMIC GROWTH AND DEVELOPMENT[1]

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Abstract

The identification, introduction and development of cassava drying technology has led to a more stable and wider cassava market in several important cassava growing regions in Latin America. In turn, this has been an incentive for small-scale cassava farmers to increase both cassava area and production using improved cassava production technologies.

Farmer cooperatives are managing cassava drying plants where cassava is chipped, sun-dried on concrete floors, and sold as a low-cost energy substitute to animal feed ration manufacturers. The drying plants need an initial investment of 11,000 US$ and the average drying floor has an annual capacity of processing 100 ha of cassava in a region where the average farm is 4-6 ha. Local governmental and non-governmental institutions provide support in management and marketing.

The first drying project started in Colombia in 1982, and since then, the project has been through 3 phases: (1) pilot phase; (2) semi-commercial phase; and (3) expansion phase. Currently, approximately 51 farmer cooperative managed drying plants are in operation, producing 10,500 ton of dried cassava chips. In addition, some 6,000 ton of chips are being produced and utilized on-farm. The drying technology has spread to Ecuador, Panama, and Brazil, where it has been adopted with great success. Currently it is estimated that some 150-170 drying plants are in operation in Latin America.

The cassava drying technology has shown an impact at various levels of beneficiaries and in different forms. Small-scale cassava farmers are the foremost beneficiaries in terms of increased cassava revenues and employment. In addition, improved rural purchasing power increases the demand for urban manufactured goods. Hence, cassava drying technology can improve overall economic growth and development in marginal areas of the tropics.

Introduction

Cassava is an important source of carbohydrates for low-income consumers *in* Latin America. In some regions of the continent, such as North East Brazil, it is the principal crop, on which the livelihood and income of humans and animals depend.

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During the 1960s and 70s, investment in agriculture by Latin American countries was concentrated on the major cereal crops and export commodities. This situation resulted in the need from time to time to import food and other raw materials, with adverse effects on the balance of payments and on the continuity of supply and production capacity of locally grown commodities. In addition, the rapid process of urbanization led to a declining demand for traditional rural staples, such as cassava, which were replaced in the diet by more convenient cereal foods such as rice and wheat based products. Faced with the economic crisis brought about by Latin America's external debt, countries have had to face the double necessity of increasing their investment in exportable agricultural products, while at the same time ensuring profitable internal agricultural production, avoiding the use of foreign exchange, ensuring the timely supply of food, improving the internal capacity for generating technology, maintaining social peace in rural communities and reducing large scale migration to towns and cities.

Cassava is mainly produced by small farmers in complex production systems, with little use of modern technology, in particular agrochemicals. Two features of its production are important in explaining its widespread use as a food crop: its capacity for using water efficiently and for being able to grow well in poor soils where other crop species do not prosper.

Its capacity for using water efficiently enables cassava to grow in seasonally dry regions, such as North East Brazil, North Colombia and Coastal Ecuador, where it plays a predominant role in small farm production systems and is an important source of food. It also enables it to grow in areas where there are unpredictable and occasional droughts as in Central America and the Caribbean. Its ability to grow in poor soils makes it possible to efficiently convert solar energy into carbohydrates without competing with other nutritionally more demanding crops which are of value either as food or for export, such as sugar cane, and which require better soils.

Until recently cassava's potential as a multi-purpose carbohydrate source for food, feed and industrial uses had not been fully exploited in Latin America. Several attempts in the 1970s had been made to promote the agroindustrial transformation of cassava to produce meal, flour, starch, alcohol or other derived products. However, relatively few of these projects met with the success that was anticipated when they were originally formulated; those that attempted to improve production ran into marketing problems, others that have invested in processing plant have encountered problems related to the availability and/or price of the raw material. None of these projects were able to form a sustainable link between the cassava farmer and an expanding market.

The analysis of these projects highlighted the need for an integrated approach to cassava production, processing and market development. In addition, recent experiences in Latin America have demonstrated the need for a logical procedure for cassava projects, which involves the identification and subsequent development of markets for fresh roots and/or their derivatives. Actions to be taken, once a suitable market has been identified, should simultaneously take into account production, processing and commercialization activities so as to develop the market effectively.

Integrated Cassava Projects

Ten years ago CIAT, together with Colombian institutions, began developing an integrated cassava project for Colombia's Atlantic Coast. This project concentrated on technical support for the production and processing of cassava roots into dried chips for animal feed and the realization of production and marketing studies. The dried chip market for cassava had been regarded as promising because of the rapid development of the national poultry and swine industries. A pilot project was started with a small farmers' association and since then has grown to the proportions of a regional project involving more than 60 farmers' groups.

The concept of a pilot scheme as a place where research and development is carried out on a reduced scale, which is then extended later to a semi-commercial or commercial level has also met with great success in other countries. Cassava-based development schemes have been set up along these lines in Ecuador, Brazil, Paraguay and Panama.

As a result of the experience acquired in different countries, a generalized methodology for integrated projects has been developed with national institutions. Basically, this consists of a macro-level analysis in which the priorities of the government related to overall socio-economic and rural development are studied at a national and regional level. From these studies, a potential market for cassava and the most appropriate region for executing an integrated project are identified. Following a detailed characterization of the chosen region, a site is selected where the pilot project will be established. The pilot project itself evolves from in-situ research on production, processing and marketing to semi-commercial operation of the appropriate technology with farmers and processors. This in turn provides the relevant technical, economic and operational information on which to base an expansion of the project to other areas within the chosen region.

The projects underway in the above mentioned countries have been based on the establishment of small scale cassava natural drying plants managed and operated by farmer organizations.

This paper will present details about the processing technology that is being introduced and discuss how the diffusion of the technology has created a demand for improved production components. Finally, production technology adoption and the socio-economic impact that is being achieved are presented.

Drying Technology

A cassava natural-drying plant has three principal components: the concrete floor, a chipping machine, and a storage area. Members of the farmers' group that will later operate the drying plant provide the labor for building the infrastructure. Farmer participation in constructing the drying installations is considered an important factor in group cohesiveness. The drying plant also has a chipping machine with a gasoline, diesel, or electric motor, plastic covers, carts, shovels, rakes, and a weighing scale. table 1 shows the investment costs for a plant with a 1000-m² concrete floor.

For carrying out the drying process, farmers organize themselves into working groups and each group is responsible for the overall processing of a batch of fresh cassava. The cooperative establishes a purchase price for the cassava received at the drying plant, and farmers are responsible for harvesting and transporting the roots to the plant on mules or in vehicles. Once at the plant, the cassava is weighed and then chipped. The chipping machine produces small cassava chips and has a capacity of 8-12 tons per hour. After chipping, the chipped cassava is spread out on the drying floor at a loading rate of between 10 and 12 kilograms of fresh chips for each square meter of drying floor. The cassava chips are turned over every hour or two using a wooden rake, which ensures a faster and more uniform drying.

Farmers begin processing a batch of fresh cassava between 4 and 6 o'clock in the morning, and the cassava chips remain exposed to the sun during all of the first day and on the second day up to 4 or 5 o'clock in the afternoon.

When the cassava has reached less than 14% moisture, the dry chips are collected, packed and stored. On the average, the dry cassava is held in store for eight days before being sent to the concentrated feed plant. A major advantage of these drying projects is the fact that the farmers can now manage a stable product that offers them a marketing system in which they are less vulnerable. Previously, they marketed fresh cassava, a highly perishable product that was unsuitable for human consumption after only two days.

Cassava natural drying is an activity that generates employment. On the average, one man-day is required for each ton of fresh cassava that is processed. Between 2.4 and 2.6 tons of fresh cassava are required to produce one ton of dry cassava, that is, a yield of between 38% and 42%.

A drying plant with a 1000-m² floor, on which 12 kilograms of fresh cassava are placed on each square meter, can process 12 tons of cassava, and two days are needed to complete the drying. Under these conditions, the plant has the capacity to process three lots per week for a total of 36 tons of fresh cassava chips. On the Atlantic Coast of Colombia for example, there is a 4-5 month dry period, and it is estimated that there is a minimum of 20 weeks per year that have favorable conditions for cassava natural drying. the annual capacity of a drying plant with a 1000-m² floor is 720 tons of fresh cassava, that is around 280 tons of dry cassava. Considering local cassava yields (8 tons/ha), a 1000-m² drying plant will require around 90 hectares of cassava annually to operate at full capacity.

Table 1. Investment costs for a cassava natural-drying plant with a 1000 m² concrete floor.

Item	Amount (US$)
Construction[a]	
Patio (1000 m^2)[b]	5,042
Storage area (60 m^2)[b]	2,857
Chipping area[b]	420
Subtotal	8,319
Equipment	
Scale (500 kg)	252
Plastic covers	269
Chipping machine	629
Hopper	67
Motor for chipping machine	269
Wooden pallets (4)	101
Carts (3)	101
Funnels(2)	168
Metal shovels (6)	30
Wooden rakes (10)	92
Sisal sacks (250)	168
Subtotal	2,146
Incidental expenses (%)	523
Total	10,988

a. It is assumed that the land is donated by the cooperative.
b. It is assumed that the cooperative supplies labor.

The economic viablity of drying cassava depends on the potential of the dry cassava to compete with coarse grains, usually sorghum, in the animal feed concentrate industry. Dry cassava is a good carbohydrate source but it has a relatively low protein content; in comparison, sorghum has a similar carbohydrate content but a larger proportion of protein and, consequently, greater nutritional value. The difference in nutritional value results in the price of dry cassava being discounted by a factor that can fluctuate between 10% and 20%. However, the price of dry cassava must be sufficient to cover production, processing, and transportation costs, and should leave some profit margin for the dry-cassava producer.

In the case of Colombia and Panama, dry cassava replaces sorghum in animal feed rations, while in Ecuador the findy milled cassava chips are used as an agglutinant and energy source in shrimp feed pellets. In Ceara, Brazil, the dry cassava is sold mostly to local dairy farmers. In the case of Colombia, the market for dry cassava has been consolidated and the product has gained acceptance among consumers, prices have evolved and farmers' profit margins have improved. Likewise, farmers have easily assimilated and dominated the technology, and they feel motivated to increase the installed capacity of the drying plants, thus improving yields and reducing processing costs.

Adoption of cassava drying technology:

Since the construction of the first cassava drying pilot plant in 1981 in the North Coast of Colombia, cassava drying plants have been constructed in five Latin American countries. Fig. 1 shows the total number of cassava processing plants in Latin America. The acceleration of plant adoption has been very obvious during the last two years. To a major extent this has been caused by the rapid adoption of cooperatives in Brazil, and the acceleration of commercial plants in Colombia (Fig. 2) and Brazil. The data for 1991 are estimated however, since it has no longer been possible to keep an accurate count through monitoring activities because of the fast, widespread and diverse types of cassava drying adoption.

During the initial phase of the project in Colombia, the cassava drying cooperatives sold the dried chips to several large animal feed manufacturers near large urban centers i.e. Barranquilla, Bucaramanga and Medellin, in the North Coast of Colombia. However during the last couple of years, we have observed several changes.

First, the market for dried chips has broadened towards Central and Southern Colombia, including large feed companies in Bogota, Buga and Cali. It is estimated that the majority of the chips for these latter markets, are being supplied by plants in the North Coast. However, the share supplied by local Southern plants and private chippers has been increasing significantly. This is another indication that the cassava processing technology is spreading into new areas.

Secondly, while the initial chip buyers were largely animal feed factories, the current user group is much less homogenous. We can observe a strong demand from (i) swine, broilers and egg producers, who mix their own feed rations; (ii) cattle operations that need an energy source (on-farm) to reduce animal weight losses during the dry season, which coincides with the cassava processing season; (iii) besides the animal feed sector a growing demand has become evident from cassava starch producers.

Thirdly, the initial cassava processing "model" as started in Sucre in 1982 was based on a small-scale cassava farmers cooperative concept. However, during the last couple of years this model has been adapted because of different commercial objectives and markets. Fig. 3 shows that in 1990 only an estimated 60% of dry chips (sold to factories only)[2], were produced according to the basic model. The remander was produced by a heterogenous group of processors, based on a large variety of "models". For 1991 it is estimated that the latter group has surpassed production of the former.

Currently we can distinguish between the following cassava drying "models":

- A small-scale cassava farmer cooperative, with an average of 20 (legal) members.
- A cooperative as in (1) but with 200-400 members.
- An association with 2-4 members who on the average farm more land. The drying plant is on one of the members farm (typical for Santander).
- Both large and small private commercial plants, owned by one or more people.
- Private entrepreneur, who rents his floor and chipper by unit of weight (or time), to local cassava farmers.
- Large-scale drying plant, vertically integrated with an animal feed company who is the owner and manager.
- On-farm small and medium drying plant as part of a cattle operation.
- Cassava starch processors (Cauca) who, when starch prices are low, produce dried cassava chips.
- Individual small-scale cassava farmers, who manually chip and dry (on any kind of surface) cassava from secondary quality roots, and/or when the cassava fresh price is too low, or because they are isolated from the fresh cassava market.

Fourthly, initial dry chip marketing was basically direct negotiating between chip producing plants (or its marketing association) and feed factories. Due to the increasing diversity of producers and "consumers", volumes traded, and the geographical spreading of demand and

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[2] Sales to feed factories is the only reliable information that currently exist. It is estimated that these sales comprise between 50-75% of total chip production.

supply zones, intermediaries have entered the marketing channels, introducing one or more pricing points. Among other things, this has made it possible for isolated small-scale, sporadic, and low-volume cassava chippers to sell their product. It goes without saying, that the introduction of intermediation has increased the marketing margin.

It is evident that this cassava processing technology has been rapidly and widely adopted, in time, space, for different uses and audiences. Strong commercial interest and adoption is probably a fair indicator of the potential benefits to be gained from the technology. Also, the adaptation of the original model into a wide array of "applied models" increases the sustainability of the technology (Ceteris paribus).

Integrated projects as a technology diffusion vehicle:

The underlying philosophy behind the Integrated Cassava Projects was that declining traditional cassava markets didn't offer incentives for cassava farmers to adopt technologies to increase production, and therefore the introduction of dried cassava chips could broaden demand and create adoption incentives at the farm level.

The formula of integrating cassava utilization, marketing and production aspects in this research has offered the opportunity to use the drying plants (farmers associations) as a vehicle to develop, test and diffuse improved cassava production and management technologies. One methodology to realize this is with "pre-production plots", where a package of technology components are tested and validated on-farm on commercial-size plots in areas were cassava drying plants have been established. An other method has been to directly involve drying plants in the multiplication and diffusion of improved cassava (and maize) varieties, and in stake selection and treatment methodologies.

Although the cassava variety Venezolana wasn't developed by ICA/CIAT, they were instrumental in the diffusion of this Venezuelan variety. As shown in Table 2, Venezolana has been adopted by 91% of the surveyed farmers, covering an average of 73% of cassava planted area. It is striking to see that Venezolana was adopted by more farmers and planted in a larger area in level 1 than in the other levels. It can be assumed that this variety is currently close to its adoption ceiling. Given this adoption level, it is estimated that Venezolana currently covers approximately 44,000 ha in the three principal cassava producing departments of Colombia.

The variety MP12 or locally called Verdecita, "escaped" from on-farm trials during the early 1980's, but wasn't officially released until 1984. Currently it has only been adopted by 5% of the farmers in the sample. It covers 2% of cassava area. The majority of adopters are in level 1 (13%), which can be explained by the fact that diffusion was started in areas with relative high concentration of drying plants and institutional presence and support. In the absence of this (level 3), no adoption has occurred[3]. It is expected that MP12 will gain only slightly more adoption before leveling off, since a very promising variety (ICA-Costeño) has recently been released, which is a highly farmer-preferred variety. Notwithstanding, Venezolana and MP12 together, represent 3/4 of planted cassava area in the sample. The remainder is made up of traditional local varieties.

Table 3 shows the adoption rates of several production technology components. Stake treatment and storage show an overall adoption rate of 10% and 72%, respectively. As was hypothesized, level 1 shows significantly higher rates than the other levels. Stake treatment adoption appears rather low, given that the technology was released in 1980. The major constraining factor in the adoption, has been the technical (and structural) problem of the absence of water in farmers fields after harvesting (the dry season). However, the stake storage methodology, has only been released in 1988, but has demonstrates a very fast adoption.

Increased planting density and chemical weed control are components from a "package", released in 1986 (in Cordoba), which shows a very high adóption rate across technology levels, of 60% and 53%, respectively. Herbicide usage demonstrates larger differences between technology levels than planting density. To a major extent, this can be explained by the increased financial resources needed to adopt herbicide usage, which is relatively easier accessible through cassava drying cooperative credit in level 1. In addition, the higher expected returns from cassava production at level 1 warrant relatively higher input purchases.

Tractor usage for land preparation, as such, has never been an official recommendation. However, cassava drying plants have increasingly made tractors available to (non) members, at cost price, for their private use. In addition, relative labor scarcity, increased cultivated areas and increased cassava revenues have augmented tractor usage. Table 3 shows that an overall 41% of farmers are using tractors for all or part of their land preparation. Even more significant is, that 82% of farmers of level 1 are using tractors, as could be expected from the above reasoning.

The above mentioned technology components are all production focused. As such, one proof of these technology components adoption is the realized change in yield (and of course, the change in cassava net revenues). Table 4 shows an overall cassava yield average of 12.0 t/ha (for cassava/maize intercrop). Given the fact that significant technology adoption has also taken place in level 3, this will not correctly serve as an approximation of a traditional (absolute) base. Hence, we analyzed our present data by department and compare this with

[3] Three levels of technology influence were used for stratification. Level 1 representing high concentration of drying plants and institutional support, level 3 representing low or absence of institutional support and few drying plants.

results from a survey[4] in 1982. The comparison shows that since 1982, cassava yields have increased by 52%, 56%, and 76% in Bolivar, Sucre and Cordoba respectively. In addition, comparing current yield averages with the national statistics estimates (Table 5), we cannot show any significant differences.

Besides the influences of technology adoption on the cassava production system and area, remarkable changes have been observed for on-farm cassava consumption and sales. The data showed, demonstrates that farmers consumed 22% of cassava production on-farm. The majority of this going to human consumption. While on-farm cassava consumption by farm animals is virtually the same across levels, level 1 typically retains less cassava for on-farm household consumption and sells more to the market than level 3 farmers. In other words, cassava farmers in high technology influence areas have become more market oriented.

What is even more striking is that currently 22% of cassava production is sold to cassava drying plants. The remainder is sold to the fresh consumption market. Given the criteria for selection of the different levels, used in this study, it is consistent to observe that level 1 farmers sell twice as much cassava to drying plants than level 3 farmers. Subsequently, the latter still sell relatively more cassava to the fresh market.

Given the strong influence of the cassava drying technology and its demand across technology levels, it would be useful to compare (the little existing) data in time. Table 5 shows a comparison of cassava consumption and sales data between cassava 1982 and 1991. The differences are very significant and consistent with the analysis across levels. It shows that the share of cassava production consumed on the farm has halved during this period. While the production share sold to the fresh market in Cordoba and Bolivar virtually remained the same, Sucre experienced a major decline in this market, from 62% in 1982, to 35% in 1991. The major and most obvious explanation for this is the high concentration of drying plants in this department which is also the reason for the 47% of cassava production being sold to drying plants in Sucre. While Cordoba shows a respectable 24%, farmers in Bolivar sell only 2% for chip production. Compared to 9 years ago, this trend is a very significant proof of the strong adoption of cassava drying technology.

So far this study has shown an analysis of technology components. When looking at overall adoption figures, Table 6 shows that 71% of the surveyed farmers had adopted at least one production technology component. Again, this figure was significantly higher at the level 1. It also shows that 59% of cassava farmers have experienced increased cassava demand and a broader over the last half decade. In order to capture the effect of the introduced technologies, the farmers were asked if they had experienced again in cassava revenues resulting from technology adoption. 80% of the farmers agreed to this statement. The reason for this income improvement could be divided in "better prices", "better markets", and "better production". Better markets and prices captured 83%, while the reason of a better

[4] W. Janssen, 1982, "Produccion, mercadeo, y el potencial industrial de la yuca en los departamentos de Atlantico, Cordoba, Sucre y Bolivar", CIAT mimeograph.

cassava production was 9%. It is especially interesting to analyze these results across levels. This shows that see better prices as importance more farmers at level 3 find better cassava prices important for income improvement than at level 1. The latter farmers showed a relatively higher response for better production. This is very consistent with observed adoption levels. Level 1 farmers have experienced more adoption of production technologies than level 3 farmers.

Impact of Cassava Drying Plants:

Cassava drying plants have caused impact at various levels and for different beneficeries. As shown in Fig. 4, increased market opportunities and more stable prices results at the farm level, in an cassava area increase. In the intermediate run farmers start to adopt production technologies in order to intensify production, resulting in higher productivity. The latter augmented supply under better market conditions improves farmers cassava revenues. In addition, cassava producers slowly change from subsistence farmers to market-oriented farmers. This has shown an effect in less on-farm cassava consumption. At the farm household level, this will gradually change expenditure patterns and diets.

Fig. 4 also shows that the increased cassava supplies will decrease fresh root prices. Given cassava demand elasticity and relative prices of substitute carbohydrates, it is visualized that fresh cassava consumption in the lower income strata of the population will increase. In this manner, cassava consumers are directly benefitting from lower retail cassava prices.

Several studies are underway to analyze the benefit distribution of dried cassava technology. However, it can be shown that currently, the additional value of dried cassava amounts to US$ 7,500,000 per year. In addition, the decreased (partial) reliance of the Colombian animal feed industry on sorghum imports, translates in an annual foreign exchange savings of US$ 5,100,000. Part of this sum represents the government savings on decreased domestic sorghum subsidies (in the form of high support prices), since dried cassava substitutes either imported and/or domestically produced sorghum.

Besides direct and indirect monetary benefits, the cassava drying technology has generated substantial employment opportunities. It is estimated that with current production, approximately 1,263 man-years of labour are being directly generated each year. In addition, cassava drying has produced backward and forward linkages in other industries and services. This is estimated to amount to 252 man-years. Creation of employment opportunities in these marginal cassava producing areas is crucial, since poverty and unemployment indices are most often the highest (as is the case for Brazil, Ecuador and Colombia).

The above measures of technology impact have been relatively easy to quantify. However, additional indirect impact on community welfare, institutional support, and the environment, at this stage can only be described qualitatively. It has been observed that the introduction of cassava drying cooperatives has increased community development in general. As such, cooperatives form an incentive to start other non-cassava related community activities.

Moreover, cooperatives serve as a vehicle for strenghtening local institutional support and technical assistance in the area. Besides, cassava drying activities have sparked a "dialogue" between local institutions.

Cassava, traditionally has always been discriminated against in favor of primary crops like grains, in the allocation of (national) research, extension and credit resources. With the introduction of cassava drying activities, and the subsequent increased institutional collaboration and awareness of the significant benefits and future potential for this crop, cassava is gaining more political "cloud". This will positively benefit future national cassava research and development.

Conclusions:

The successful problem and opportunity identification, and subsequent cassava drying technology development, adoption and impact has been based on well-founded strategies of CIAT's Cassava Program. Keys to success included an integrated and inter-institutional approach combining production, processing and marketing research activities. Also, the development of alternative cassava markets combined with appropriate processing technologies was crucial. In addition, exogenous factors like unbiased governmental policies and the increased urgency for rural development have favoured the outcome.

It can be concluded that improved market opportunities can provide the basis from which sustainable agriculture can be attained. The expansion of demand can link small-scale subsistence farmers to growth markets. As such, generating increased on-farm cash flow, improving farm household wellfare, and augmenting the farmers" degrees of freedom".

Cassava Integrated Projects have proven to effectively serve as a vehicle for diffusing production technology components. Besides, they function as a catylisor for increased community development and non-cassava related income generating activities.

In the aggregate, small rural agroindustries can increase overall rural incomes and employment opportunities. Subsequent improved economic purchasing power creates a demand for basic goods and services manufactured in urban areas. Hence, small-scale rural agro-industries fuction as an important vehicle for overall economic and social growth and development in Latin America.

Bibliography

CIAT. 1987. Guia de estudio: Secado natural de raices de yuca en pisos de concreto. Series 04SC-07.02. Cali, Colombia 48 p.

CIAT/DRI. 1988. El desarrollo agro-industrial del cultivo de la yuca en la Costa Atlántica de Colombia. Proyecto Coopeativo DRI/CIAT, sexto informe, diciembre 1986-noviembre 1987. Cali, Colombia. 31 p.

CIAT. 1991. Cassava Program Annual Report 1991. CIAT, Cali, Colombia (forthcoming).

CORFAS (Corporación Fondo de Apoyo a Empresas Asociativas). 1987. Proyecto de secado natural de yuca, costa atlántica: La asistencia técnica y seguimiento al proyecto. Bogotá, Colombia. 49 p. (In typescript).

Downing, P.J. 1991. "Developing a New Market for Smallholder Cassava Producers: The Experience of the Fondo DRI-CIAT Feedstuff Project in Colombia's Atlantic Coast Region". Project Report, Cornell University.

Janssen, W. 1986. Market impact on cassava's development potential in the Atlantic Coast region of Colombia. Centro International de Agricultura Tropical (CIAT), Cali, Colombia. 357 p.

Henry, Guy. 1991. "Adoption of Cassava Technologies: Constraints, Strategies and Impact" in Trends in CIAT commodities, 1991, CIAT Working Document No.93, CIAT, Cali, Colombia.

Huffstular, Steven. 1989. UAPPY, Evaluación y Recomendaciones. ACDI, San José, Costa Rica.

MacGillivray, I.C. 1984. Mission-end report: Integrated rural development, Córdoba and Sucre, Zone 4, Colombia. Canadian International Development Agency, Bogotá, Colombia.

Pérez S., R. 1989. Experiencias sobre la agroindustria de la yuca en Colombia. In:Pérez Crespo, C.A. (ed.). Metodologías aplicadas a proyectos integrados de yuca: Memorias del Congreso Latinoamericano celebrado en Villahermosa, Mexico, 26-28 October 1987. Céntro International de Agricultura Tropical (CIAT), Cali, Colombia p.21-42.

Vásquez V., F. and Cuero O., J.L. 1987. Manual actualizado de la fabricación de la máquina trozadora de yuca tipo Tailandia. Sección Utilización de Yuca, Centro Internacional de Agricultura Tropical (CIAT), Palmira, Colombia. 46 p.

W.K. Kellogg Foundation, International Center for Tropical Agriculture (CIAT), and the Ceara State Cassava Committee. 1991. Cassava Development: Pilot Project in Ceara, Northeast Brazil. Integrated Production, Processing and Commercialization of Dry cassava Chips for Animal Consumption. Second Technical Progress Report, March 1990 - February 1991. 46 p.

Table 2. Adoption of new cassava varieties[1/] in selected departments of Colombia, by level of technology influence, 1991.

	Average	Technology level 1	2	3
Percentage of farmers planting:				
- Venezolana	91	98	83	91
- MP 12 "Verdecita"	5	13	2	0
- Regional	43	26	59	45
Average area (ha) with:				
- Venezolana	1.8	2.1	1.8	1.7
- MP 12 "Verdecita"	1.1	1.3	0.3	-
- Regional	1.4	0.9	1.7	1.3
Percentage of total cassava area with:				
- Venezolana	73	85	58	72
- MP 12 "Verdecita"	2	4	1	0
- Regional	25	11	41	28

1/ New introduced varieties are Venzolana (M Col 2215) and MP 12 (M Col 1505). "Regional" comprises of several local traditional varieties.

Source: Preliminary results from Cassava Technology Adoption Survey in Colombia, CIAT Cassava Economics, 1991.

Table 3. Adoption of cassava production technologies in selected departments of Colombia, by level of technology influence, 1991.

	Average	Technology Level 1 N=96	Technology Level 2 N=100	Technology Level 3 N=103
		--- % of respondents ---		
Tractor use in land preparation	41	82	20	15
Stake treatment	10	19	5	5
Stake storage	72	82	63	72
Herbicide use	53	69	50	39
Increased planting density	60	65	68	46
Technical assistance	40	61	45	12

Source: Preliminary data, Cassava Technology Adoption Survey, CIAT Cassava Economics, 1991.

Table 4. Comparison of cassava yields (cassava/maize intercrop) between selected departments in Colombia, 1982 and 1991.

	Sucre	Cordoba	Bolivar
Yield (ton/ha)			
1982 study[1/]	7.0	6.8	7.5
1991 study[2/]	10.7	12.0	11.4

1/ Janssen, W., 1982, "Producción, mercadeo y el potencial industrial de la yuca en los departamentos de Atlántico, Bolívar, Sucre y Córdoba, CIAT, mimeograph.

2/ Preliminary data, Cassava Adoption Survey, CIAT Cassava Economics, 1991.

Table 5. Comparison of cassava yield, consumption and sales in selected departments of Colombia, 1982 and 1991.

	Sucre	Cordoba	Bolivar
On-farm cassava consumption[2/] (% of total production)			
1982 study[1/]	34	38	37
1991 study[3/]	17	18	28
Sale to fresh market (% of total production)			
1982 study[1/]	62	53	60
1991 study[3/]	35	57	69
Sales to drying plants (% of total production)			
1982 study[1/]	0	0	0
1991 study[3/]	47	24	2

1/ Janssen, W., 1982, "Producción, mercadeo y el potencial industrial de la yuca en los departamentos de Atlántico, Bolivar, Sucre y Córdoba, CIAT, mimeograph.
2/ This includes both human and animal cassava consumption.
3/ Preliminary data, cassava Adoption Survey, CIAT Cassava Economics, 1991.

Table 6. Comparison of cassava technology components adoption in selected departments of Colombia, by level of technology influence, 1991.

	Average	Technology level 1	2	3
		% of respondents		
Adoption of at least one production technology component	71	85	69	59
Increased demand and broader market	59	71	57	49
Income improvement from cassava technology	80	91	73	75
Reasons for income improvement:				
. better prices	43	33	53	49
. better markets	40	48	26	41
. better production	9	16	7	1

Source: Cassava technology adoption survey, CIAT cassava economics, 1991.