OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

08254

RESTRICTED

DP/ID/SER.B/151
27 April 1978
English

INTEGRATED INDUSTRIAL PROCESSING OF MANIOC

SI/SRL/74/875

SRI LANKA

Terminal Report

Prepared for the Government of Sri Lanka
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of
E.S. Normanha, cassava production and processing expert

United Nations Industrial Development Organization
Vienna

id.78-2305

Explanatory notes

A comma (,) is used to distinguish thousands and millions.

A full stop (.) is used to indicate decimals.

A slash between dates (e.g., 1970/71) indicates a crop year.

References to "tons" are to metric tons, unless otherwise specified.

References to dollars ($) are to United States dollars, unless otherwise stated.

The monetary unit in Sri Lanka is the rupee (SRs). During the period covered by the report, the value of the rupee in relation to the United States dollar was $US 1 = 15.70 Rupees.

The following abbreviations are used in this report:

CARI	Central Agricultural Research Institute
CISIR	Ceylon Institute of Scientific and Industrial Research
IDB	Industrial Development Board

ABSTRACT

The project entitled "Industrial Processing of Manioc" (IS/SRL/74/875) originated in a request submitted in January 1975 by the Government of Sri Lanka for the assistance of the United Nations Development Programme in the processing of manioc and examination of the technical and economic feasibility of manufacturing various products derived therefrom. The request was approved in February 1975, with the United Nations Industrial Development Organization (UNIDO) designated as executing agency, and the Ministry of Industries and Scientific Affairs as government co-operating agency. The three-month mission began in October 1977.

The main conclusions of the report include the following:

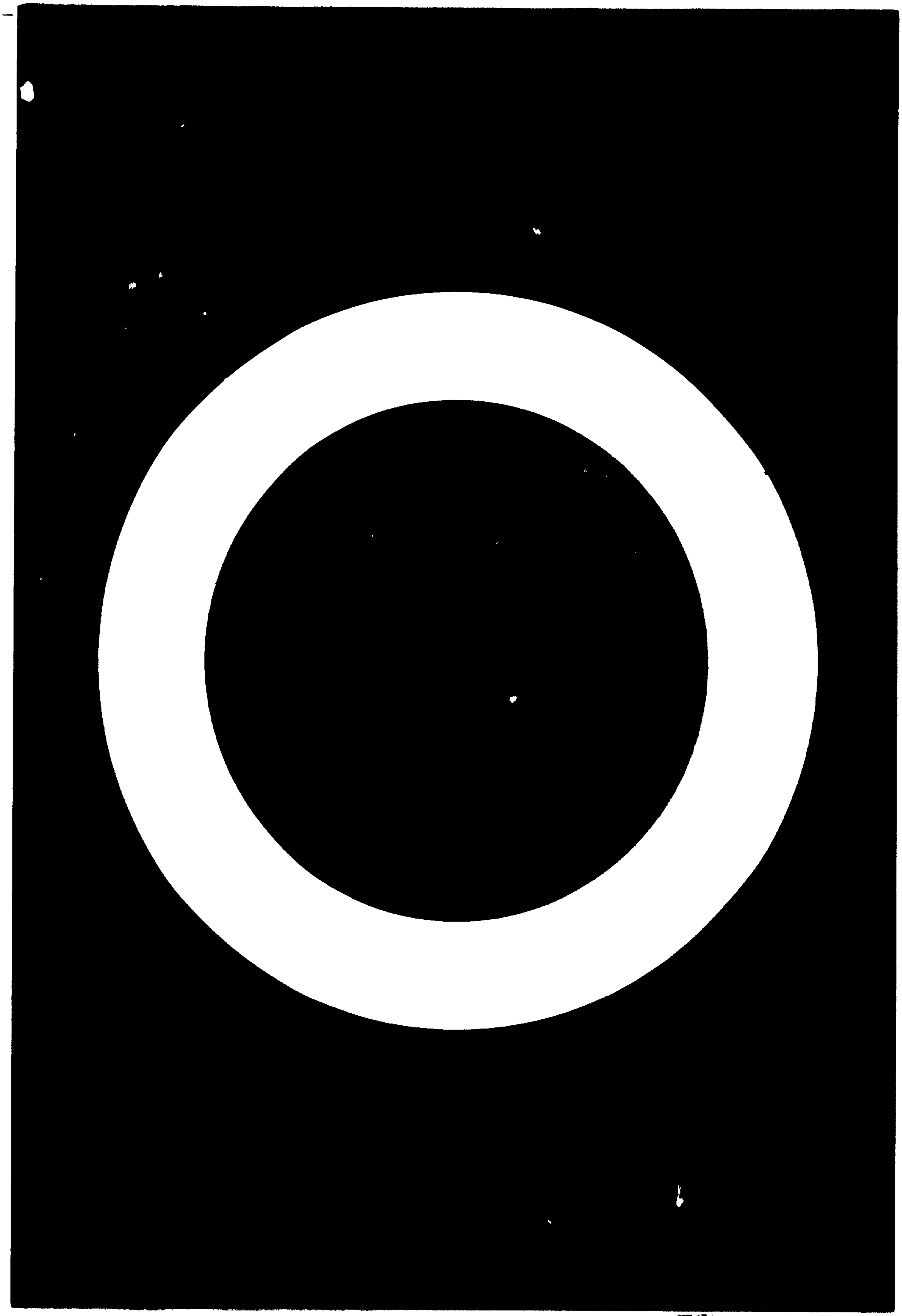
(a) At least six different vigorous wild species of manioc exist throughout Sri Lanka, which, among manioc-growing countries, is one of the producers of the healthiest cassava plants in the world;

(b) Cassava cultivation in Sri Lanka provides a suitable basis for the establishment of a cassava processing industry, with special emphasis on the production of industrial starches.

The following recommendations are noteworthy:

(a) A cassava processing factory should be established using non-sophisticated but efficient and practical equipment for the production of chips, flour and starch;

(b) Coir and paddy husk should be ploughed into compact, hard soils to soften them for cultivation.



CONTENTS

Annexes

Tables

I. INTRODUCTION

The manioc tuber grows easily in most parts of Sri Lanka. Until recently, however, it was not cultivated as a plantation crop and commercially exploited, although it was known that productivity could be increased by the selection of proper strains. The need for increased cassava production became apparent with the development of domestic industries, such as paper, textiles, plywood, food and medicines, which use starch and other cassava derivatives. To meet growing domestic demand for manioc tuber and for products derived therefrom, the Government of Sri Lanka therefore decided to request assistance from the United Nations Development Programme (UNDP) in the processing of manioc and examination of the technical and economic feasibility of manufacturing chips, starch, sago, glucose etc. from manioc. The request was made in January 1975 and approved by UNDP in February 1975, with the United Nations Industrial Development Organization (UNIDO) designated as executing agency, and the Ministry of Industries and Scientific Affairs as government co-operating agency. The project had a budget of $12,450.

The three-month mission began in October 1977, and the expert had the following specific duties to perform:

(a) Surveying the quantities and quality of manioc (cassava) tuber produced in Sri Lanka and determining its current industrial uses;

(b) Examining the economics of cultivation of manioc on a large scale to meet the continuous demand of domestic integrated processing units, and exploring export market potential for manioc products;

(c) Examining the technical and economic feasibility of manufacture of chips and flakes, flour, industrial starch, starch derivatives (i.e syrup, glucose and dextrose), compound feedingstuffs and industrial edible production (needles, crispies etc.);

(d) Working out the economics of production as an integrated agro-industrial complex, and providing all technical information on processes, know-how, machinery requirements, investment costs and layout.

A. Geography and weather conditions

Sri Lanka is an island with an area of 25,000 square miles, or 16 million acres, situated between lat. 6°N and lat. 10°N, and between long. 78°E and long. 82°E, of Greenwich and south-east of India. Despite its insular characteristics and typically equatorial situation, the country surface configuration presents altitudes from sea level up to 6,000 feet, resulting in fairly well diversified climatic conditions.

The central relief, with slopes draining rivers and fountain waters used in rural irrigation, creates two main distinct climatic conditions in the island: the Maha season, during which the winds blowing from north-east to the interior bring rains from November to January to the northern, north-eastern and eastern regions; the Yala season, when the winds coming from south-west bring rains from May to July to the western and south-western regions of the country. The quantity and distribution of rains throughout the year and in the different altitudes vary from zone to zone and are responsible for the warm and humid, warm and dry, dry, and temperate climates which permit the present agricultural diversification. In the main agricultural regions, the annual rainfall fluctuations have a marked effect on the nation's economic life, primarily because when it rains less, rice production decreases, and this cereal is the basic staple food in the country.

Eighty percent of the population of Sri Lanka live in the rural areas which which accounted for 31% of the gross national product in 1976.

B. Crop production

The main agricultural activities in Sri Lanka are based on a small number of crops. The tea (Tea sinensis) plantations covering a total area of about 600,000 acres on the slopes and hilltops of the higher mountains are the major source of earnings in the country's export trade.

The coconut (Cocos nucifera) plantations cover nearly 1,200,000 acres on a wide strip of land all along the sea coast and up the foothills of the lower mountains. Copra (the dried fruit nut), cooking oil extracted from the fruit nut, and coir (the outer husk of the coconut fruit) are important products which also help to improve the balance of payments.

The rubber tree (Hevea brasiliensis), brought by the British from Brazil into Ceylon exactly one century ago, is grown near the coconut plantations along the seacoast and also a little farther to the interior on the sides of the lower mountains, covering an area of approximately 560,000 acres and playing an important role in the country's economy.

Rice, the most important basic staple food of Sri Lanka, is grown almost all over the country, but mainly in the low lands along the coasts and further inland on the flat expanses between hills planted with coconut or rubber crops, and even on the man-made terraces down slopes of humid mountains which drain enough water for local irrigation. Water is frequently taken from artificial dams provided by the Government. The paddy area reaches nearly 1,400,000 acres in the Maha season and about 800,000 acres in the Yala season. The rural population depends heavily on this staple commodity for its general welfare.

Tea, coconut and rubber are the predominant crops and have been up to now the main generators of foreign exchange earnings. But irrigated paddies, almost all of which are under a double-cropping system, have not yet brought self-sufficiency, despite the efforts devoted by the officers of the research and extension services of the Department of Agriculture during the last 30 years. In 1974 Sri Lanka imported 200,000 tons of rice from China.

Many other crops have for years been traditionally grown in the country for internal consumption. A number of them are potentially important for the Government's export programme: cocoa, coffee, bananas, mangoes, pineapple and other tropical fruits, cassava, chillies, pepper and other spices, and a variety of horticultural plants mainly grown in Nuwara Eliya District.

The Government has prepared projects to develop agricultural activities in several export-oriented crops involving also the production of milk and its derivatives, the internal demand for which has been increasing for a number of years. The production of raw material to supply cattle-feed industries is also part of the programme.

II. FINDINGS

A. Manioc production

The growing and consumption of manioc (Manihot esculenta) in Ceylon is a tradition of many years. The plant was introduced in the island about two hundred years ago during the period of Dutch colonization, and was used until recently almost entirely as human food, principally in years or periods of shortages of rice, which is one of the country's main staple food products. Diminishing rice crops are the result of occasional or periodical shortages of irrigation water caused by insufficient rainfall. Food shortages due to insufficient rainfall are not limited to Sri Lanka, having also occurred in Brazil, in Thailand (1977), in the United States, in West Africa etc.

The selection of edible manioc to supplement the human diet during periods when there is a rice deficit may be explained by the fact that the manioc plant is easier to cultivate than other food crops; its harvesting period may be reliably determined from the time when its roots reach their maturity; it is well adapted to the soil and to the climate of the country and, like rice, it is a starchy food and a source of energy and calories, although it is less nutritious in terms of proteins and vitamins. Its selection as a food supplement has therefore been spontaneous and natural. A similar phenomenon has occurred in some Brazilian States, in some African countries and also in Indonesia. Very often in these countries manioc is the only local resource and there is no other option in times of food shortage. Had manioc not been available, another tropical root or tuber crop would probably have been sought for, since no other grain crop would thrive economically in those regions.

Wild species

A finding of considerable importance so far as concerns the ecological potential for the development and expansion of manioc plantations in the country is the existence practically all over the island of at least six different wild species of Manihot observed by the expert in the ten districts visited during his mission in Ceylon: Colombo, Kegala, Kurunegala, Kandy, Nuwara Eliya, Amparai, Batticaloa, Trincomalee, Anuradhapura and Puttalam. Vigorous, healthy, treelike plants of the unidentified wild species can be seen along the edges of paved roads crossing the island, in flat lands or on foothills, and even among the natural vegetation growing wild at an elevation of over 3,000 feet.

Two of the wild species seem to be Manihot glaziovii and M. dichotoma because they show the general botanical characteristics of those species, which have been used by geneticists and cassava breeders of several tropical countries to obtain improved interspecific commercial hybrids by crossing them with M. esculenta varieties (this has been done in Brazil). As this is a "natural gift", their utilization in Sri Lanka for identical purposes is expected to yield better varieties for different uses.

One of the two arborescent species of wild cassava, probably the one similar to M. glaziovii, is used in the villages and in Colombo city as an ornamental and shade tree in gardens and house backyards. Very commonly it is used as a shade tree to shelter rustic shopping tents or huts displayed along country roads, in villages and in the suburban Colombo area. Due to its woody, thick, strong trunk, it is also used to strengthen home fences almost everywhere.

However such Manihot wild species are not native or indigenous to Ceylon. The natural habitat of Manihot species includes some widely separated regions of Central and South America, with more than 100 of the approximately 170 so far known Manihot species being accepted as indigenous to Brazil. It is very likely that the above-mentioned manioc wild species were introduced into Ceylon in the form of seeds brought from Brazil about a century ago, together with the rubber tree seeds, during the British colonization of the island, as it is known that the British were the first to plant this important crop in colonial Ceylon. The colonists must also have considered the advantage of taking with them the seeds of other latex-producing plants, as is the case of Manihot glaziovii, known in English as Ceará rubber, from which Maniçoba, a special type of rubber, was formerly prepared in the north-east of Brazil, for example in the State of Ceará.

Bearing in mind that plants of the genus Manihot develop flowers and then fruits which at maturity open violently, spreading widely their seeds (three in each capsule), it may be easily understood how rapidly they propagate in nature.

Cultivated varieties

The number of manioc varieties in official institutions do not exceed 20, and perhaps no more than five are planted for consumption and for small industries. Almost all of these are edible, non-poisonous varieties.

At the Central Agricultural Research Institute (CARI), Peradiniya, there is a collection of 16 beautiful varieties and a manioc research project involving field trials to evaluate the 16 varieties in eight different localities where the plant material is grown. As most of the varieties were setting plenty of fruits, the expert suggested that all the seeds should be gathered and planted separately so as to obtain new clones as a starting point for the breeding of improved varieties without importing living plant material from abroad, which is dangerous.

Varieties having a tall and straight stem are also used as stakes to fill the spaces between the wooden poles of domestic fences. The long stems are planted along the fence wires very close together in order to provide a strong protection against the entry of small animals. The stems sprout and set roots, standing firmly fixed in the ground. They are also used as fences to delimit or divide private property backyards in suburban and rural areas. When long, straight and woody, the stems also serve to strengthen the laterals of rural carts used in the transportation of cassava roots etc.

This diversity of cassava stem uses can only exist for a fundamental reason: in Sri Lanka manioc plants are not affected by bacterial or mosaic diseases, stem borers or shoot flies. The occurrence of such phytopathological agents would rule out such uses. This factor is of far greater importance in the growing of cassava for commercial uses. In this connection, Sri Lanka and perhaps Thailand have, among the manioc-growing countries, the healthiest cassava plant. But while in Thailand brown leaf spot caused by Cercospora sp and the leaf spider mite may commonly occur in commercial plantations, only the former might have some importance in Sri Lanka. However this cassava leaf disease does not seem to arouse much concern in Sri Lanka. During his mission the expert observed very few spider mites and found thrips to be extremely rare and difficult to detect.

No evidence was found, or is likely to be found, of the leaf eater or caterpillar (Erinnyis ello, E. allope), the stem borers of the genus Coelosternus, the thrips (Scirtothrips sp, Frankliniella sp) and the spider mites (Tetranychus sp, Mononychellus sp), the witches-broom (caused by microplasma), mosaics or virus, and the bacterial blight (caused by Xanthomonas manihotis). All of these are of much importance in Latin America. But the African mosaic, which has also been found in India, the nearest neighbour of Sri Lanka, is probably the most threatening to all cassava-growing countries. This would suggest an urgent need for government legislation in the plant protection sector to prohibit the entry of any kind of living parts of manioc plant from abroad.

The highest-yielding varieties recommended by CARI must be multiplied and delivered to the manioc planters, including the MU-20 variety, which in nine to ten months yielded about 18 to 20 tons of roots per acre in experimental plots.

Production systems

The small holders usually do not plough the soil. When the rainy season starts they dig holes 2 ft x 2 ft x 1 ft and in the loose soil of a small elevated bed they stick two or three separate manioc cuttings in a slanting position so that the hills stay 3 ft x 3 ft apart.

Sometimes weed control is very difficult. Generally three hoe weedings are practised. Cuttings are commonly somewhat thin and small. As a rule, mature and healthy cuttings eight inches long and almost one inch thick should be used.

Intercropping should not be done, especially in very densely planted coconut, since shaded places are not good for manioc production. In this connection, in coconut plantations the intercropping of arrowroot (Marantha arundinacea) should be tried by planting about 10 rows of it between the coconut rows at 2 ft x 2 ft apart. Arrowroot requirements in respect of sunlight intensity are not so high as those of manioc plants. On the other hand its starch qualities and digestibility are, for human consumption, much better than those of manioc starch. The United States would be a very good market. CARI, in Peradeniya, could supply the initial planting material.

As compact soils become hard during the dry and hot season, which may last from six to eight months in the dry zone, root digging is almost impossible during this period, unless some soil conditioning agent, such as paddy husk or coir, abundant in many places on the island, is incorporated. Manioc is only harvested at the beginning of the second rainy season, 11 to 12 months after planting. Manioc is harvested for human consumption five to six months after planting, but root yield is much less. It is generally accepted that 12 tons of roots per acre could be harvested in one crop year, but 2.5 to 6 tons/acre may normally be expected, the final result depending on several factors.

Acreage and main growing districts

The small areas planted with cassava are disseminated practically throughout the country, except in higher altitudes where the climate is less favourable. The cassava acreage in Sri Lanka accounts for an estimated 3% of world output.

Some statistics reveal the relatively large extension of the manioc crop in Sri Lanka. It is officially estimated that in 1973/74 some 834,000 tons of roots were obtained from about 225,000 acres.

In "An appraisal of Manioc in Ceylon", by S.N.U. Fernande, it is stated that from 1964 to 1969 cassava aareage in the Maha season (see chapter I, section A) was rather larger than that of the Yala season (see chapter I, section A), as reflected in table 1 below.

Table 1. Cassava crop statistics

1964 to 1969 (seasons)	Acreage	Yield	
		Tons	Tons per acre
Maha	80,400	189,100	2.35
Yala	68,100	169,000	2.48
Total	148,500	358,100	2.41

Manioc has been rather intensely cultivated in the districts of Anuradhapura, Colombo, Kegalle, Kurunegala, Matara, Moneragala and Ratnapura, each one having an area of over 3,000 acres of manioc. For a national production estimated at 551,000 tons and a cultivated area of 145,000 acres, the highest-yielding districts in 1974 were as follows:

	Yield (thousands of tons)
Colombo	60
Kurunegala	78
Ratnapura	70
Total	208

In 1974/75 the country produced 754,000 tons from 195,000 acres, which means a higher gross output from an expanded area due probably to an increase in internal demand. In 1975/76 during both the Maha and Yala periods the figures for the most important districts were as follows:

	Yield (thousands of tons)
Colombo	110 (60 in 1974)
Kurunegala	284 (78 in 1974)
Monaragala	100
Ratnapura	171 (70 in 1974)
Total	665

for a national production estimated at 1,250,000 tons.

The country's manioc yields for three consecutive years are given below.

	Yield (thousands of tons)
1974	551
1974/75	754
1975/76	1,250

There has thus been a pronounced increase in production from year to year, which may be attributed to the reaction of producers to internal market demand involving all uses of manioc.

According to official statistics, manioc is more extensively cultivated in the districts listed below:

Amparai	Jaffna	Matara
Anuradhapura	Kandy	Nuwara Eliya
Badulla	Kegalla	Puttalam
Batticaloa	Kukutera	Trincomalee
Galle	Kurunegala	Vavuniya
Hambantota	Mannar	Walawe
	Matale	

Climate in some manioc-growing regions

In general, only in those regions over 3,000 ft above sea level or where it is too dry does the manioc crop fail to thrive in Sri Lanka. As a rule, the average temperature of producing areas is around 80°F (26°C), and environmental conditions for the manioc life cycle have been generally found satisfactory not only in the dry zone, where it rains from 50 to 75 inches a year and there is a dry, hot period of about six months, but also in the wet zone, where it rains over 100 inches a year and there is no dry period.

The total rainfall in the manioc-growing areas is good enough, but in many of them the rain distribution is bad. It rains very satisfactorily during three or four months following a hot and dry period the rest of the year. The soil becomes dry and hard, making root digging very difficult and expensive. This is the case in some places in Anuradhapura, Batticaloa, Chilaw, Polonnaruwa, Puttalam and Vannativullu.

The annual rainfall of some manioc-growing regions is shown in table 2.

Table 2. Annual rainfall in selected manioc-growing regions

Region	Annual rainfall (inches)	
	1976	1977
Anuradhapura	47.08	129.36
Batticaloa	62.10	27.63
Chilaw	51.89	79.37
Kurunegala	64.83	123.25
Polonnaruwa	77.67	41.72
Puttalam	35.35	107.37

At least for the six localities named in table 2 the figures show a marked difference from one year (1976) to another (1977) in the annual rainfall recorded. Higher figures were recorded in localities in the western part of the island or during the Yala season.

In the so-called wet zone, mainly in the eastern central region, the rain distribution throughout the year is much better and more favorable to manioc growing. On the other hand, land and labour are more expensive; the density of population competing for land use and food is greater; the availability of agricultural land is restricted; and the competition of more profitable crops comes into play. Such factors therefore play an important role in holding back any attempt to expand manioc commercial areas beyond the actual scattered small plantings on marginal lands. In this region the Yala season predominates.

Nevertheless, in at least 13 localities of the wet zone small industrial starch units were set up, some of them making sago but using a raw material (manioc roots) brought from distant sites where there is still some land available for planting. Such transport of a raw material with from 60% to 65% water will result in excessive costs of the industrial product in the form of starch, sago and manioc flour.

In the dry zone during the Maha season, as pointed out above, the biggest drawback for manioc, from the point of view of climate is the long dry period of the year under soil water deficiency due to the lack of rain. But despite such climatic conditions in the dry zone, it is worthwhile to carry out a long-term study of what could be called a potential manioc belt, comprising the areas along the line from Batticaloa through Polonnawura and Anuradhapura, extending on to Puttalam, most of them under the Maha season, and where large, non-continuous areas must be surveyed as a vast potential site for future cassava agro-industrial activities.

B. Industrial manioc

Prior to 1970, probably no official initiative had been undertaken in Sri Lanka to stimulate a cassava-based industry in the country.

The early 1960s saw the start of the development of some of the domestic industries, such as paper, paperboard, textiles, food and medicines, plywood and other, which use starch and its derivatives. To meet the requirements of those industries, Sri Lanka had to import starches, glucose, adhesives, glues and sago (some of these are still imported). None of them was produced in the island. But soon the need was felt to achieve self sufficiency in those items, thereby reducing import costs and stimulating employment in the rural and urban areas.

Statistics provided by the Industrial Development Board (IDB) of the Ministry of Industries show that in 1973 and 1974 the country imported, respectively, 223 and 6,300 tons of starch (probably maize starch) for different purposes, and 225 and 1,751 tons of glucose.

In 1975 and 1976, respectively, 1,773 and 10,154 tons of adhesives and glues were imported.

The National Textile Corporation, taking into account the starch requirements for the activities of its associated members, requested from the IDB the promotion of incentives schemes for the production of manioc starch in the country.

Subsequently, in 1974, the IDB surveyed 48 small holders producing manioc starch throughout the country and approved eventual financial assistance for 32 of them. But it is thought that a higher number of such units may exist in the island. Interest in the production of industrial manioc has therefore risen in Sri Lanka.

The earliest cassava derivatives to attract attention on the domestic market were pure starch and manioc flour (milled chips), with a view to their use in the textile, paper and food industries. Thus, starch consumption by textile industries in 1974 was estimated at more than 1,000 tons, and according to IDB statistics, starch consumption by textile, spinning and weaving mills, and in the battery, match, pharmaceutical and paper industries, is estimated at over 1,800 tons.

An increase in starch production by private initiative has been achieved, in most cases by using the same unsophisticated equipment and methods formerly employed. However, despite their technological simplicity, such equipment and methods at least provided a range of resources and workable systems. In this connection, it should be noted that official technicians are well aware of manioc technology, some of them having been trained abroad.

Starch extraction

Not only the acceptability of manioc plant in the country, but also the ease of extraction of its starch component has made possible its manufacture in rural areas.

In the simplest units roots are washed and peeled and bark is removed with knives. Rasping of the pulp is effected by pressing it against a rotating cylinder which is driven manually and provided with a metal surface with sharp protusions made by piercing it with a nail. The pulp slurry is thoroughly washed with clean well water by shaking it when spreaded on a fine metal screen. The starch milk is received in a metal drum, and settles in a few hours. Water is removed and new clean water is added to suspend, agitate and wash the staroh. After a second settling and water revmoval starch is spread and sun-dried on a cement floor for two or three days. Dried starch is stored in cotton or polythene bags. While some industrial units deliver their starch in the granulated form, others mill and sieve it into a fine flour.

The starch thus obtained presents fine, coarse and granulated fractions. Its color is not so white, being sometimes rather yellowish. Dirt, foreign matter and specks can easily be detected by suspending a small sample in a glass with water.

The need for a small unit to process manioc roots depends on whether there is likely to be sufficient sunshine to dry the starch in the open air. The expert saw one such unit in Vanativullu, about 12 miles from Puttalam. Its capacity is far less than one ton of roots per day.

This poor quality starch still serves for sizing warp yarn, where the main requirement is high viscosity, which must be at 90°C. The major inconvenience of the starch is the presence of soluble and insoluble impurities (colloids, specks, sand) that increase ash content and adhere to the surface of the squeeze rolls, where the yarns coming from the size box and wetted by the viscous and hot liquid are stretched before entering the drying chamber.

Some still infant starch industries adopt better equipment, such as a motor-driven rasper provided with saw-tooth steel blades, but additional operations, as already mentioned,are required.

In Pullumalay, district of Batticaloa, the supervisor of the Eastern Technical Institute (ETI), a private organization for industrial training of local workmen, took the initiative to make a simple and portable set of equipment to extract, wash and dry manioc starch. The equipment may be easily carried from one to another manioc plantation belonging to different families. About Rs 300 per ton are paid for the roots. The working system is the same: manual grating, iron-drum settling and sun-drying in metal trays. The product is bagged, tranported to ETI, milled and sieved with a one-hundred-mesh screen. The starch is white, fine and of good quality. The rate of extraction is six kg of roots to one kg of starch with 12% moisture. The National Textile Corporation, a government industry in Pugoda, uses this starch in the warp sizing phase at the rate of 12.5% of its weight.

The domestic cassava starch for textiles is much more expensive, costing perhaps twice as much as the imported one (selling prices vary between Rs 5,000 and Rs 8,000 per ton), but its use enables the country to reduce the cost of its foreign trade.

Technology improvements

Certainly the small-scale starch producers will improve the standards of their equipment and product quality if they are encouraged by market and starch prices and if they are given the necessary official financial aid and the benefits of technology transfer. In order to assist the starch manufacturers, the IDB took the initiative to create among them the Manioc Starch Manufacturers Association. With the same end in view, the Government, through the District Development Council, established at Nikawiratiya a low-capacity starch factory equipped with more adequate machinery. In this factory manioc roots are washed and peeled by hand. The machinery includes a motor-driven rasper having a hopper and a perforated metal plate as the grating piece, and two vibrating sieves holding sixty-mesh metal screens. The slurry pipes come out through two distributors, one over each sieve, with abundant clean water addition to take the starch milk off to the cement settling tanks in the open air. The starch is sun-dried.

The regional office of the IDB for Badulla, Moneragala and Nuwara Eliya at Badulla is one of the extension services units intended to assist agriculture-based small industries. IDB officers are preparing a starch project like that at Nikaweratiya for the Bibile Kotagama Co-operative Society Ltd, which with official financial aid will make starch for textile and paper industries. The capacity will be two tons of roots per day, with 225 work days a year. Initially the roots will be brought from six miles away, since so far no one is interested in manioc planting in the surroundings.

In Kosgama a manioc starch co-operative is also equipped with more adequate machinery. Roots are as always washed and peeled by hand. The available machinery includes the following: one motor-driven rasper, a motor driven vibrating screen, a cement tank for starch settling, a simple centrifugal separator, and a drying chamber where heat irradiates from a central metal tube and on whose walls the starch is displayed on wooden trays. Drying takes 24 hours, and the granulated starch is triturated in a motor-driven mill, followed by sieving in a 100-mesh screen. The product has a good appearance, is white in colour and seems to be of good quality. It is sold at Rs 500 per ton. The unit works three tons of roots a day, and these cost Rs 25 per cwt (112 lb).

In Pugoda the firm of Laksam Mills is engaged in several commercial activities involving products such as laminated rubber and rice. During the off-season for rubber and rice the building, space and labour are used to make manioc starch with equipment adapted for this purpose. As the raw material is not produced in the region, the roots are brought from Chillaw and Puttalam, 40 to 50 miles away. The starch is sold to the National Textile Corporation, located near the factory. Motor-driven equipment and plenty of hand labour are used concomitantly.

The roots are washed, peeled and sliced by hand. Slices of roots are mechanically pressed by using foot and hand-controlled tools against a motor-driven (three hp) rasper. Two persons work here. The coarsely-grated pulp collects on the floor since the grater is at floor level. From here it is carried by hand for a second and finer rasping in two motor-driven raspers (10 hp each) with a manual addition of a very small amount of water. Two persons are required for each rasper. The second grated mass gets directly into an iron drum and is transported manually to two vibrating sieves (60-mesh, motor-driven) with an abundant spraying of water. Four workers manually assist in the pulp slurry agitation in order to improve starch liberation. From here the bagasse is carried back to the second rasper to improve starch extraction.

The humid starch, after settling in cement tanks, is sun-dried on gunny bags on a cement floor. After drying it is ground in a motor-driven mill and stored in 100-kilogramme polythene bags.

When the volume of the grated mass is large enough it is stored in deep cement tanks where from one day to another lactic and butyric fermentation takes place, thus impairing the quality of the product, giving it a yellow colour, acidity and low viscosity.

In the processing phase there is no mechanical transport device, and about 15 women are employed in this and other services. The distance between the first and second raspers is about 30 ft and there are about 40 ft between these and the vibrating sieves, thus requiring more time and hand labour in the internal transporting.

There is some oonfusion in the working system. There is no clean condition and a lack of hygiene prevails. The available equipment oould be better used. But this may not be possible when they need to use all the roots coming from a considerable distanoe.

Manufacturing units

In connection with starch manufacture in Sri Lanka it might be said that there are three different industrial patterns: small-size, low-capacity installations where all operations are carried out by hand (unsophisticated working systems); small-size, low-capacity installations with some mechanical operations but no motor-driven equipment (also unsophisticated working systems); small-size, low-capacity installations with some motor-driven operations and better equipment.

In all of them washing and peeling of roots are done by hand, probably owing to the local availability of labour. The starch is extracted only out of the pulp (central cylinder). In Brazilian industries, where labour is more expensive, the mechanical washing and peeling of roots removes only the outer brown or white skin.

The expert observed one case of saw-toothed blades being used in raspers. They are much more efficient in disintegrating the roots into a very fine pulp slurry, thereby improving the extraction of starch granules. But certainly this kind of machine is expected to be used only in better equipped starch plants.

Laksam Mills, at Pugoda, seem to have the best screening equipment fitted with abundant and well-distributed spray water to wash the pulp slurry under vibrating movements.

Cement tanks do not seem to be better than wooden settling tables when starch can be previously washed by suspension in clean water. Also, under open air conditions, as is mostly the case, starch is more easily contaminated by sand, specks, micro-organisms and other dirts from the air and surroundings.

The starch units with the exception of that at Kosgama, where starch is dried by radiant heat, only use direct solar heat on the starch spread over cement floors. This is less expensive when starch specifications are not so high, since quality control is difficult in sun drying.

Apparently none of the industrialists utilize the residual pulp after starch extraction. It can be used for animal feed stuffs, incorporating a certain proportion in the manioc meal (farinha), and blending with ground ohips to make pellets as in Thailand.

When necessary, starch cleanliness, colour, purity and rate of extraction may be improved by grinding the residual pulp from the first 60-mesh screen in a second strong and efficient desintegrator, and sieving all the starch milk thereafter in a sequence of more effective 80, 100 and 140-mesh screens. For Sri Lankan textile industries this has not yet been achieved, although it is probably desirable. Indeed starch quality produced in the country varies too much from one unit to another, and lacks the desired specifications for that purpose. The utilization of better equipment and processing to improve starch quality will certainly be imposed when this commodity becomes usable for human food, high-grade paper, pharmacology, modified starches, glucose and dextrins.

Some of the IDB specifications for industrial starch are: 98% dry starch; 15% maximum moisture; 0.4% ash; 0.61% crude fibre.

Of all kinds of starch observed and examined by the expert in the small factories visited, none presented the peculiar creaking sound and harsh texture of a very good starch when the bag is compressed by the fingers.

C. Other manioc products

In Sri Lanka the ground dried whole root is called manioc flour and corresponds to "farinha de raspas" in Brazil or "gaplek meal" in Indonesia and Madagascar, and can also be called "tapioca meal" in contrast to "tapioca flour" or "tapioca starch". In Sri Lanka manioc flour processing is designated as "dry milling", in contrast to manioc starch processing, which is known as "wet milling".

Manioc flour, which is also sieved after grinding, is being tested in textile industries, since it is cheaper (Rs 3,000 per ton) than pure starch (Rs 5,000 per ton). But for this use it has to have a low fibre content.

In Brazil manioc flour, or milled chips (farinha de raspas), has been used since 1940 mixed with wheat flour at about 5% or 10% for bread-making, or even more for pastry. At present the mixture is not being used regularly. The economic feasibility of such a procedure in Sri Lanka could be tried, since wheat imports may exceed 300,000 tons a year. This commodity could also be used in feedingstuffs, as is the practice in the European Economic Community, where it is employed as a substitute for maize corn or barley, and in Brazil, where it serves as a partial or total substitute for maize corn when this cereal costs too much.

The Ceylon Institute of Scientific and Industrial Research (CISIR) has a research programme on manioc technology. One project deals with improving chips and manioc flour qualities and decreasing their hydrogen cyanide (HCN) content, since traditional methods of sun-drying do not totally remove the poison (HCN). However the recommended method is more difficult, expensive and long-lasting. The roots undergo hand-washing and peeling, thin slicing, sun-drying for three days on wooden, metal or polythene trays, then a remoistening in water for eight hours, followed by sun-drying for two days when the chips reach 14% moisture, and immediate oven drying at 100°C for two hours when they have 6% or 8% moisture. The product is stored in polythene bags to be milled into a flour which may be mixed with wheat for bread-making. The product is also being studied for use in the production of textiles and dextrins.

The expert considers that the detoxication of chips, milled chips or manioc flour is not achieved in Sri Lanka following traditional methods of immediate sun-drying only because the sliced fresh roots are not pressed, as is done in Brazil, to remove excess water and facilitate oven or sun-drying. Hot air temperature in the drying chamber oscillates between about 60°C initially and about 100°C at the end during a period of 10 to 15 hours.

During the pressing phase at about 2,500 p.s.i. for 10 minutes, the hydrolysis of the cyanogenetic glycoside is accomplished with its HCN liberation. Its presence in the ambient air is easily detected near the press in the factory by its odour, because most or a large portion of its is taken away with the root "green waters" expelled during pressing. During drying the rest of the poisonous gas volatilizes. Near the drying equipment the presence of HCN gas in the air can also be smelt. But as far as is known, no fatal case or personal damage has been recorded as a result.

On a commercial scale, therefore it will be easier, faster, more economical and more suitable for human food if the Brazilian system for detoxicating cassava root flour is used for poisonous varieties. However, the pressing of manioc chips adopted in Brazil is designed to remove excess water and facilitate drying. The starch accompanying the green waters is recovered.

The expert has not found mention of high pressure detoxication of manioc chips and flour in the literature on the subject. In the course of his research the expert has found that the poisonous varieties liberate practically all their HCN content by the action of autochthonous enzymes if their pulp slurry is allowed to macerate for 24 hours. But volatilization of the gas only takes place through proper heating. In this connection, it should be noted that in Brazilian rural areas it is widely known that animals, mainly horses that occasionally drink the "green waters" flowing in the manioc pressing operation, die in a few hours.

Sago, in the form of small, white, spherical granules, are a manioc starch-based product, the outer surface of which is more or less gelatinized. In Sri Lanka it has been imported for human consumption, but can be used for textiles and adhesives. Manioc starch-based sago is the substitute for the genuine original sago made with a starch from the pith of certain palm trees, such as Metroxylon sagu and M. rumphii.

In 1962 Sri Lanka imported 3,360 tons of sago costing Rs 895,000. Thereafter it was produced in the island, though not competing in price with the similar imported article. It is said to be produced at present in sufficient amounts by small holders using their own very simple home-made equipment. It is estimated that about 1,000 acres of manioc should be planted to meet sago domestic demand.

In 1977 sago prices oscillated between 15 and 20 Rs/lb. Indonesia and Malaysia are the main producers, and Australia, France and the United Kingdom are the main markets.

In order to have a high-grade sago the starch must be white and possess the lowest fibre and ash contents. In general, in producing sago the moist starch cake is coarsely pulverized and granulated (there are different systems for doing this); and the granules formed are size-graded by screening (there is different equipment for this), and then toasted in shallow, flat or round pans for about 15 minutes, moving on trays with a thin film of coconut oil. The outer layer of the granules will gelatinize and get a smooth texture. Further drying is accomplished with a hot air stream.

As the name "manioc pellets" has been proposed in Sri Lanka for "sago", the expert suggests that the traditional name "sago", or "tapioca sago", or, as it is called in America, "tapioca pearls", should be maintained for the common product, and "tapioca seeds" should be used if the granule size is very small. When the granules are not spherical but irregular in shape they are "tapioca flakes". This suggestion is based on the fact that "manioc pellets", or "cassava pellets", or simply "pellets", have in recent years been the manioc derivative with the largest international trade, involving over three million tons a year. The foremost exporters are Indonesia and Thailand, and the major market is the European Economic Community. Then cassava pellets are sliced and sun-dried roots made into small sticks about 5 mm to 8 mm in diameter, and 20 mm to 30 mm in length, by compression and extrusion processing.

In 1962 Sri Lanka imported 3,103 tons of powdered and liquid glucose for food industries at a cost of Rs 870,430. Research work is now being done by CISIR to obtain glucose from manioc starch by saccharifying the latter with Aspergillus niger. So far a conversion of 80% of not very high-grade liquid glucose has been obtained.

Corn starch and potato starch are the main raw materials so far used throughout the world to make glucose. In Japan sweet potato starch is employed. In Brazil corn starch is the major source, but there is one glucose factory in the north-east of Brazil using manioc starch with success. If necessary, the know-how may be easily obtained.

Dextrin production is also a matter of interest in CISIR laboratories. So far there is a factory producing dextrin for labelling purposes, and which works with CISIR-transferred know-how.

Modified starches are also imported for industrial uses. In CISIR laboratories they are being obtained experimentally with manioc starch.

D. Basic research on manioc poison

In connection with cassava toxicity CISIR has reached the following important conclusions:

(a) Ginger (*Zingiber officinale*) tuberous roots and manioc roots when eaten together may intoxicate through inducing manioc HCN liberation;

(b) Old manioc roots contain higher percentages of the cyanogenetic glycoside and are potentially more dangerous than fresh roots;

(c) Guava leaves, an antidote for cassava poisoning in rural areas of the country, contain an inhibitor which prevents HCN liberation.

These conclusions are very much important as additional knowledge about manioc toxicity. The following comments on these conclusions seem necessary:

(a) If the cyanogenetic glycoside level is not high enough to cause intoxication, ginger addition would not induce total HCN increases. But if the level is high enough to intoxicate ginger addition may accelerate HCN liberation and the development of symptoms of poisoning. On the other hand, the presence of ginger may help the actual potential level of intoxication when other natural hydrolysis agents are deficient or absent;

(b) Very probably the total amount of the cyanogenetic glycoside does not increase with time after digging. Fresh roots immediately after digging and old similar roots (some days after digging) are expected to have the same, identical quantity of the glycoside, but the older ones may have a higher percentage of HCN already liberated by autochthonous enzymes than the fresh ones before cooking. If this is true, as the expert thinks, the old roots after cooking in boiling water may show less HCN content than the similarly cooked fresh ones if the time of maceration and the hydrolysis agents are the same;

(c) In connection with the inhibiting action of guava leaves on HCN liberation in poisonous manioc roots, the expert considers that such an agent is the tannin component which, being astringent, coagulates proteins, thus inactivating the enzymes.

The expert has found in his laboratory research that poisonous cassava roots having 30 mg to 35 mg of HCN per 100 g of fresh pulp may retain almost all their HCN content after being cooked in boiling water, or, in other words, boiling water does not destroy the glycoside. This explains the cases of human poisoning due to eating cooked poisonous manioc roots.

III. RECOMMENDATIONS

1. As apparently no serious manioc diseases or pests are present in Sri Lanka, the Government should enact laws prohibiting the introduction of any kind of living manioc plant material from abroad, except in the cases of certified true seeds or officially-introduced tissue culture derived from cuttings of recommended superior clones.

2. With a view to increasing and improving manioc germ plasm in the country, which has only a few known varieties, a manioc breeding programme should be drawn up covering the following plant types: the wild Manihot species growing in the island; the existing varieties in the CARI field collection. The programme should include intervarietal and interspecific crossings under control, besides open pollination among the superior varieties.

3. In view of the fact that more than 11 million people live in the rural areas and that manioc is used as human food, the above-mentioned breeding programme should aim at obtaining edible varieties that are better-yielding, early-maturing, richer in protein and yellow-pulped. The latter characteristic is related to carotenoids or provitamin A contents.

4. The production of higher-yielding and better-adapted varieties for the different industrial uses and for feedstuffs, mainly for dairy cows and pigs, should be considered.

5. With regard to cultivation, if the soil cannot be ploughed it should be loosened to become soft and aerated to a depth of 8 in. to 10 in. in every hill site for planting, or to provide narrow ploughed strips of land for the future rows of plants. If necessary, this would be the occasion to plough in any type of economically available organic matter, or coir or paddy husk into compact, hard soils in experimental areas. Eight-inch-long, mature cuttings should be used, planted 3 ft x 3 ft apart in the traditional slanting position or horizontally, and covered by a three-inch layer of loose soil.

6. Taking into account the existence of an apparently favourable region for manioc production along the line from Batticaloa through Polonnawura, Anuradhapura to Puttalam, mostly used during the Maha season, a long-term agricultural research programme should be outlined with a view to obtaining agronomical information based on field trials.

7. In order to improve manioc industrial processing methods, non-sophisticated but efficient and practical machinery and equipment should be used for manufacturing high-grade chips, milled chips or manioc flour and starch, since these commodities may have a market in the country. A list of the necessary equipment is included in annex II. If necessary, IDB officers will provide further information concerning installation.

8. As trained technical personnel will be required in manioc industries, Sri Lankan technicians engaged in the development of manioc processing should be given the opportunity to study abroad at suitable institutions offering training in manioc technology.

9. In order to meet an urgent need, should one arise, to manufacture in Sri Lanka essential starch derivatives imported by the Government or private enterprises, such as modified or oxidized starches, pregelatinized starches, dextrins, liquid and powder glucose, and other starch derivatives, the necessary know-how should be obtained from abroad.

Annex I

VISITS INCLUDED IN PROGRAMME OF ACTIVITIES

Bodies, institutions and establishments

Bibile Kotagama Cooperative Society

Botanical Garden, Peradiniya

Central Agricultural Research Institute, Peradiniya

Ceylon Institute of Scientific and Industrial Research

DDC Manioc Starch Factory, at Nikawiratiwa

Eastern Technical Institute, Batticaloa

Farm Women's Agricultural Extension, Peradiniya

Industrial Development Board, Colombo

Laksam Mills, Pugoda

Manioc Starch Cooperative Society, Kosgama Village

National Paper Mills Corporation, Valachchenai

National Textile Corporation, Pugoda

Nikado Trading Company (Papadam), Kadawata

Regional Office for Badula and Moneragala, at Badula

Localities

Anuradhapura
Badulla
Bandarawela
Batticaloa
Bibile
Chilaw
Kadawata
Kandy
Kegalla
Kosgama
Maradankadawala
Minneriya
Nikaweratiya
Peradeniya
Polonnaruwa
Pugoda
Pullumalai
Puttalam
Vannativullu

Annex II

EQUIPMENT SPECIFICATIONS FOR A CASSAVA-PROCESSING PLANT

The list below contains equipment specifications for a cassava-processing factory for the production of cassava chips, flour and starch, with a capacity of 1,000 kg/day of chips or bread flour or 500 kg/day of starch, plus around 500 kg of animal feed (from peels, leaves, branches and bagasse)

Equipment

Rotary washer-peeler, model 2, 5-hp motor

Small cart to receive product from the washer-peeler

Rotary chipper to cut the roots, 5-hp motor

Bucket elevator, 4 m long, working with motor of the chipper (type 400)

Hydraulic press, model 2, 3-hp motor

Extra basket for the press

Bucket elevator to feed drier, 5 m long, 1-hp motor (type 400)

Cassava drier, model 1, 7.5-hp motor

Two furnaces, heat exchanger type, to supply pure hot air to drier, supplied with metallic parts, suitable for burning wood, masonry to be built locally by buyer

Bucket elevator to feed the mill,5 m long, 1-hp motor (type 400)

Two hammer mills with cyclone, model 2, 10-hp motor

Two centrifugal nylon screens (with filter), model 2, 3-hp motor

Rotary grinder No. 2, combined with depurator to separate the liquid starch, 5-hp motor

Pump for liquid starch, 10-hp motor

Decantation tanks, to be built locally by the buyer

Agitator to clean the starch, model 2, 1-hp motor

Centrifugal turbine, model 3, for the partial elimination of the water of the starch, 10-hp motor

Drier, tunnel 8 m long, 7.5-hp motor

Two bucket elevators, 4 m long, 1-hp motor (type 400)

Pulverisating mill model 1, with 10-hp motor

Disintegrating mill for branches and leaves, model 2, 5-hp motor

Continuous roaster suitable for burning wood, model 1, 8 m long, 5-hp motor

Feed mixer, model 1, 2-hp motor

Spare parts for two years operation

Accessories: axles, pulleys, belts, screws etc.

Bibliography

Ceylon Institute of Scientific and Industrial Research. A process for improved manioc chips and flour.

Fernando, L.J. Some notes on the potential for the organized exploitation of manioc in Ceylon.

Fernando, S.N.V. An appraisal of manioc in Ceylon.

Herath, H.M.P. Manioc starch, flour and their standards.

Ministry of Agriculture and Lands. Agriculture implementation programme. Working document. 1975/76.

Nijholt, J.A. Report of the survey on cassava production processing in Ceylon.

Pharmapala, W.A. Sago production.

Wholey, Douglas W. Versatile cassava is at home in Asia.

G-13

79.11.14