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AGRI-BUSINESS PROJECT PROFILES

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For

THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

And

THE CARIBBEAN DEVELOPMENT BANK

March 1980

This document does not assume the approval (nor imply such) of the United States Agency for International Development, the Caribbean Development Bank or any of their officers.

AID/LAC-C-1364

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SUMMARY

This report contains descriptive profiles of seven specific agri-business investment opportunities in the Eastern Caribbean region. These descriptive profiles were prepared as part of an on-going effort by the Caribbean Development Bank (CDB) and the USAID Regional Development Office/Caribbean (RDO/C) to increase agri-business investments in the region. In particular, it is envisioned that these projects will be appropriate for loan financing from CDB Agri-Business Development Fund, established with the assistance of USAID Loan 007.

The seven project profiles presented here include agricultural marketing, processing, and service enterprises. All of these projects are private sector or joint private/public sector ventures. Two of the seven are located in St. Vincent and the remaining five projects are located in St. Lucia. The total estimated loan funding requirements for all projects amount to EC$5.3 million (US$2.0 million).

The next step to move these projects forward is for CDB management to decide if an in-depth project appraisal is appropriate in light of CDB policy and the probability of project success.

It is believed that the profiles presented here are sufficient to enable CDB to prudently make this decision.

A brief summary of each project profile is presented below.

A. RIPE BANANA MARKETING

The purpose of this proposed project is to ship, ripen, and sell 50 tons of St. Vincent bananas in Trinidad each week on a routine basis. This project requires relatively modest investment in fixed capital, and relatively large investment in inventory capital. The estimated loan required is EC$300,000 for a one year period.

B. ARROWROOT INDUSTRY RESUSITATION

This is a proposal to double the volume of arrowroot starch exported from St. Vincent within a five year period. It proposes substantial changes in the structure and conduct of the industry, and will involve investment in both the physical infrastructure and organizational development. The estimated loan required is EC$3,000,000 for a fifteen year period.

C. MULTI-LINE FOOD CANNERY

This project's purpose is to establish a food canning operation in St. Lucia with the capacity to produce 6,000 cans (10 ounces each) of processed fruit juices per day. This operation will enable greater utilization of local fruits and will decrease the volume of canned juices now imported to St. Lucia. The estimated loan required is EC$360,000 for a twelve year period.

D. PORK MARKETING

The purpose of this project is to increase the volume of nationally produced fresh pork meat in St. Lucia by at least 100%

within five years, through a national pig producers' processing and marketing cooperative. The estimated loan required is EC$650,000 over a twelve year period.

E. ANTHURIUM PRODUCTION/MARKETING

This project in St. Lucia proposes to produce and export 186,000 dozen/year anthurium lilies as cut-flowers, within eight years. The estimated loan required is EC$190,000 for a five year period.

F. SOILLESS CULTURE VEGETABLE PRODUCTION

The purpose of this project is to increase the volume of selected vegetables produced in St. Lucia by establishing special chambers to utilize a relatively new cultivation method known as NFT or Nutrient Film Technique. The estimated loan required is EC$1,000,000 over a twelve year period.

G. FRUIT JUICE CANNERY

The purpose of this project is to establish a cannery in St. Lucia to annually produce and market about 2 million 10 oz. cans of fruit juice, fruit pieces, and tomato juice. The estimated loan requirement is EC$200,000 over a ten year period.

RIPE BANANA MARKETING

An

AGRI-BUSINESS PROJECT PROFILE

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AGRI-BUSINESS PROJECT PROFILE

DATE:	MARCH 20, 1980
PROJECT:	RIPE BANANA MARKETING
LOCATION:	ST. VINCENT
CLIENT:	EASTERN CARIBBEAN AGENCIES, LIMITED
LOAN AMOUNT:	EC$300,000

I. BACKGROUND

The importance of the banana industry in the four Windward Islands is well known. These islands have established an effective production and marketing system for bananas that is geared to the U.K. market. Weekly banana shipments to the U.K. are in excess of 2,500 M.T. and coconut for about EC$1.8 million in sales.

In contrast to this trade with the U.K. the marketing of bananas in the region is not well organized and the market performance is poor. Notwithstanding the proximity of several non-banana producing CARICOM countries to their Windward Island neighbours, the bananas offered for sale are frequently of poor quality and prices are relatively high. The demand for ripe bananas in Barbados, Trinidad and the Leeward Islands is not known with certainty, but if we can assume a per capita demand of 5.5 kgs/year (as it is in the U.K.) then at least 200 M.T. of bananas per week could be sold in these markets. In other words, CARICOM might be equivalent to 10% of the U.K. market for bananas.

Banana trade between the Windward and nearby population centers is conducted in the main by small volume traders; none of whom have the facilities, e.g. ripening chambers, to provide a reliable wholesale supply of quality fruit. This atomistic structure of the regional banana market is partially responsible for relatively poor quality/high prices bananas offered for sale in Barbados, Trinidad and other non-banana producing countries in the region.

It is proposed that a banana ripening/wholesale business can be profitably established in selected regional markets. Such a business would perform essentially the same marketing functions in the region that Geest Industries performs for the U.K. market, albeit on a much smaller scale.

II. ORIGIN

The proposed venture described here to establish a wholesale banana trade between St. Vincent and Trinidad was conceived by Mr. Marcus DeFreitas, owner/manager of Eastern Caribbean Agencies, Ltd. Based on his experience of successfully shipping and selling selected agricultural commodities to the U.K. and North America over the past 7 years, Mr. DeFreitas has gained a solid appreciation for relative price spreads and marketing margins of produce traded in international markets. With this knowledge, Mr. DeFreitas has observed with growing interest the prices paid for ripe bananas in Trinidad on the one hand, compared to the

prices received by the St. Vincent Banana Growers Association on the other hand. Upon further investigation, Mr. DeFreitas has determined to his satisfaction, that boxed bananas can be purchased from the SVBGA at prevailing prices and profitably sold in Trinidad after allowing for all cost associated with transport, ripening, storage and handling. Moreover, Mr. De Freitas believes that by doing so the quality of bananas available in Trinidad would be improved at no increase in prevailing prices.

During a recent trip to St. Vincent by CDB Loan Officers, Mr. DeFreitas discussed his plan and indicated his interest in securing loan financing from CDB to begin banana marketing in the near future.

III. PROJECT DESCRIPTION

A. PURPOSE

The purpose of this project is to profitably ship, ripen and sell 50 tons of St. Vincent bananas in Trinidad each week on a routine basis. In addition, a lesser volume of other agricultural commodities i.e. plantain, figs, etc. will be successfully exported from St. Vincent and sold in Trinidad.

B. PROJECT COMPONENTS

1. SUPPLY

Eastern Caribbean Agencies, Ltd. (ECA) intends to purchase bananas from the SVBGA. ECA will take delivery of

boxed fruit at the port in Kingstown, and will therefore not be engaged directly in any primary assembly, grading or packing functions. ECA expects to pay at least as much as Geest does for similar quality fruit.

2. OCEAN TRANSPORT AND HAULAGE

The physical transfer of bananas from the Kingstown docks to the storage facility in Trinidad will be accomplished through the contracted services of an independent boat operator and an established customs clearing agent in Trinidad. Mr. De Freitas of ECA reports that he already has an agreement in principal with a boat owner to undertake the ocean transport. This boat owner is willing to modify the ship's hole to accommodate the shipment of bananas under optimum conditions. Likewise, a customs agent in Trinidad has been identified who will attend to all those functions required to take bananas from the Port-of-Spain docks and deliver them to ECA facilities. Mr. DeFreitas estimates that ocean transport will cost about EC$4,000 per trip. Customs clearing and haulage is estimated EC$0.10/lb, or about EC$10,000 per week.

3. STORAGE AND RIPENING

A major function that ECA will perform directly is the storage, ripening and handling of bananas in Trinidad. Thus, ECA will lease an appropriately sited building, i.e. factory shell and install at least three controlled atmospheric ripening

chambers. In addition, a modest amount of equipment, including pallets, scales, dollies etc. will be required. Mr. DeFreitas estimates that leased space will cost about EC$12,000 per month, and capital expenditure of about EC$80,000 will be required to install the necessary facilities and equipment to ripen and handle bananas. Recurrent operating cost of the facility, e.g. utilities, insurance, maintenance etc. are estimated at EC$5,000 per month.

4. WHOLESALE DISTRIBUTION

According to Mr. DeFreitas, ECA will operate primarily as a wholesale banana depot in Trinidad. Thus, it is expected that the principal clients will be larger supermarkets, wholesale produce distributing firms, and institutions. These firms will buy and take delivery of ripe bananas at the ECA warehouse. If clients want ripe bananas delivered to their stores, then ECA will hire commercial trucking services and charge the cost directly to the buyer.

C. PROJECT MANAGEMENT

The marketing of ripe bananas would be one of several profit centers in ECA's overall operations. Activities related to bananas purchase in St. Vincent would be managed directly by Mr. DeFreitas with no increase in the present level of personnel. The same is true of the activities related to ocean transport and haulage.

The operations in Trinidad will require the services of a small full-time staff composed of a general manager, operations supervisor, and four labourers. It is proposed that other services as required, e.g. accounting, billing, legal, equipment repair etc., will be secured on a fee basis. The cost of increased personnel and related expenses is estimated to be EC$9,000 per month.

IV. PROJECT COST AND RETURNS

Projected cost and returns for the banana ripening project for a five year period are presented in Table 1, with explanatory notes on the following pages. These estimates show a positive cash return of EC$980,500 at the end of the first year.

All cost have been increased in years 2 through 5 at a rate of 10% per year, while revenue has been increased over the same period by only 5% per year.

At the end of year 5, the project is expected to generate a cumulative positive cash flow of EC$4,064,400.

Repayment of the entire loan of EC$300,000 can be accomplished in the first year.

TABLE I

COST AND REVENUE PROJECTIONS

FOR RIPE BANANAS MARKETING

(EC $000's)

	Years				
	1	2	3	4	5
1. CAPITAL ITEMS					
1.1 Facilities					
Renovation	100.0				
2. OPERATING COST					
2.1 Salaries & Wages					
2.11 Supervision	94.7	104.2	114.6	126.1	138.7
2.12 Labour	13.5	14.9	16.3	18.0	19,8
2.2 Purchase of bananas	1820.0	2002.0	2202.0	2422.4	2664.7
2.3 Ocean Transport	208.0	228.8	251.7	276.8	304.5
2.4 Customs and haulage	520.0	572.0	629.2	692.1	761.3
2.5 Rent	135.3	148.6	163.7	180.1	198.1
2.5 Repair and maintenance	4.0	4.4	4.8	5.3	5.9
2.7 Spoilage (15%)	273.0	300.3	330.3	363.4	399.7

		1	2	3	4	5
2.8	Utilities	40.0	44.0	48.4	53.2	58.6
2.9	Misc.	10.0	11.0	12.1	15.3	14.6
2.10	Sub-total	3118.5	3430.2	3773.1	4150.7	4565.9
2.11	Total annual cost	3218.5	3430.2	3773.1	4150.7	4565.9
3.	REVENUE					
3.1	Sales (ooo's lbs)	4420.0	4420.0	4420.0	4420.0	4420.0
3.2	Price (EC$ooo/ooo lbs)	950.0	997.5	1047.4	1099.8	1154.8
3.3	Gross Revenue (EC$ooo's)	4299.0	4409.0	4629.5	4864.1	5104.2
4.	CASH FLOW					
4.1	Income Less Cost (3.3 - 2.10)	980.5	978.8	856.4	710.4	538.3
4.2	Cumulative Cash Flow	980.5	1959.3	2815.7	3526.1	4064.4
4.3	Finance Required	339.9				
5.	SOURCE OF FINANCE					
5.1	Equity	39.9				
5.2	Loan	300.0				

	1	2	3	4	5
6. REPAYMENT SCHEDULE					
6.1 Interest	27.0				
6.2 Principal	300.0				

NOTES ON PROJECT COST

1. **Facilities:** The estimate of EC$100,000 is not based on any firm quotes. This amount is judged to be adequate for establishing three ripening chambers and ancillary handling equipment in Trinidad. Note that this is not building construction, but rather retro-fitting the fixtures in a r nted factory shell.

2. **Salaries & Wages:** This budget item is for staff in Trinidad. The amount of EC$94,700 is expected to support 5 full-time staff and EC$13,500 will be adequate for casual labour. These costs have been increased at 10% per year, compounded.

3. **Price of Bananas:** Price of bananas purchased in St. Vincent is estimated at EC$0.35 per pound, boxed and delivered to the port in Kingstown. This is slightly above current prices paid by Geest Industries. Project cost of bananas has been increased at 10% per year.

4. Ocean Transport:	Contracted ocean transport is estimated to cost about EC$0.40 per pound or EC$4,000 per week. This cost includes all associated port and dock fees. Project costs here, too, have been inflated at 10% per year.
5. Customs and: Haulage :	This category of cost is to cover all services associated with clearing shipments in Trinidad and delivering bananas to the wholesale/ripening warehouse. This service will be contracted at an estimated cost of EC$0.10 per pound. Projected costs are increased at 10% per year.
6. Rent:	Rented warehouse facilities in Trinidad are expected to cost about EC$11,300 per month (TT$10,000). Rent is costed at an increase of 10% per year, compounded.
7. Repair & Main-: tenance :	Annual cost estimated at 4% of total capital outlay, inflated at 10% per year.

8. Spoilage: An allowance for spoilage is estimated at 15% of the annual cost of bananas purchased.

9. Utilities: Gross estimate of EC$40,000 per year, inflated at 10% per year. Cooling equipment and fans will be principal energy requirements.

10. Miscellaneous: An amount of EC$10,000 was arbitrarily assumed for miscellaneous supplies.

11. Revenue: Gross revenues are based on estimated sales of 85,000 pounds of bananas per week, allowing for 15% spoilage. Expected wholesale price received is EC$0.95 per pound (TT$0.80/lb). Prices received have been inflated at only 5% per year, compounded.

12. Finance Required: Estimated finance required includes the total capital cost (EC$100,000) plus an amount equal to 4 weeks operating cost (EC$239,900). Thus a total of EC$339,000. This estimate assumes that working capital will be tied-up for less than 30 days.

14. Repayment: Based on projected earnings, the client can repay the EC$300,000 loan at the end of year one, plus interest of 9%, for a total of EC$327,000.

V. PROJECT ISSUES

A. SUPPLY AGREEMENT

The proposed project will be dependent on the willingness of SVBGA to sell bananas. Moreover, the project is apparently going to compete with Geest Industries for "first quality" exportable fruit. Given that Geest is frequently not supplied with enough bananas to fill their ship capacity, is it likely that the SVBGA (and other WIBAN members) will accommodate another buyer? What will be the reaction of Geest to this competitive action? These and other questions related to assured supply will need to be settled.

B. OCEAN TRANSPORT

The proposed project will secure ocean transport from an independent shipper under contract, rather than using a scheduled carrier. The absence of a scheduled ship service between St. Vincent and Trinidad is, of course, precisely the problem. Given the key role of ocean transport to the success of this project the appraisal must include as detailed review of this element, and of the individuals involved, as it would if it were a part of the client's direct operations. Questions related to insurability, suitability of ship hardware, and the reliability of the owner are issues to be explored. Central to this issue is: can the contract be enforced? and what are the

"fall-back" alternatives?

C. MARKET OPPORTUNITY

The project is aimed at selling 50 tons of bananas per week in Trinidad. Given a population of about 1.5 million, this volume amounts to about 3.5 lbs/person/year. What is the volume of bananas now demanded in Trinidad? And what proportion would be accounted for by 50 tons/week? What are the current sources of banana supply in Trinidad and what is likely to be their competitive behaviour when ECA begins to penetrate this market? The project appraisal should demonstrate, through market studies and analysis, that the assumptions put forward by ECA regarding its ability to capture a significant share of the market are valid.

D. UTILIZATION OF LOAN FUNDS

The major cost of this proposed project, and therefore the principal use of the requested loan funds, is the investment in the bananas, in a word: "inventory capital". Because of the perishable nature of the product, the associated risks are high. Loan financing of a perishable product, transported across the high seas on an unscheduled carrier, is not the kind of business any banker is anxious to support as a client. The project appraisal must address this issue of risk in light of the CDB policy.

ARROWROOT INDUSTRY RESUSCITATION

An

AGRI-BUSINESS PROJECT PROFILE

Prepared by:

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E. Reginald Buckmire

For

THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

And

THE CARIBBEAN DEVELOPMENT BANK

March 1980

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AGRIBUSINESS PROJECT PROFILE

DATE: March 20, 1980

PROJECT TITLE: Arrowroot Industry Resuscitation

LOCATION: St. Vincent

CLIENT: Arrowroot Industry Association

LOAN AMOUNT: EC$3,000,000

I. Background

The arrowroot industry in St. Vincent is among the oldest commercial enterprises in the state, and indeed for a period prior to 1957 dominated the national economy in terms of employment as well as contribution to the national accounts. For the past twenty-five years however, the arrowroot industry has been caught in the double-bind of contracting production in favour of an expanding banana industry on the one hand, and on the other hand shrinking markets abroad as substitutes have been developed for arrowroot starch.

During the past two decades, the balance between the quantity of arrowroot starch produced and the quantity required by external markets has been poorly co-ordinated. Thus, this supply and demand imbalance resulted in a large buildup of unsold stocks in the 1960's followed by an inability to meet all market orders in the 1970's.

Notwithstanding the problems and contractions of the arrowroot industry over the recent past, this commodity still makes a significant contribution to the economy of St. Vincent. Arrowroot starch ranks second only to bananas in value of agricultural exports, accounting for more than EC$2,000,000 annually in recent years. Moreover, it is estimated that more than 1,000 individuals - or about 4% of the total labour force-find at least seasonal employment in arrowroot. In addition, about 300 growers, most of whom are small farm holders, depend on arrow-

root cultivation as a cash crop.

It is important to note that St. Vincent arrowroot starch is a unique commodity in world markets. Although modest amounts of arrowroot starch are produced in Brazil, Australia, and China, the attributes of St. Vincent arrowroot enable buyers to differentiate it from all others. These superior attributes include purity, viscosity, colour and pH - because of these qualities a premium price is paid. Utilization of St. Vincent arrowroot starch is apparently concentrated in the processed food industry, although pharmaceutical manufacturers and certain medical diets are also thought to be significant markets.

II. Current Situation

The present estimates of arrowroot harvested in St. Vincent are around 750 acres, accounted for by about 300 growers. With the exception of one large estate, the typical arrowroot grower is thought to cultivate 1 to 3 acres. Almost all arrowroot in St. Vincent is grown in the central and northern windward districts of the island.

The initial starch extraction is accomplished in five factories, which operate for about six months each year during the harvest season. A new factory is under construction in Owia, with loan financing from the CDB, and is expected to become operational for the 1980/81 crop year. Estimated maximum factory capacity from the existing 5 plants is about 170 barrels of starch per day.

The Arrowroot Industry Association, (AIA) established under the Arrowroot Industry Act of 1976, controls the processing, assembly, pulverization and marketing of all arrowroot starch in St. Vincent. This control is accomplished with a full-time staff of thirteen persons, acting under a general manager, who in turn is responsible to an eleven member Board of Directors. The AIA advances short-term pro-

duction credit to growers, controls directly or indirectly all factory operations, buys all the starch produced, and arranges final sales in the U.S.A., U.K. and Canada.

Exports of arrowroot starch for 1978/79 amounted to about 1,800,000 pounds valued at almost US$840,000. This represents about a 15% increase in revenue from 1977/78, when about 1.9 million pounds of starch was exported with a value of about US$742,000.

III. Opportunities and Constraints

According to the St. Vincent National Agricultural Plan (SNAP), adopted in 1976, exports of arrowroot starch were to be increased to 4.5 million pounds (22,500 barrels), within a five year period. This volume of starch would represent well over a 100% increase over current production levels. This increase in volume was determined to be reasonable given the apparent market demand and allocation of agricultural sector resources. That is, the targeted expansion of arrowroot production was to be achieved concurrently with the establishment of sugarcane and the expansion of certain other crops.

While little progress has been made toward this planned level of arrowroot production, there are several reasons to believe that opportunities for an expanded arrowroot industry are greater today than they were five years ago. For one thing, the prices paid in metropolitan markets are comparatively high, and secondly there is an apparently growing and unsatisfied regional demand for arrowroot. Thus, the objectives for arrowroot set forth in SNAP are still valid, but certain constraints will need to be specifically addressed if the implementation of SNAP is to move forward in a timely manner.

Some of the major constraints to increased arrowroot starch production are summarized below.

A. Expansion of Area Cultivated

To achieve an annual production of 4.5 million pounds of starch, about 1,500 acres of arrowroot must be cultivated and harvested. This represents about twice the current area reported to be harvested in St. Vincent. Moreover, since 150 acres of land now planted to arrowroot is to be replaced with sugarcane, a total of 900 acres of new arrowroot plantings will need to be established over the project period - say, the next five years. This effort will require substantial amounts of root stock, fertilizer and other production inputs - as well as an intensive promotion and technical assistance program to encourage hundreds of small farmers to plant arrowroot. There is little evidence than any well planned promotion program and ancillary services are being aggressively implemented. Thus, the indifference towards participation by farmers could represent a serious constraint to expanding arrowroot production.

B. Harvest and Reaping Labour

The most frequently cited problem regarding arrowroot production in St. Vincent is the reported unavailability of labourers willing to perform the "back-breaking work" of digging the arrowroot at harvest. In addition to the particularly difficult physical work involved (extracting roots that sometimes are 15 inches below the surface), it is said that an extremely negative social stigma is associated with arrowroot. It would seem, therefore, both monetary and non-monetary social rewards will need to be implemented to attract the needed work-force into this activity.

With the exception of some research on mechanical harvesting (which apparently has limited application), little attention has been given to innovations that would attract labourers to arrowroot harvesting activities. While the task of addressing the problems related to labour for digging arrowroot is complex and demanding, there seems to be no way to avoid this question if the arrowroot industry is to expand.

C. Factory Processing Capacity

The facilities and hardware required to accomplish the extraction of starch in St. Vincent are now in place to handle current production, and with the expected completion of the new factory at Owia there should be enough capacity to process all the arrowroot produced up to 1500 acres. The problem appears to be not so much the volume of capacity - rather the reliability and access of this processing capacity. Regarding reliability, since most of the factories are quite old, break downs frequently occur. This problem might be partially solved with a program of certain factory renovations and a schedule of preventative maintenance, coupled with a sufficient inventory of key spare-parts. The problem of access may require re-siting certain existing factories to be closer to the production areas. In any case, the question of reliable and convenient factory capacity presents a significant constraint to an expanded arrowroot industry.

D. Post-Harvest Losses

The theoretical proportion of arrowroot starch that can be extracted from mature rhizomes is about 22% by weight. Under optimal commercial conditions the yield of starch should be in the range of 16% to 18%. Current estimates in St. Vincent show about a 13% yield of starch. It is reported that a major source of loss in starch yields is the time which elapses between field digging and initial processing. In St. Vincent, it is said that rhizomes are typically processed two to three weeks after harvest, during which time natural biological processes occur which convert starch to sugars - and thereby reduce the starch yields.

Another point of significant starch loss is said to occur during the grinding process itself. The key variable here seems to be the adjustment of the grinding mills to ensure optimum maceration of the rhizomes.

In any case, there are apparent and significant post-harvest losses of starch.

One of the most cost-effective and profitiable areas of action may well be the reduction of these losses. At current operating levels, each percentage point of starch yield increase would have a value of about EC$173,000 - and this would be proportionately greater at higher levels of production.

The key to reducing post-harvest losses is dependent on a workable plan to better coordinate reaping activity with factory capacities, so that rhizomes are processed quickly after harvest. Current efforts in this area will need to be reviewed and modified as required.

E. Other Constraints

In addition to those areas mentioned above, it is likely that present activities in the areas of policy determination, operational management, and research will need to be modified to attain the levels of arrowroot production envisioned in SHAP.

With regard to policy determination: to the extent that the role and objectives of the arrowroot industry in St. Vincent are not clear or well known - they should be clarified; to the extent that land use policies are in doubt, in the minds of farmers or industry managers - steps should be taken to remove any doubt; to the extent that farmers, industry officials, or civil servants are not sure of their responsibilities - then the policy decision makers should attempt to assign definite responsibilities regarding arrowroot production.

The operational managers whose responsibility it is to implement policies will need to have action plans and resources that are consistent with the scope of the policies. These plans will need to clearly define what is to be done and how it is to be accomplished.

Finally, some resource allocation may be required to perform research on problems of immediate and medium term interest. Three such research areas might

include:

(1) Mechanically assisted harvesting.

(2) Marketing alternatives for bulk starch, and

(3) Manufacturing of value-added products, e.g. baby foods, pie-fillings and special diet preparations.

IV. The Project Description

The purpose of this project is to increase the volume of arrowroot starch exported from St. Vincent to 4,000,000 pounds (20,000 barrels) by the crop year 1985/86. This represents a 166% increase in export volumes over the next 5 years.

B. Outcomes

The project will accomplish the purpose by achieving the following outcomes:

(1) At least 750 acres of arrowroot now in production will be maintained and improved so that at least 20,000 pounds of rhizomes per acre will be harvested each year, beginning in 1983.

(2) Beginning in 1981, 100 acres of new arrowroot plantings will be established each year for 5 years; so that by April 1985 a total of 1,250 acres of arrowroot will be under improved cultivation in St. Vincent.

(3) By 1985/86 crop year, a labor use coordination scheme will be established so that growers will be assured of an even flow of work at fair wages. Two key elements of this activity are:

(a) A rigidly enforced system of harvest notifications for growers; and,

(b) The organization of harvest work crews.

The principal operating criteria for this outcome will be to ensure that no rhizomes are dug more than 3 days before processing; and conversely, to ensure that no unplanned idle factory capacity is caused by a lack of rhizomes.

(4) Beginning in 1981, one factory each year will be renovated/ re-sited or otherwise modified so that by 1985/86 crop year a reliable maximum daily capacity of 250,000 pounds of rhizomes (185 barrels of starch) will be available when required at the peak of the harvest season. In this way, all five existing factories will be up-graded as required by the end of the project. (Note: it is assumed that the new Owia factory will require no modification during the life of this project).

(5) By the beginning of the crop year 1985/86, the AIA will have secured assembly and transportation services that will enable delivery of all rhizomes to a factory within 48 hours after harvest.

(6) Within two years after the project begins (1982/83) the AIA will establish a routine of farm visits so that each arrowroot grower is visited by an AIA field officer or other official no less than once each calendar quarter. Moreover, the AIA will, through the employment of short-term staff if necessary, visit every grower within a five day period prior to harvest.

(7) Beginning in 1981, the AIA will undertake, with support from other agencies as may be available, research in:

(a) Mechanically assisted harvesting.

(b) Marketing alternatives.

(c) Value added product manufacturing.

C. Inputs and Activities

To ensure that the outcomes are achieved, the project will require the following inputs and resources.

1. Field Production

It is assumed that arrowroot production agronomy is well known and the husbandry/inputs required to attain harvest yields of 20,000 pounds of rhizomes per acre can be promoted. For purposes of this project, it is assumed that the cost of establishing new plantings of arrowroot is about EC$1,000 per acre, and the annual cost of maintaining an acre of arrowroot is about EC$500. Therefore, over the next five years approximately EC$100,000 per year will be required by farmers wishing to establish new plantings of arrowroot. Moreover, production cost of about EC$325,000 will be required the first year of the project to properly maintain existing cultivations of arrowroot. Total annual production cost will increase about EC$50,000 per year as 100 additional acres are established each year for five years.

Based on these cost assumptions and estimated increase in acres of arrowroot, it is proposed that a production credit fund of about EC$650,000 be established to serve the arrowroot growers' production cost requirements. This fund would be administered by the AIA, using its current authority to advance production credit and to collect the amounts due at the time of starch or root purchase from the grower.

2. Labor Utilization Scheme

It is proposed that the AIA consider arranging for the coordinated harvesting of arrowroot in St. Vincent. This activity would be accomplished by organizing harvest work crews, say in groups of 20 persons, that would work in the fields assigned by the AIA, and be paid on a piece-work basis as is now the custom. The grower will

also be paid for roots on the basis of weight as is now widely practiced. It should be noted that the AIA would hire temporary labor on a piece-work basis and would therefore not increase the number of permanent employees.

The AIA would most likely need to provide transport for the labor crews from certain central locations to the assigned work sites; and provide baskets, implements or other tools required by the crews.

There are several alternative organizational configurations that may be appropriate to the situation in St. Vincent. For example, the AIA might choose to deal with only crew chiefs who in turn would organize and pay the individual crew members. On the other hand, the AIA could pay each individual for his work.

In any case, it is estimated that about 36,000 man-days of labor will be required to harvest 1,250 acres of arrowroot yielding an average of 20,000 pounds of roots per acre. This is assuming that each worker can dig about 700 pounds per day (i.e. 10 "baskets"). If an average price per "hundred weight" of roots is taken to be EC$4.00 (EC$2.80/basket)- EC$4.00 x 250,000 cwt. amounts to EC$1,000,000 for harvest labour. Assuming an average worker can dig 700 pounds of roots per day, then an average daily earning of EC$28.00 would be anticipated. This is a 40% ($8/day) increase over current rates reported to be paid.

It is proposed therefore, that the AIA establish a labor cost fund of about EC$1,000,000 to undertake this function on a national basis. The advantages of such a scheme are:

(a) Post harvest losses will be reduced since the AIA will be able to coordinate harvest volumes with available factory capacity, and therefore keep the interval between digging and processing within acceptable limits, e.g. not more than 72 hours.

(b) Growers will be relieved of the difficult task of finding labor and competing with each other for the limited labor available.

(c) Workers will be assured of a steady flow of work during the harvest season, and be provided with ancillary services (i.e. transport) to enable them to achieve greater productivity and therefore income.

3. Factory Capacity

When the new factory at Owia becomes operational, St. Vincent should have the maximum daily capacity among the six factories to produce 200 barrels of starch (or grind 260,000 pounds of rhizomes). This level of capacity should be adequate to process the targeted yields required by the project. Nevertheless, this theoretical processing capacity is not entirely reliable, nor is it necessarily sited in proper locations. Therefore, it is proposed that a planned schedule of factory renovation or factory re-siting be undertaken as an element of this project. Since no engineering appraisals are currently available, as estimated EC$100,000 is assumed to be the average cost to renovate a single factory. If one factory each year is renovated, then a project cost of EC$500,000 will be required.

4. Transport Services

A key element of the project proposed here is the reliable availability of trucks to: (1) mobilize labor crews, (2) transport harvested rhizomes, and (3) haul pearl (crude) starch from factories to Kingstown. It is proposed that the AIA contract these services from private truck owners. It is estimated that an annual total requirement would account for 600 truck-days. As a crude estimate, assume a truck with driver could be contracted at a flat price of EC$500 per day

or EC$2,500 per week. Total transport cost would then amount to about EC$300,000 per year.

5. Organization Management

If the AIA is to take on increased responsibility regarding harvest activity, and is to achieve better coordination and control of the volume of rhizomes into the factory system, then the field staff of AIA will need to be seasonally increased. It is estimated that annual requirement will be equivalent to approximately 64 work-weeks of seasonal field staff. This would cost about EC$200 per week per man, or an additional total cost of about EC$16,000 per year.

6. Research

During the five year period of this project, the AIA will undertake research in three areas: (1) mechanical harvesting, (2) market alternatives, and (3) manufactured products. It may not be reasonable to undertake research in all three areas simultaneously. Nevertheless, an annual allocation of EC$120,000 is estimated for research, or a total of EC$500,000 over the life of this project.

V. PROJECT FINANCE

A. Cost

To implement the activities previously discussed to resuscitate the arrowroot industry in St. Vincent, an estimated investment of EC$3.0 million would be required over the five year life of the project. First year cost are estimated at EC$1.6 million, with additional annual cost of about EC$350,000 for each of the following four years. Project cost estimated by activity are as follows:

(1)	Production Credit	EC$ 650,000
(2)	Labor Utilization	1,000,000
(3)	Factory Renovation	500,000
(4)	Transportation Services	300,000
(5)	Management Expansion	50,000
(6)	Research Activities	500,000
	Total	EC$3,000,000

B. Revenue

The expansion in the area of harvested arrowroot from 750 acres to 1,250 acres should increase the gross revenue from starch sales current (1979/80) levels of EC$2.2 million to EC$3.8 million, assuming no change in price or in the efficiency of the industry.

Of course, as a result of the project activities, it is reasoned that at least two measures of productive efficiency will improve: (1) the yield of rhizomes per acre will increase by 10% because of improved cultivation practices; and, (2) the starch yield per pound of roots processed is expected to rise from 13% to 16%, as a result of improved harvesting/processing coordination. If these assumptions prove correct, and assuming no change in prices or other factors, then gross revenue will rise to about EC$5.1 million - or approximately 231% greater

than current gross revenue.

C. Loan Financing and Repayment

Assuming an EC$3.0 million loan disbursed over a five year period (as prescribed in (A) above); and further assuming that no repayment of the loan is required for the initial five years, while interest due at 4% annually is compounded and added to the loan principal - then the total outstanding loan principal at the end of year five would amount to EC$3,492,400.

This outstanding principal could then be repaid over a ten year period in equal annual instalments of EC$414,020.47, assuming an interest rate of 4%.

D. Summary

On the following pages the cost, returns, and loan servicing of this proposed project are summarized in Table 1 and accompanying notes.

In preparing this summary, all projected unit costs have been inflated at 8% per year. Likewise, the estimated price of units sold have been increased at 8% per year. Base unit costs and prices were taken from the most recent data available.

The summary project estimates also assume that all loan funds will be applied to current operating cost, and therefore no allowance is made for depreciation or residual salvage value. Even under this assumption, the estimates show a positive cash balance beginning in year five.

The project is estimated to achieve a cumulative net cash balance of EC$8.9 million at the end of year 15, allowing for total operating cost and complete loan repayment.

IV. Loan Repayment

1. Loan Disbursement: The projected figures assume EC$3.0 million is disbursed over the first five years. The first years disbursement amounting to EC$1.6 million, followed by four additional annual disbursements of EC$350,000 each.

2. Principal Outstanding: This item shows the principal amount of money owed by the AIA at the end of each year. Note that interest due in the first years has been included in the principal amount outstanding. Beginning in year six, the principal is gradually reduced and paid over a ten year period.

3. Payments: The projected pay-back in ten equal instalments of EC$414,020 annually is shown, along with the amount applied to interest and the amount applied to principal.

TABLE 1
ST. VINCENT ARROWROOT INDUSTRY ASSOCIATION
SUMMARY OF ESTIMATED COST AND REVENUE FOR
EXPANDED STARCH PRODUCTION

	YEARS															
	1978	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. OPERATING COST (EC$000's)																
1.1 Cost of Starch																
1.11 Cost of Roots		1067.6	1313.3	1597.0	1927.5	2304.6	2489.0									
1.12 Digging		533.8	656.6	798.5	963.8	1152.3	1244.5									
1.13 Transport (Field)		200.2	246.2	299.4	361.4	432.1	466.7									
1.14 Grinding		520.4	689.5	896.3	1120.4	1382.8	1493.4			Inflated at 8% Per Year						
1.15 Transport (Factory)		26.0	34.5	94.9	56.0	69.1	74.7									
1.16 Pulverizing, Packing & Shipping		86.7	114.9	149.7	186.7	230.5	248.9									
1.7 SUB-TOTAL	1284.2	2434.7	3055.0	3787.8	4585.8	5571.4	6017.2	6498.6	7018.5	7579.9	8186.4	8841.3	9548.6	10312.5	11137.5	12028.5
1.2 General & Administrative (EC$000's)	222.2	305.0	339.4	365.7	394.2	424.9	458.9	495.6	535.3	578.1	624.3	674.3	728.3	786.5	849.5	917.4
1.3 Other Costs (EC$000's)																
1.31 Fert. Subsidy	29.1	39.8	42.9	46.4	50.1	54.1	58.4									
1.32 Research	34.4	120.0	120.0	120.0	120.0	120.0	- 0 -			Inflated at 8% Per Year						
1.34 Factory Repair	8.1	110.0	110.8	111.7	112.6	113.6	14.7									
1.35 SUB-TOTAL	71.6	269.8	273.7	278.1	282.7	287.7	73.1	78.9	85.3	92.1	99.5	107.4	116.1	125.3	135.4	146.2
1.4 TOTAL COST (EC$000's)	1578.8	3009.5	3668.1	4431.6	5292.7	6284.0	6549.2	7073.1	7639.1	8250.1	8910.2	9623.0	10393.0	11224.3	12122.4	13092.1

	YEARS															
	1978	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2. REVENUE																
2.1 Number of Acres (000's)	750	850	950	1050	1150	1250	1250									
2.2 Yield Per Acre (000's lbs.)	15.4	15.7	16.0	16.3	16.6	16.9	16.9									
2.3 Total Rhizomes (Million lbs.)	11.55	13.35	15.2	17.12	19.13	21.12	21.12			All Numbers Remain The Same as Year Five						
2.4 Starch Yield Ratio (Percent)	13.0	13.0	14.0	15.0	15.5	16.0	16.0									
2.5 Starch Produced (000's lbs.)	1501.5	1734.8	2128.0	2567.3	2964.6	3388.0	3388.0									
2.6 Price of Starch (EC$ per lb.)	1.21	1.50	1.62	1.75	1.89	2.04	2.20	2.38	2.57	2.78	3.00	3.24	3.50	3.78	4.08	4.41
2.7 Gross Revenue (EC$000's)	1828.1	2602.2	3447.4	4492.8	5603.1	6911.5	7453.6	8063.4	8707.2	9418.6	10164.0	10977.1	11858.0	12806.6	13823.0	14941.1
3. CASH FLOW																
3.1 Annual	249.3	(407.3)	(220.7)	61.2	310.4	627.5	904.4	1026.3	1068.2	1168.5	1253.9	1354.2	1465.0	1582.3	1700.6	1849.0
3.2 Cumulative		(407.3)	(628.0)	(566.8)	(256.4)	371.1	1275.5	2301.8	3370.0	4538.5	5792.4	7146.6	8611.6	10193.9	11894.5	13743.5

	YEARS															
	1978	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4. LOAN REPAYMENT (EC$000's)																
4.1 Loan Amount Disbursed		1600.0	350.0	350.0	350.0	350.0										
4.2 Principal Outstanding (Including Compounded 4% Interest Due)		1664.0	2094.6	2542.3	3008.0	3492.4	3218.8	2932.78	2636.07	2327.49	2006.57	1672.81	1325.70	964.71	589.28	390.45
4.3 Interest Payment							139.70	128.72	117.31	105.44	93.10	80.26	66.91	53.03	38.59	23.57
4.4 Principal Payment							274.32	285.30	296.71	308.58	320.92	333.76	347.11	360.99	375.43	390.45
4.5 Total Payment							414.02	414.02	414.02	414.02	414.02	414.02	414.02	414.02	414.02	414.02

NOTES ON TABLE 1

I. Operating Cost

A. Cost For 1978

All cost shown for 1978 are taken directly from audited financial statements of the AIA for that year.

B. Cost For Project Years

1. Cost of Roots: is the total estimated national production multiplied by EC$8.00 per 100 pounds. Note that this cost is for unharvested roots.

2. Digging: is the cost of labor for harvesting the roots, and is estimated by multiplying the projected national production by EC$4.00 per 100 pounds.

3. Transport (Field): is the cost of hauling roots from field to factory, and is estimated by multiplying the projected national production by EC$1.50 per 100 pounds.

4. Grinding: is the factory processing required to extract crude dry starch. This cost is estimated by multiplying total projected starch production by EC$30.00 per pound.

5. Transport (Factory): is the cost of moving crude starch from factories to Kingstown warehouse, and is estimated by multiplying projected starch production by EC$1.50 per 100 pounds.

6. Pulverizing, Packing and Shipping: is the cost of all operations carried out in Kingstown warehouse, and is estimated by multiplying projected starch production by EC$5.00 per 100 pounds.

7. General & Administrative Expense: includes all salaries, supplies, and other cost of the AIA. This cost is estimated by: (1) inflating 1978 cost by 8% per year; and (2) adding EC$10,000 each year over the first five years of the project.

8. Other Cost: includes fertilizer subsidies, research activity, and factory repair renovation. These costs are estimated by: (1) inflating current expenses at 8% per year; (2) adding EC$120,000 for research each year for five years; and (3) adding EC$100,000 for major factory renovations each year for the first five years.

9. NOTE: All unit cost have been increased at a rate of 8% per year, compounded, for all years projected.

II. Revenue

A. Revenue For 1978

The gross revenue shown for 1978 is taken directly from audited financial [illegible] of the AIA. The price received per pound in 1978 is taken from other AIA records. All other figures shown under revenue for 1978 are estimated.

B. Revenue for Projected Years

1. Number of Acres: Current estimated area of arrowroot cultivated and harvested in St. Vincent is 750 acres. Projections assume an increase in area of 100 acres per year for five years, and this area will be sustained thereafter at a total of 1,250 acres.

2. Yield Per Acre: Current yield of arrowroot rhizomes per acre is estimated to average 15,400 pounds. Projected estimates assume average yields will increase at a rate of 2% per year over the first five years of the project, and will be sustained thereafter at about 16,900 pounds per acre.

3. Starch Yield Ratio: The proportion of starch rendered per unit of rhizomes processed is currently estimated at 13%. Projected estimates assume a gradual increase in this proportion over the first years, so that 16% is achieved by year five, and sustained thereafter.

4. Starch Produced: This estimate is simply the projected total production of roots multipled by the starch yield ratio.

5. Price of Starch: The AIA is expecting to sell starch from the 1979/80 crop for EC$1.50 per pound. This reported price has been inflated at a rate of 8% per year, compounded, for all years shown.

6. Gross Revenues: These projections are estimated by multiplying the expected volume of starch production by the expected prices.

III. Cash Flow

A. Cash For 1978

The positive cash earnings figure shown for 1978 is taken directly from audited financial statements of the AIA for that year.

B. Projected Cash Flow

1. Annual: These estimates of net cash balances are calculated by substracting the amount of total cost from the amount of gross revenues in any year shown.

2. Cumulative: These estimates are the summation of any given year's net cash balance and all previous years' net cash balances.

MULTI-LINE FOOD CANNERY

An

AGRI-BUSINESS PROJECT PROFILE

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For

THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

And

THE CARIBBEAN DEVELOPMENT BANK

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This document does not assume the approval (nor imply such) of the United States Agency for International Development, the Caribbean Development Bank or any of their officers.

AGRIBUSINESS PROJECT PROFILE

DATE:	MARCH 20, 1980
PROJECT TITLE:	MULTI-LINE FOOD CANNERY
LOCATION:	ST. LUCIA
CLIENT:	SEXPO LIMITED
LOAN REQUIREMENT:	EC$375,000

I. BACKGROUND:

St. Lucia has no well established food canning industry. Until very recently, food processing in general has been limited to very small scale "kitchen operations" producing limited volumes of jams, jellies and fruit syrups. About four years ago, the Ministry of Agriculture established the Agro-Lab facility to experiment on a pilot basis with the processing and formulation of certain food products. More recently, one private individual has undertaken the establishment of a cannery that will reportedly concentrate on the canning of akee fruit and certain other fruit juices, as well as mango slices. This private venture, while not yet in operation, is well along in construction and in the establishment of the canning line equipment.

Although St. Lucia produces a multiplicity of tropical fruits and evidences a high percentage of waste in crops like mangoes and golden apples (See Table 1), the absence of commercial canning operations can be attributed to several factors, including:

1. Limited market opportunities;

Table 1

ESTIMATED ANNUAL PRODUCTION LEVELS

AND PROPORTION WASTED FOR SELECTED TROPICAL FRUIT, IN ST.LUCIA

(000's lbs)

Product	Estimated Production 1979[1/]	Production by District and Est. Waste[2/]					
		South	% Waste	North	% Waste	East	% Waste
Long Mango	5429	225	79	719	35	4484	64
Graham Mango	564	NA		NA		1444	73
Julie Mango	NA	NA		NA		258	62
Golden Apples	493	120	50	17	12	355	80
Guava	1762	61	74	1386	99	313	63
Tamarind	87	7	54	4	65	75	78
Siviette	250	19	86	226	57	3	95
Grapefruit	1332	85	3.4	581	3.7	664	84
Sorrel	8	NA		NA		NA	
Passion Fruit	38	NA		NA		NA	
Limes	197	NA		NA		NA	

1/ Data provided by St. Lucia Extension Service to Mr. Destang.

2/ Ministry of Agriculture and Trade.

2. Relatively high cost of cans and packaging material;
3. Lack of skilled or experienced management;
4. Insecure source of an adequate and timely supply of raw product; and
5. Relatively low cost of imported competing products.

All of these constraints to local canning operations have been mitigated to some extent over the recent past. Increased incomes in St. Lucia and the region translate into a greater market demand for processed foods; the work accomplished by the Agro-Lab has increased the practical knowledge and skills of personnel; the assembly and flow of raw supplies has gradually improved, helped by improved feeder roads and the efforts of the Marketing Board; and inflation in metropolitan countries has pushed the cost of imported canned foods steadily upward. Hence, the opportunities to establish national canning operations have become more feasible. Moreover, government policies have been enacted to encourage investment in domestic industries through certain tax incentives and low import duties on required equipment.

II. ORIGIN

The proposed canning enterprise described here was conceived by a client who is seeking to diversify his business investments. The client is attracted to food canning for two reasons. First, he has a solid practical understanding of agriculture gained as a young man and reinforced through his current management of an

80 acre farm. Second, the client is attracted by the tax incentives offered by Government and the technical assistance available from the professionals at the Agro-Lab. The client's principal business is construction, where he acts as a General Contractor for both residential housing and commercial buildings.

A major portion of the technical design and cost calculations described in the following section was accomplished with the assistance of the Agro-Lab Food Technologist, Mr. D.L. Destang. It was through Mr. Destang that the client was introduced to the CDB.

III. PROJECT DESCRIPTION

A. PURPOSE

The purpose of this project is to establish a multi-product canning operation with the capacity to produce and market 12.6 million ounces of processed juices and food product per year. This volume of product is equivalent to about 1.26 million 10 ounce cans per year or a volume of 6,000 cans per operative day.

The primary products will be fruit juices, which are expected to account for at least 85% of total output. The remaining small proportion of final product will be comprised of fruit chunks or vegetable paste, most frequently based on bulk imported stocks. The projected volumes and proportion of each product is listed below:

PRODUCT	VOLUME (ooo's of oz.)	PROPORTION OF TOTAL OUTPUT
• Orange Juice	1,312	10.4%
• Mango Juice	2,135	16.9%
• Grapefruit Juice	1,872	14.9%
• Guava Juice	1,522	12.0%
• Golden Apple Juice	1,172	9.3%
• Tamarind Juice	2,275	18.0%
• Other Products	2,312	18.5%
Totals	12,600	100.0%

NOTE: Other products include relatively small volume of Paw-paw juice, soursop juice, passion fruit juice, tomato paste, fruit cocktails, etc.

B. THE PROCESS

1. RAW MATERIAL SUPPLY & ASSEMBLY

The proposed enterprise will secure the required raw materials in three ways. Certain fruits such as mangoes, grapefruit and oranges will most frequently be purchased directly from farmers, and the enterprise will arrange for transportation using its own or contracted trucks. Raw material supply will also be secured through the St. Lucian Marketing Board (SLMB). The SLMB has successfully supplied the Agro-Lab with required fruits over the past several years. Thirdly, there are a few itinerate trucker/assembliers that have also supplied the Agro-Lab in the

recent past. It is expected that a timely supply of raw product can be adequately arranged using these methods.

With regard to the volumes of raw material required, it is estimated that a total of about 608,000 pounds per year will be purchased from local farmers. The volume of each fruit required is as follows:

FRUIT	POUNDS REQUIRED PER YEAR	PROPORTION OF TOTAL REQUIREMENT
• Oranges	95,391	15.7%
• Grapefruit	92,973	15.3%
• Mango	84,656	13.9%
• Guava	36,492	6.0%
• Golden Apple	174,502	28.7%
• Tamarind	11,556	1.9%
• Other Fruits	112,400	18.5%
Totals	607,970	100.0%

To estimate cost of raw material, an average price of EC$0.40 per pound is believed to be adequate. Thus, an annual cost of raw fruits is estimated to be EC$243,188.

2. MATERIAL PREPARATION

The functions required to wash, inspect, peel, cut, slice and otherwise prepare the raw material for processing will be accomplished in simple, sanitary facilities. No equipment or special skills that are not already well known and locally available will be required.

3. TRANSFORMATION

Since most of the product lines are juices, the transformation process will utilize a relatively simple and well understood technology. Juice extraction will be accomplished mechanically using electrically powered depulpers and blenders. The extracted juice is homogenized to attain a physically consistent liquid. Water, sugar, and certain stabilizers are added to the liquid so that a uniform quality is attained. The juice is heated and transferred to a holding tank, ready for canning. The hot juice is then put into the can, using a manually operated filler and can sealer. Finally, a semi-manual process is used to label and box the finished product.

C. THE PLANT

1. LOCATION

It is anticipated that the processing plant will be located in Grand Riviere community in the Dennery District, situated on a lot of about 3/4 acres alongside the East Coast Highway. This site is reported to have adequate supplies of water and easy access to electrical and telephone services which are currently available in the community.

2. THE BUILDINGS

A suitable building will need to be constructed, enclosing an area of about 3,000 ft^2. It is anticipated that the building need not be particularly elaborate and should not cost more than EC$50 per sq.ft. to erect.

3. EQUIPMENT

The processing equipment as proposed is based on a plant design recommended by a U.S. manufacturer (The Dixie Co.,) with certain modifications and additions recommended by the Agro-Lab food technologist. Total equipment cost, including machinery, utensils, work benches, and chilling equipment is estimated to be about EC$190,000. Most of this amount (95%) will require foreign exchange, since only about EC$8,000 of the required equipment is available locally.

4. PROCESSING SUPPLIES

a. CANS

It is anticipated that cans will be imported from Trinidad, and about 1,400,000 units will be required per year. Estimated cost per unit is about EC$0.40 C.I.F. Therefore, an annual expense for cans and lids amounts to EC$558,500. However, it may be possible to reduce this cost if the cans are purchased in "collapsed" form and "reshaped" in St. Lucia. If this method is appropriate, it may be that the cost per can could be as low as EC$0.33 each.

b. LABELS AND CARTONS

Labels and cartons are available from local manufacturers. The estimated cost for labels is EC$0.10 each for an annual requirement of 1.38 million. Since each carton will hold 24 cans, the annual requirement is about 52,500 units; each costing about EC$2.00. Therefore, total annual cost of labels amounts to EC$138,000; and cartons amount to EC$105,000.

c. SUGAR

The major additive to the juice products that will require imported supplies is sugar. It is estimated that sugar will be about 15% of the product weight, therefore about 123,000 pounds of sugar, at EC$0.75 per pound, results in an annual cost of about EC$92,250.

5. PERSONNEL

The cannery will employ a total of about 28 persons, as indicated below:

1 - manager @ EC$1,400 per month	EC$ 16,800
2 - canning supervisors @ EC$800/month	19,200
1 - sales supervisor/storekeeper @ EC$700 per month	8,400
1 - secretary @ EC$500/month	6,000
1 - security officer @ EC$300/month	3,600
2 - drivers @ EC$450/month	10,800
20 - workers @ EC$250/month	60,000
Total	EC$ 104,800
Plus 10% for workers' insurance & overhead	10,480
Total	EC$ 115,280

In addition to paid personnel, it is expected that close and frequent technical assistance will be provided by the Agro-Lab staff, especially the senior food technologist. Much of the initial training of the project staff in the applied techniques of cannery operations will be accomplished with the assistance of the Agro-Lab.

6. UTILITIES AND OTHER SERVICES

a. UTILITIES

All required utilities are available to the plant.

i. Electricity required to power all machines (which total about 50 horsepower) and lighting is estimated to amount to EC$11,600 per year.

ii. Gas required to provide heat for kettles is estimated at 6,000 gallons per year at a total cost of EC$12,900.

iii. Water consumption, from municipal sources, is estimated at 1 million gallons per year, costing a total of EC$2,200.

iv. Telephone service will cost about EC$1,200 per year.

v. Insurance against fire and natural disaster is estimated to cost about EC$5.00 per 1000 dollars of valuation. Based on an estimated value of building and equipment of EC$393,000, the insurance will cost about EC$1,965 per year.

b. TRANSPORT SERVICES

Trucking services will be secured by either contractual arrangement or by hired drivers who will assemble produce for the plant. In particular, the client now has several trucks used in his construction business that can be utilized for this project. The canning project is estimated to require the equivalent of 10 trips per week, each averaging 60 miles. Cost per trip-mile,

including driver, is estimated to be EC$1.50. Therefore, transportation services are estimated at EC$900 per week or EC$46,800 per year.

D. THE MARKET

The proposed cannery will sell products ex-factory. The primary clients will be the larger wholesale merchants, large hotels and self-service supermarkets. It is anticipated that the total production can be sold in the domestic market. Import data for 1977 and 1978 show an annual volume of fruit juice imports in excess of 14 million ounces of canned juice per year. The proposed output of this project, targeted at 12.6 million ounces per year, represents 90% of the recent imported volumes.

IV. PROJECT COST, RETURNS AND FINANCIAL PLAN

Project cost and returns projections for a 12 year period are summarized in Table 2. These estimates assume a maximum operating capacity of 1.26 million 10 oz. cans of product per year, which is attained in the 5th year of operations and sustained thereafter.

At the end of year 12, the projections show a cumulative net return less interest of EC$1,431,798 on an initial investment of EC$401,100 or a ratio of 3.57.

Almost all cost and revenue figures have been inflated at a rate of 8%, compounded annually.

It is noteworthy that "packaging", i.e. cans, labels,

TABLE 2

MULTI-LINE FOOD CANNERY - ST. LUCIA

ANNUAL PROJECTIONS OF COST AND RETURNS

(Years)

		1	2	3	4	5	6	7	8	9	10	11	12
1.	CAPITAL ITEMS												
1.1.	Fixed Assets												
1.11	Land	3.0											
1.12	Site Work	3.0											
1.13	Buildings	89.6											
1.2	Equipment												
1.21	Machinery	138.9											
1.22	Tools and Hardware	17.6											
1.23	Fixtures	7.8											
1.24	Chilling Equip.	41.2											
1.25	Trucks	100.0					161.1						285.3
1.3	Sub-total	401.1					161.1						185.3

	1	2	3	4	5	6	7	8	9	10	11	12.
2. OPERATING COST												
2.1 Salaries & Wages												
2.11 Manager	16.8	18.1	19.5	21.2	22.8	24.7	26.6	28.8	31.1	33.6	36.3	39.2
2.12 Supervisors	27.6	29.8	32.2	34.8	37.5	40.5	43.8	47.3	51.1	55.2	59.6	64.3
2.13 Labour	12.0	38.9	56.0	68.0	82.2	88.7	95.8	103.5	111.8	120.7	130.4	140.8
2.2 Processing Material												
2.21 Raw Fruit	48.6	157.6	226.9	274.6	331.4	357.9	386.6	417.5	450.9	486.9	525.9	567.9
2.22 Sugar	18.7	60.6	87.2	106.1	114.6	123.7	133.6	144.3	155.9	168.3	181.8	196.4
2.23 Water	.5	1.5	2.0	2.2	2.2	2.4	2.6	2.8	3.0	3.2	3.5	3.8
2.24 Other	3.5	10.5	14.0	15.5	17.1	18.8	20.3	21.9	23.7	25.6	27.6	29.8
2.3 Cans	110.9	359.2	517.3	628.5	754.2	814.3	879.4	949.8	1025.8	1107.8	1196.5	1292.2
2.32 Labels	27.7	89.7	129.2	156.9	188.6	203.6	219.9	237.5	256.5	277.0	299.2	323.2
2.33 Cartons	21.0	68.0	97.9	119.0	142.8	154.2	166.6	179.9	194.3	209.8	226.6	244.7
2.4 Utilities												
2.41 Elec.	2.3	6.9	9.2	10.4	11.6	12.5	13.5	14.6	15.8	17.0	18.4	19.9
2.42 Gas	2.6	7.8	10.4	11.7	12.9	13.9	15.0	16.2	17.5	18.9	20.5	22.1
2.43 Telephone	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.2	2.4	2.6	2.8

	1	2	3	4	5	6	7	8	9	10	11	12
2.10 Sub-total	333.4	911.8	1296.2	1563.2	1846.5	1991.9	2149.4	2319.3	2502.9	2700.1	2913.9	3144.5
3.1 Total Annual Cost (1.3 Plus 2.10)	734.5	911.8	1296.2	1563.2	1846.5	2153.0	2149.4	2319.3	2502.9	2700.1	2913.9	3429.8
4. REVENUE												
4.1 Output (ooo's of cans)	432	576	1008	1134	1260	1260	1260	1260	1260	1260	1260	1260
4.2 Price (EC$ooo's/ooo cans)	1.2	1.3	1.4	1.51	1.63	1.76	1.90	2.05	2.21	2.39	2.58	2.79
4.3 Gross Revenue (EC$ooo's)	518.2	748.8	1411.2	1712.3	2053.8	2217.6	2394.0	2583.0	2784.60	3011.4	3250.8	3515.4
5. CASH FLOW												
5.1 Income Less Cost (4.3 - 3.1)	(216.3)	(163.0)	115.0	149.1	207.3	64.6	244.6	263.7	281.7	311.3	336.9	85.6
5.2 Cumulative Return	(216.3)	(379.3)	(264.3)	(115.2)	92.1	156.7	401.3	665.0	946.7	1258.0	1594.9	1680.5
5.3 Finance Required	567.8											
6. SOURCE OF FINANCE												
6.1 Equity	192.8											
6.2 Loan	375.0											
7. REPAYMENT SCHEDULE												
7.1 Interest (EC$)			40099	37459	34582	31447	28029	24303	20242	15816	1099.1	5732
7.2 Principal (EC$)			29325	31965	34842	37977	41395	45121	49182	53608	58433	63692

NOTES ON COST AND RETURN PROJECTIONS FOR MULTI-LINE FOOD CANNERY

1. **Land:** Proposed cannery site is currently owned by the client, and fair value is estimated at EC$3,000 for about three quarter acres.

2. **Site-Work:** Ground levelling, road entrance, drainage and water connection estimated at EC$3,000.

3. **Building:** Factory shell construction of about 2100 ft^2 in area is proposed. Estimated cost/ft^2 is EC$42.70.

4. **Machinery:** Basic cannery lay-out recommended by Dixie Co. costed in 1979 quotations plus shipping from U.S.A. Thus, EC$138,938 is C.I.F., St. Lucia.

5. **Tools & Hardware:** Includes pans, knives, buckets, and other processing tools. Price of EC$17,644 is C.I.F. St. Lucia.

6. **Fixtures:** These items include benches, tables, stools and other associated fixtures (mostly from local sources). Cost is currently estimated at EC$7,829.

7. **Chilling Equipment:** To be used for short period storage of fresh fruit. Quotation from Griffen International Inc. EC$41,250.

8. **Trucks:** Two medium sized trucks, with bodies, to collect raw product: EC$100,000 trucks are

replaced every six years, at inflated prices.

9. Salaries & Wages:

At full production, the cannery will require about 27 persons full-time employed; as follows:

1	- General Manager	EC$1400/month
2	- Skilled Operators	800/ "
1	- Sales Supervisor	700/ "
1	- Secretary/Bookeeper	500/ "
2	- Drivers	450/ "
1	- Watchman	300/ "
20	- Labourers (@ EC$10/day)	4000/ "

Cost of salaries and wages have been inflated at 8% per year, compounded. All salaried employers are assumed to be employed from year 1, while labour has been costed in proportion to output during first years of operation.

10. Processing: Material:

A total of 623,432 pounds of fresh fruit is estimated to be required at full capacity. The volume purchased during the first four years of operation has been proportionately reduced with expected output. The volumes of sugar purchased has similarly been reduced during the first years of operation.

An average cost of fruit of EC$0.40/lb. is assumed; while sugar is estimated to cost EC$ .75/lb. Both these commodities' cost have been inflated at 8% per year, compounded.

11. Packaging: Cans, labels, and cartons are projected in direct proportion to output, plus 10% for damaged items. Current cost quotations are:

- Cans - EC$403/1000
- Labels - 100/1000
- Cartons - 2000/1000

All these prices have been increased at 8% per year, compounded.

12. Utilities: Current prices inflated at 8% per year, compounded. Utility cost have been projected in direct proportion to output.

13. Maintenance & Repair: Cost estimated at 2% of total capital investment, inflated at 8% per year.

14. Fuel: Estimated truck usage of 600 miles per week, for 40 weeks per year when factory at full capacity. Current cost estimated at EC$ .75/mile, and inflated at 8% per year.

15. Interest on Working Capital: Projections assume short-term loans, using finished product inventory as security, of amount equal to value of 3 months output. Cost of interest is 10% per annum.

16. Miscellaneous: Contingencies equal to 1% of gross revenue.

17. Output: Assume full capacity of 1.2. million 10 oz. cans of product. Start-up production estimated at: 20%, 60% 80%, and 90% for years 1, 2, 3, and 4 respectively. Further, 100% production is assumed in year 5 and thereafter.

18. Selling Price: Current estimated selling price (wholesale) is EC$1.20 per can of product. This price has been increased 8% per year compounded.

19. Finance Required: Start-up cost estimated to be equal to total capital items (EC$401,000) plus amount equal to one-half first year operating cost (EC$166,800), or EC$567.800. Of this amount, the client would provide EC$192,800 for land, site work, building and trucks. Loan financing of EC$375,000 would be needed for balance of cost.

20. Repayment: Projections assume a two-year moratorium of repayment, with 9% interest due compounded and added to principal. Thus the principal amount due in year 3 is EC$445,540. Pay-back is projected over 10 years, beginning in year 3, at an equal annual payment of EC$69,424.

cartons are the largest operating expense, accounting for 58% of total operating cost.

V. ISSUES

A. MANAGEMENT & SUPERVISION

The proposed canning project will be an entirely new business venture for the client, and generally unrelated to the experience gained in his current successful construction enterprise. Moreover, the client does not envision becoming less involved in his construction business; rather, he will assume the overall management of the cannery in addition to his current activity. Day-to-day supervision of cannery operations will be accomplished by a hired staff, including a general manager and two senior line technicians or supervisors.

Is it reasonable to assume that the client can take on this increased responsibility? Closely related to this issue is another question of the availability of appropriately trained or skilled personnel to assume the day-to-day operational positions called for in the project design. The CDB should discuss these issues with the client, and perhaps explore the feasibility of including training experiences for key staff members as part of the project design and financial plan.

B. RAW MATERIAL SUPPLY

The volume of fruits required by the proposed cannery and the methods for assembly appear to be clear in the project description. Although St. Lucia appears to have adequate raw

material supply, the scattered nature of the supply across the island calls into question the problem of assembling the supply in the right time and place. How will the raw material supply be coordinated and delivered to the plant?

The issue here is what evidence is there to assume that more than 600,000 pounds of these various fruits are readily available in the commercial sense? That is, produced in a location that makes harvest and transport practical; and allows for a timely flow to meet plant requirements?

The CDB should assist the client to more clearly identify sources of supply. Experience with food processing enterprises in the region and in other areas indicates that the question of adequate raw material supply is too frequently overlooked.

PORK MARKETING

An

AGRI-BUSINESS PROJECT PROFILE

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For

THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

And

THE CARIBBEAN DEVELOPMENT BANK

March 1980

This document does not assume the approval (nor imply such) of the United States Agency for International Development, the Caribbean Development Bank or any of their officers.

AGRIBUSINESS PROJECT PROFILE

DATE: March 20, 1980

PROJECT TITLE: Pork Marketing

LOCATION: St. Lucia

CLIENT: St. Lucia Pig Producers' Cooperative Society

LOAN REQUIRED: EC$650,000

I. Background

The annual consumption of pork and pork products in St. Lucia is estimated to be 1.8 million pounds. More than half (55%) of this volume of pork is said to be supplied by imports, while about 800,000 pounds of pork are produced by local growers. The policy of the National Government is to become more self-sufficient in pork production, and toward this end it has established a program to produce improved breeding stock that are sold to qualified farmers at reasonable prices. Extension training and veterinary services are also provided to St. Lucian pig farmers as an incentive to increase national pig production.

Nevertheless, most pig producers point to several major constraints to national pig production that yet remain to be resolved. First, the cost of proper feed is very high in St. Lucia, and the conversion of feed to weight is significantly lower in tropical conditions when compared with similar feed rations in temperate climates. Secondly, pig producers point to the inadequate structure and conduct of the present market for pigs and pork. The market is highly fragmented, being dependent mostly on part-time village butchers and a very few buyers in Castries. The pig producer is therefore faced with a high degree of uncertainty as to who might buy his pigs. This uncertainty is magnified as the number of pigs any individual may have for sale is increased. Therefore, most farmers are unwilling to assume the exposure to marketing risks that

increased pig production would require under the present marketing structure. Thirdly, pig producers in St. Lucia point to the administratively set price controls of pork as a disincentive to increased pig production. Control prices for pork are said to be used by pig buyers as a reason to give unfairly low prices to farmers, while some of these same buyers are reportedly finding ways to elude the price controls when they sell. The pig producers feel that the current level and system of price control is especially unfair in view of the absence of any control on the prices of imported pork meat. Finally, the inadequate facilities for slaughtering and butchering pigs in St. Lucia is cited as a constraint to increased production of pigs. The absence of such facilities is said to limit the market for St. Lucia pork - not only on grounds of poor sanitation, but because of the poor cutting techniques utilized. Thus, those restaurant, hotel, supermarket and other potential clients that require standard cuts cannot depend on local butchers to reliably supply their needs.

II. Origin of Project

Through the efforts of several pig farmers, assisted by the Government livestock officer, the St. Lucian Pig Producers' Cooperative Society was recently organised and duly registered (February 1980). It is the intention of this co-op to address the problems of St. Lucian pig producers by providing needed services not now available and to provide an organized channel for promoting needed policy changes.

The cooperative membership has agreed that its first efforts should be directed toward improving the market structure for pigs. The Government of St. Lucia is apparently very supportive of the pig co-op and is actively assisting the co-op to assume a leadership role in the pig industry. The CDB has undertaken discussions with key co-op leaders at the request of the current Minister

of Agriculture and Chief Agricultural Officer. In addition, the Senior Livestock Officer has actively participated in these discussions.

III. Project Description

A. Purpose

The purpose of this project is to increase the volume of nationally produced fresh pork meat by at least 100% within 5 years, through a national pig producers' processing and marketing cooperative.

B. Project Strategy

The major element of project strategy is to reduce the risks and uncertainty of marketing faced by most St. Lucian pig producers. This will be accomplished by establishing a series of activities, which together, will provide an orderly and routine marketing procedure for pigs. The establishment of an orderly pig market will, in turn, remove a major constraint to increased production.

C. Project Activities

The project will perform six pig/pork marketing functions required to achieve the project purpose.

1. Production Monitoring

The St. Lucia Pig Producers Cooperative is expected to represent 50 growers who will account for about 75% of national pig production. Thus, through voluntary reporting of members as to the number of sows and size of litter, the co-op will be able to forecast with acceptable certainty what the future volume of pig marketing will be. This is an essential function to enable market co-ordination and planning. Given the natural growing cycle of pigs, expected pig production and resulting market volumes can be predicted by the co-op 5 to 6 months in advance.

2. Purchase and Assembly

The cooperative will perform the functions of "farm-gate" purchase, assembly, and transport of live pigs. This activity is of central importance since pig producers currently are faced with considerable uncertainty regarding farm level sales. It is envisioned that with prior notification, the co-op will fix a definite date, time and place where farmers' pigs will be collected. The farmer will be given a receipt for his pigs and the co-op will then transport them to a central slaughter facility where the pigs are inspected, weighed, and a price per pound established. The farmer will then be issued a cheque in the amount of the total purchase price. This system of collection and payment is not unlike the procedures used in the banana industry.

While minimum base prices may be established at the point of pick-up, so that the farmer may know at least the minimum price he will receive, it is of greater importance to the farmer to know that a market buyer is insured. Thus, it is the combined function or service of physical collection, transport, and ultimate purchase that will reduce the farmer's exposure to risk in marketing that he now faces.

3. Slaughtering and Carcass Dressing

The cooperative will also perform the function of pig slaughtering. This function includes all those activities required to transform live pigs into dressed warm carcasses. Currently, there is no slaughter facility exclusively for pigs in St. Lucia. Aside from the multi-purpose slaughter facilities in a few urban areas, (usually associated with the central market building) pigs are slaughtered and "cut-up" by part-time village butchers.

4. Butchering and Meat Cutting

The cooperative will undertake the function of proper butchering and producing standard cuts of pork. A major outcome of this activity will be the

ability to differentiate among the more desirable cuts, and therefore higher value cuts, so that a more profitable pricing strategy can be employed. Restaurants and hotels can be supplied with standardized cuts of certain roast, chops, etc; while meat processors can be supplied with hams, bacon cuts and sausage meats; and lower income families can be supplied with less expensive trotters, shoulders, etc.

5. Storage and Distribution

The cooperative will necessarily perform storage and wholesale distribution functions. These functions will include chilling and freezing of pork, as well as wrapping and packaging as necessary. It is important to note that the cooperative does not intend to establish a retail outlet, but rather will sell in wholesale lots, ex-storage facility. At present there is no well organized wholesale pork outlet in St. Lucia for local production, and this is partly responsible for the continuing dependence on imported pork supplies. It is believed that a significant proportion of the current demand for pork supplied by imports can be satisfied by national production if buyers can be assured of a reliable source of properly prepared cuts. Hence, the storage and wholesale function of this project is the final link in the chain of activities to provide a more orderly and routine marketing procedure for pigs and fresh pork in St. Lucia.

VI. Project Cost and Returns

Preliminary projections of project cost and returns for a 12 year period are presented in Table 1. These projections assumed a full operating capacity of 10,000 pigs per year, which would be attained in the fifth year of operation and sustained thereafter. During the first years of operation, projections have assumed only 2,000 pigs in year 1: 3,000 in year 2; 6,000 in year 3; and 8,000 in year 4.

All cost for year 1 are based on current prices of pigs, which is put at EC$2.15/lb (live weight) and is substantially above current prices received by farmers. Similarly, selling price of fresh pork projected in year 1 is EC$3.50/lb (wrapped and frozen) which is 40% above current price ceilings. For years 2 through 12, all prices paid and received by the co-op have been increased at a compounded rate of 8% per year.

At the end of year 12, a cumulative cash return, less the amount of interest paid, is EC$1,849,341 on an initial investment of EC$320,000; for a ratio of 5.78 to 1.

An estimated loan of EC$650,000 is assumed (equivalent to about 97% of total finance required). This loan, carried at an annual interest rate of 9%, would be repaid over a nine year period in equal annual payments of EC$153,042. As can be seen in Table 1, a three year moratorium is given on loan repayment, with interest due being compounded and added to the principal amount due.

TABLE 1

PROJECTED COST AND RETURN FOR PIG/PORK MARKETING PROJECT

(EC$000's)

YEARS

	1	2	3	4	5	6	7	8	9	10	11	12
1. CAPITAL ITEMS												
1.1 Fixed Assets												
1.11 Land	2.0											
1.12 Site Preparation	5.0											
1.13 Building	70.0											
1.2 Equipment												
1.21 Office	15.0											
1.22 Trucks & Collection Equipment	38.0				51.7					75.9		
1.23 Slaughter Equipment	40.0											
1.24 Butcher Equipment	40.0											
1.25 Storage & Sales	95.0											
1.26 Miscellaneous	15.0											
1.27 Sub-Total	320.0				51.7					75.9		

TABLE 1 (CONT'D)

	1	2	3	4	5	6	7	8	9	10	11	12
2. OPERATING COST												
2.1 Salaries & Wages												
2.11 Manager	24.0	25.9	28.0	30.2	32.6	35.3	38.1	41.1	44.4	47.9	51.8	55.9
2.12 Supervisors	32.0	34.6	37.3	40.3	43.5	47.0	50.8	54.8	59.2	63.9	69.1	74.6
2.13 Labor	15.0	16.2	30.8	50.4	54.4	58.8	63.5	68.6	74.0	79.9	86.4	93.3
2.2 Purchase of Pigs	560.0	907.2	1959.5	2821.8	3809.4	4114.2	4443.3	4798.8	5182.7	5597.3	6045.1	6527.7
2.3 Utilities	5.0	7.0	10.0	20.0	25.0	27.0	29.2	31.5	34.0	36.7	39.7	42.8
2.4 Transport Fuel & Maintenance	6.0	9.9	19.8	26.4	33.0	35.6	38.5	41.6	44.9	48.5	52.4	56.6
2.5 Packaging												
2.51 Poly-wrap	1.0	1.7	3.6	5.3	7.1	7.7	8.3	8.9	9.7	10.4	11.3	12.2
2.52 Cartons	5.0	8.3	18.2	26.6	36.6	39.5	42.7	46.1	49.8	53.8	58.1	62.7
2.6 Repair & Maintenance	9.6	10.4	11.2	12.1	13.1	14.1	15.3	16.5	17.8	19.2	20.7	22.4
2.7 Interest on Inventory Capital	5.3	8.6	18.6	26.7	36.1	38.9	42.1	45.4	49.1	53.0	57.3	61.9
2.8 Miscellaneous Supplies	5.6	9.1	19.6	28.2	38.1	41.1	44.4	47.9	51.8	55.9	60.4	65.3
2.9 Sub-Total	669.6	1038.9	2156.6	3088.0	4128.9	4459.2	4816.2	5201.2	5617.4	6066.5	6552.3	7076.4

TABLE 1 (CONT'D)

	1	2	3	4	5	6	7	8	9	10	11	12
3. TOTAL ANNUAL COST	989.6	1038.9	2156.6	3088.0	4180.6	4459.2	4816.2	5201.2	5617.4	6142.4	6552.3	7076.4
4. REVENUE												
4.1 Output (000's lbs)	182.0	273.0	546.0	728.0	910.0	910.0	910.0	910.0	910.0	910.0	910.0	910.0
4.2 Price (EC$000/000lbs)	3.5	3.78	4.08	4.41	4.76	5.14	5.55	5.99	6.48	6.99	7.56	8.16
4.3 Gross Revenue (EC$000's)	637.0	1031.9	2227.7	3210.5	4331.6	4677.4	5050.5	5450.9	5896.8	6360.9	6879.6	7425.6
5. CASH FLOW												
5.1 Income less Cost (5.3-4)	(32.6)	(7.0)	71.1	122.5	202.7	218.2	234.3	249.7	279.4	294.4	327.3	349.2
5.2 Cumulative Return	(32.6)	(39.6)	31.5	154.0	356.7	574.9	809.2	1058.9	1338.3	1632.7	1960.0	2309.2
5.3 Finance Required	669.8	-	-	-	-	-	-	-	-	-	-	-
6. SOURCE OF FINANCE												
6.1 Equity	19.8	-	-	-	-	-	-	-	-	-	-	-
6.2 Loan	650.0	-	-	-	-	-	-	-	-	-	-	-
7. REPAYMENT SCHEDULE												
7.1 Principal Due	708500	772265	841769	917528	847064	770258	686539	595286	495820	387401	269225	140405
7.2 Interest (EC$)	-	-		82578	76236	69323	61789	53576	44624	34866	24230	12637
7.3 Principal (EC$)	-	-		70464	76806	83719	91253	99466	108418	118176	128812	140405
7.4 Total Payment (EC$)	-	-		153042	153042	153042	153042	153042	153042	153042	153042	153042

NOTES ON TABLE 1

1. Fixed Assets: A small area (1 acre) in the Cul-de-Sac Valley is anticipated to be acquired for the project. A building of about 1500 ft^2 is considered adequate. Total cost of land, site preparation and building construction is put at EC$77,000.

2. Equipment: None of the costs shown for equipment are based on firm price quotations. Among the most expensive items of equipment envisioned are (1) a chill room estimated to cost EC$25,000 and (2) a freezer estimated to cost EC$75,000. Total equipment at EC$243,000. Note that trucks and collection equipment, e.g. scales, are replaced in years 5 and 10 - with replacement cost inflated at 8% per year, compounded.

3. Salaries and Wages: The manager and all supervisory personnel, e.g. skill slaughtermen and meat cutters, are assumed to be hired in year 1. Casual labor has been increased proportionally with output during the first years of operation. All salaries and wages are increased by 8% per year.

4. Purchase of Pigs: An average weight of live pigs purchased is estimated to be 130 lbs, at EC$2.15 per lb, or EC$280 per animal. Projected cost are simply the total number of pigs, multiplied by the price, which has been increased at 8% per year, compounded.

5. Packaging: Poly-wrap material for meats is estimated to cost about EC$.50/100 pounds. Cartons suitable for boxing frozen meats are estimated to cost about EC$2.75 each. Assuming each carton to hold about 100 pounds, the project will require about 9,100 at full capacity. Prices of packaging have been increased at 8% per year.

6. Repair and maintenance: These cost are estimated at 3% of total capital items annually, and increased at a rate of 8% per year.

7. Interest on inventory capital: These projections assume that short farm financing will be borrowed against finished product in inventory. An amount equal to one month's production value is assumed at an interest of 10%. For example, in year 7 total production value is EC$5,050 million. Thus, one month's production value is EC$420,875. If this amount is borrowed at 10% interest, then annual cost of interest is about EC$42,100.

8. Misc. Supplies: Cost is estimated to amount to 1% of cost of pigs.

9. Revenue: Output is estimated to be 91 lbs of pork per pig slaughtered. Average price received is put at EC$3.50 per pound, and this price is increased at 8% per year, compounded.

10. Finance Required: Projections assume initial finance required to cover all capital items, plus an amount equivalent to 52% of first year operating cost, or EC$320.000 plus EC$348.800 totalling EC$669.800. Further, assume co-op members will invest EC$400 each as equity and loan will finance the balance required, or EC$650,000.

11. Repayment Schedule: Projections assume three year moratorium on repayment, with interest due being added to the principal at the rate of 9% per year, compounded. Thus, total principal due at the end of year 4 amounts to EC$917,528. This amount is projected to be paid back over a 9 year period in equal annual instalments of EC$153,042.

V. Issues

A. Public Policy of Pork Prices

A key assumption of this project is that the current policy of administered price ceilings on fresh pork produced in St. Lucia will be modified. The first change in this policy concerns the willingness of the GOSL to allow maximum prices of pork to rise to levels significantly higher than the EC$2.50 currently allowed. Secondly, it appears that some system of differential pork prices, based on different cuts and quality, must be put into effect so that a more rational marketing strategy can be employed to serve the different market clients.

If a workable policy is to be established that will encourage increased national pig production on the one hand, and on the other hand, accomplish the public welfare goals of keeping food cost at affordable prices, then the current "one price" approach to price control will need to be replaced with a "set of prices" that more realistically represent the demand of the various market clients.

At the heart of this issue lies the questions: "At what price is St. Lucia willing to achieve increased self-sufficiency in pork?"; "what proportion of this price is likely to be borne by whom?"; and "what are the likely developmental impacts (both positive and negative) of a nationally self-sufficient pork policy?". In the final analysis, these questions must be answered by the political leaders, and rightfully so. Nevertheless, these leaders and decision makers need information which technical analysts can provide as to the likely effect of policy alternatives.

The project proposed here could well serve as an appropriate institutional framework to implement certain policy changes that would effectively improve the

"well-offness" of both the pig producers and pork consumers in St. Lucia.

On the occasion of undertaking this loan appraisal, the CDB should, as a first step, offer to assist the GOSL to accomplish the technical analysis of alternative national pig/pork production policies. Indeed, a policy decision regarding future pork pricing policies is almost essential before a proper project appraisal can be confidently accomplished.

B. Institutional Capacity

The proposed project will be implemented by the St. Lucia Pig Producers Cooperative Society, a new organization, the membership of which has had little experience in business enterprises of the scale contemplated here. While the project operations will be accomplished under the direction of professional, full-time management team, there is still a question of how cohesive the co-op membership will be in the long-run. The success of the project, in large part, will depend on the loyalty of the co-op membership during the first years of operation when negetive cash flows are projected. In other words, the infusion of loan capital alone is not sufficient to insure the success of the project, but must be accompanied with the understanding and commitment of the membership. The issue here is what provisions are being made to assist the co-op members and officers better understand the organization and its purposes? Is any regular program of education planned so that the membership can vote with informed opinion on co-op policy issues? Should technical assistance in this area be planned as a part of the project design?

C. Market Strategy

The project description is clear that the co-op intends to wholesale "portion-cuts" of frozen pork. What is the rationale for providing this service? For example, why could not the co-op sell chilled pork to those clients that

already have freezer capacity? This is an issue because of the exceptionally high cost of freezer equipment and the associated operating cost.

Related to the question of frozen vs. chilled pork, is the question of exactly who are to be the major clients for the co-op pork? The project description lacks definition other than citing global consumption data. What is the anticipated market relationship with commercial pork processing firms in St. Lucia? And in what form would they prefer to purchase pork?

The CDB should assist the co-op to better ascertain the size and structure of the various market segments it intends to serve. Such a determination may have significant implications for the design and operation of its butchering facilities.

D. Pig Production and Supply

Little information is contained in the project description concerning the current size and distribution of pig production in St. Lucia. In particular, nothing is said to indicate the production capacity of the 50 co-op members. It is implied that "demand will create supply". While this may be true, there is a legitimate question about what evidence is available to indicate that the 50 members have the resources to increase the number of breeding stock to attain a production of 10,000 pigs annually? For example, if an average number of pigs saved per litter is assumed to be 7; and further assume each sow would farrow twice per year, then about 720 sows would be required to produce 10,000 pigs per year. This implies each co-op member would keep about 15 sows. Is this realistic?

The CDB should assist the co-op to determine with more certainty what the expected growth of the pig industry is likely to be and identify any production constraints that may need to be addressed in this project or in some other way.

ANTHURIUM PRODUCTION/MARKETING

An

AGRI-BUSINESS PROJECT PROFILE

Prepared by:

William B. Baucom

Refugio I. Rochin

James C. Cornelius

E. Reginald Buckmire

For

THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

And

THE CARIBBEAN DEVELOPMENT BANK

March 1980

This document does not assume the approval (nor imply such) of the United States Agency for International Development, the Caribbean Development Bank or any of their officers.

AGRI-BUSINESS PROJECT PROFILE

DATE: MARCH 20, 1980

PROJECT: ANTHURIUM PRODUCTION/MARKETING

LOCATION: ST. LUCIA

CLIENT: (FIRM TO BE NAMED)

MR. AIDAN FLOISSAC

DR. JOSEPH SESSION

LOAN REQUIRED: EC$190,000

I. BACKGROUND

The Anthurium Lily is a tropical flower which has an established and evidently growing market in the U.S. and Europe as an ornamental cut flower for aesthetic design purposes. The anthurium has been considered an exotic flower, but continued export sales and overseas market development are enhancing the broader acceptance of this product.

At the present, the largest producers and exporters of anthuriums are located in Holland, Hawaii, Jamaica and Mauritius. The success and growth of anthurium production in the Caribbean (Jamaica) has given rise to optimism for a commercial scheme of this flower in St. Lucia, utilizing proven growing technology.

A commercial anthurium lily production and marketing operation in St. Lucia would be expected to: 1) take advantage of a growing export market thus generating foreign exchange; 2) employ a local labour force; and 3) utilize a relatively low capital technology to sitmulate the associated commerce.

II. ORIGIN

The idea of this anthurium lily enterprise was the product of two private businessmen in St. Lucia, specifically Dr. Joseph Session and Mr. Aidan Floissac. Dr. Session has had direct professional experience with the anthurium production and exporting industry in Jamaica, and possesses the technological expertise to support this endeavour. Mr. Floissac in addition to growing bananas and livestock, is a businessman with varied commercial interests.

These businessmen conceived and formulated this project and apparently plan to approach the CDB for required financing.

III. PROJECT DESCRIPTION

This project will produce Hawaiian Red Anthurium lilies in St. Lucia for sale in overseas markets. Preliminary plans have been drawn up projecting a ten year span of operation, reaching maturity in the sixth year with a 20 acre production base, capable of growing and marketing a maximum of 186,000 dozen anthuriums in the 8th year.

Gross sales (in 1980 nominal figures) will expand from over EC$200,000 in the second year of operation, to in excess of EC$3.4 million in the 8th year. A positive cash flow (utilizing financing) has been projected for the entire 10 year life of the project. Cash flow projections and assumptions are illustrated

in the accompanying tables provided by the entrepreneurs.

To paraphrase the investor's objections: the early self-generation of revolving investment funds reduces the cash operating requirements of the enterprise. The project is expected to be a generous foreign exchange earner, is low on energy consumption and generates employment (30 employees at peak operation; 10 full time), and revenue to the St. Lucian Government.

This anthurium project is designed primarily around the production of the cut flower product.

The plants are to be grown in a modified, enclosed environment where production conditions can be closely monitored. The initial plants will be obtained from a combination of Dr.Session's own nursery and Jamaican sources. The first year's blooms (flowers) would be marketed locally, with subsequent crops of greater volume and quality destined for export markets in the US and Europe. Expansion of production in subsequent years will be facilitated through a nursery operation internal to this enterprise.

The prospective owners plan to market FOB St. Lucia, ideally through joint ventures with wholesalers, thus reducing exposure to market uncertainty. At the present time, there is some seasonality in the demand for anthuriums in the world market,

with a peak in the winter months (November and April) and a slackening in the summer.

Due to the anticipated early generation of positive flow in this project, financing requirements are projected only in the first two years, at EC$100,000 and EC$90,000 respectively. Owners' equity financing is projected only for the first year, at EC$30,000. Inclusion of joint venture with an off-shore marketing firm could further increase the amount of internal equity and thus reduce loan financing requirements.

An attractive feature of this proposal is the relatively low dependence upon fixed capital investment. As a result, particularly in latter years, nearly all costs are available in nature, such that production might be scaled up or down within fairly broad ranges without adversely affecting financial security. Only in the first two years do fixed costs comprise a majority of expenditures, at 70% and 63% respectively. Accordingly, the first two years are crucial to the success of the enterprise. A two year moratorium on principal repayment is proposed in the cash flow figures.

IV. PROJECT COST AND RETURNS

Projected project cost and returns for a 10 year period are presented in Table 1, and accompanying notes on the following pages. A positive cash flow is generated in all years.

In year 10, a cumulative net cash flow is projected at EC$13.4 million, from an initial investment of EC$220,000; or a ratio of 60.9 to 1.

CASH FLOW PROJECTION

ANTHURIUM PROJECT

YEAR	1	2	3	4	5	6	7	8	9	10
ANNUAL PLANTING (ACRES)	1	1	2	4	6	6	-	-	1	1
CUMULATING ACREAGE	1	2	4	8	14	20	20	20	20	20
INCOME:										
EQUITY	10,000	-	-	-	-	-	-	-	-	-
DIRECTOR'S LOAN	20,000	-	-	-	-	-	-	-	-	-
COMMERICIAL LOANS	100,000	90,000	-	-	-	-	-	-	-	-
SALE OF BLOOMS	-	111,360	278,400	575,360	1,150,720	2,060,160	3,089,500	3,441,000	3,192,320	2,821,120
APPLICATIONS	130,000	201,360	278,400	575,360	1,150,720	2,060,160	3,089,500	3,441,000	3,192,320	2,821,120
SITE PREPARATION	600	600	1,200	2,400	3,600	3,600	-	-	-	-
GREEN HOUSES	24,500	24,500	49,000	198,000	147,000	147,000	-	-	-	-
PLANTS	28,600	28,600	-	-	-	-	-	-	-	-
IRRIGATION	6,700	1,950	3,900	12,600	18,900	18,900	-	-	-	-
EQUIPMENT	9,600	-	-	-	-	17,280	-	-	-	-
HUSKS	6,000	6,000	12,000	24,000	36,000	36,000	-	-	6,000	6,000
ELECTRICITY	1,800	1,600	5,000	5,600	9,000	15,000	15,000	15,000	15,000	15,000
BUILDINGS	2,000	30,000	-	-	-	-	-	-	-	-
TRANSPORT	1,000	30,000	-	-	-	-	-	30,000	-	-
AGRICULTURAL CHEMICALS	1,200	2,800	5,200	10,200	16,800	22,600	27,000	27,000	26,500	36,500
SECURITY	1,500	500	1,000	2,000	3,000	3,000	-	-	-	-

C/Fwd.

PACKING MATERIALS	-	6,600	13,900	28,800	57,500	103,000	154,500	172,000	159,600	141,000
REPAIRS & MAINTENANCE	-	400	400	800	2,000	4,000	4,000	4,000	4,000	4,000
LEGAL, INS., ACC, BANK CH. ETC.	5,000	6,000	8,000	12,000	12,0000	15,000	15,000	18,000	15,000	18,000
SUPERVISION	-	12,000	12,000	14,000	15,000	15,000	16,000	18,000	18,000	18,000
LABOUR	12,000	16,000	28,000	60,000	90,000	100,000	100,000	110,000	110,000	110,000
RENTAL	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
CONTINGENCIES (5%)	5,300	8,600	7,100	13,800	20,790	25,270	16,825	19,800	17,950	17,000
INTEREST (9.5%)	11,400	19,950	19,950	13,300	6,650	-	-	-	-	-
LOAN REPAYMENT	-	-	70,000	70,000	70,000	-	-	-	-	-
TOTAL EXPENDITURE	122,200	200,100	239,650	372,500	513,240	530,650	353,325	415,800	377,050	357,500
ANNUAL BALANCE	7,800	1,260	38,750	202,860	637,480	1,529,510	2,736,175	3,025,200	2,815,270	2,463,620
NET CASH FLOW	7,800	9,060	47,810	250,670	888,150	2,417,660	5,153,835	8,179,035	10,994,305	13,457,925

NOTES ON CASH FLOW PROJECTION

INCOME.

1. EQUITY - 10,000 Ordinary shares at par E.C. $1.00.

2. LOANS - (a) Director's loan of E.C. $20,000.00.

   (b) It is proposed to seek a wholesaler who will be interested in owning upwards of 15% of equity and who will make an interest bearing loan to the businnss.

   (c) Loan finance for the rest of the cash requirement will be sought through a financing institution.

3. SALE OF BLOOMS -

   (a) Determination of Production (Export)

   Year 1 - 1 Bloom/Plant - Local market
   " 2 - 6 Blooms/Plant
   " 3 - 9 " "
   " 4 - 10 " "
   " 5 - 10 " "
   " 6 - 9 " "
   " 7 - 8 " "
   " 8 - 6 " "
   " 9 - 1 Bloom/Plant - Local market
   " 10 - 6 Blooms/Plant

   (b) Exportable Production (1000)

Acres	1	1	2	4	6	6	Total	Doz.
Year 1	-	-	-	-	-	-	-	
2	72	-	-	-	-	-	72	6
3	108	72	-	-	-	-	180	15
4	120	108	144	[illegible]	-	-	372	31
5	120	120	21[illegible]	[illegible]	-	-	744	62
6	108	120	240	432	432	-	1332	111
7	96	108	240	480	648	432	2004	167
8	72	96	216	480	720	648	2232	186
9	-	72	192	432	648	720	2064	172
10	72	-	144	384	576	648	1824	152

(c) Current IOB Prices:

					U.S.
Minis	120/cartons	-	7 CM	- US$32.00	= $3.20/doz.
Small	60/ "	-	10 CM	- US$26.40	= $5.28/doz.
Medium	50/ "	-	10/15 CM	- US$28.50	= $6.84/doz.
Large	30/ "	-	15/20 CM	- US$23.10	= $9.24/doz.
Extra Large	20/ "	-	20+ CM	- US$19.50	= $11.68/doz.

(d) Gross Sales:

Year 1		
" 2	-	EC $ 111,360
" 3	-	278,400
" 4	-	575,360
" 5	-	1,150,720
" 6	-	2,060,160
" 7	-	3,089,500
" 8	-	3,441,000
" 9	-	3,192,320
" 10	-	2,821,120

(e) Assumptions:

1. First year's blooms are not exportable and may be sold locally, but such sales are limited and are not included in the projection.
2. Income is based on an average bloom size of 10-15 CM.
3. Replant every 8 years.
4. 15,000 plants are accommodated per acre but production is based on 12,000 plants.

4. Green Houses:

Covered and enclosed with saran to give 73% shade. Supports of load-bearing tensioned heavy cable for supporting saran. Outer edges of wood to support the enclosing saran.

5. Plants:

Variety - Hawaiian Red Hybrids

Source - Jamaica and local nursery plants produced in-house for expansion in third year and onwards.

6. IRRIGATION:

Proposed to install microjet with 360 coverage at 1200 per acre.

Water supplied by stream on property.

7. EQUIPMENT:

One cremasco mascretaor and mist blowers.

8. BUILDINGS:

Basically a shell with sanitary block, storeroom and office attached. The open shell will be multipurpose for packaging, assembling, changing, recreation, dining and conference by the use of portable partitions..

9. TRANSPORT:

Vehicle adapted for carrying blooms to airport at 60- 70° F temperature.

10. AGRICULTURAL CHEMICALS: Including, Nematicides, Insectitides, Fungicides, Fertilizers, Acaricides, Calcium Oxide, trace elements.

11. PACKAGING MATERIALS: Foot stapler, shredded paper, diothene, staples, cardboard cartons, labels, secateurs.

12. LABOUR:

Permanent trained workforce of 10 persons.

Intermittent labour of up to 30 persons.

V. ISSUES

A. Probably the most outstanding issue concerning this project is the question of sustained market opportunities. More definite information is required as to the current volumes demanded, and the likely increases in this demand. Moreover, it would seem prudent to estimate the proportion of the market demand that would be accounted for by the production envisioned in this project (which is 100,000 dozen annually in year six). The project appraisal committee should assist the client to accomplish a more in-depth assessment of the anthurium market. In addition, the client should follow-up on the possibility of securing a reputable marketing agency as an equity partner and arrange for firm supply contracts of at least a portion of the anticipated production.

B. Closely related to the question of markets, is the issue of reliable air-cargo services out of St. Lucia on a regular basis. It is reported that the relatively small air-cargo space now available to Europe is frequently filled to capacity upon arrival, St. Lucia being an intermediate stop, and in general cannot be counted on with certainty. Moreover, it is reported that several businesses in St. Lucia (agricultural and manufacturing firms) are expanding their product lines and intend to utilize air-cargo services for export. The point here is that the export sale of cut flowers from St. Lucia is feasibly <u>only if</u> air-cargo services are reliably provided. What evidence is available that these services will in fact be provided for the volumes required?

C. The proposed client will be a new firm (now in the process of being registered), and therefore has no assets other than those described in the project. Since the firm intends to rent land, there is no "first-class" security which the firm can put forward as collatoral for the loan. In discussions with the principals of this proposed firm, it was indicated that one of the individuals would be willing to offer his own property as loan security. This property is apparently the same land upon which the anthurium will be sited. The loan appraisal committee will need to evaluate this element of the loan proposal in light of standard bank policy.

SOILLESS CULTURE VEGETABLE PRODUCTION

An

AGRI-BUSINESS PROJECT PROFILE

Prepared by:

William B. Baucom

Refugio I. Rochin

James C. Cornelius

E. Reginald Buckmire

For

THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

And

THE CARIBBEAN DEVELOPMENT BANK

March 1980

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AGRI-BUSINESS PROJECT PROFILE

DATE:	MARCH 20, 1980
PROJECT:	SOILLESS CULTURE VEGETABLE PRODUCTION
LOCATION:	ST. LUCIA
CLIENT:	DENNERY FARMCO LIMITED
LOAN REQUIRED:	EC$1,000,000

I. BACKGROUND

The year-round production of certain vegetables in St. Lucia is a risky enterprise. This is especially true of the so called salad vegetables such as tomatoes, lettuce, cabbage, green onions, green peppers etc. Therefore, for much of the year local production of these vegetables is not available in sufficient quantities and imports are required to satisfy the market demand. Imported vegetables are very costly and often of relatively poor quality.

The volumes demanded in St. Lucia of these vegetables are relatively small compared to traditional food crops such as ground provisions. Nevertheless, there is an estimated sustained demand for salad vegetables of at least 10,000 pounds per week accounted for by the hotel, restaurant and supermarket trade. Given the patterns of weather and other field production problems, local farmers are unable to reliably supply even this small volume of demand for much of the year.

If this problem is to be overcome, then a different production technology will need to be employed. It is proposed that a particular type of soilless culture be used, known as NFT or

Nutrient Film Technique. This technique offers protection from the mechanical damage associated with driving rains. NFT also isolates the crops from soil which has problems of disease, salinity and poor drainage. Costly cultivation is avoided and rapid "turn-around" of crops is readily achieved.

Growing of vegetables by NFT is practiced in many parts of the world, including the Caribbean. It is a capital intensive technology requiring skilled management although it is reported to be less complex than traditional "Greenhouse" culture. This project proposes to establish a relatively small, i.e. less than two acres, intensive vegetable production unit using NFT. The production will be solely for the domestic St. Lucian market.

II. ORIGIN

Dennery Farmco Ltd. is a new company (registered in 1978) and is a major agricultural production enterprise in St. Lucia, operating over 2,500 acres on a lease basis. Principal crops of this farm are bananas, copra and mangoes. Dennery Farmco intends to become more diversified in crop production and is currently evaluating several vegetable crops under traditional field-growing conditions. Certain difficulties related to poor drainage, diseases and weather patterns have convinced the management of Dennery Farmco that soilless growing techniques are appropriate for the production of selected vegetables such as tomatoes and lettuce. Of the alternative soilless technologies available, NFT has been selected as the most appropriate.

The CDB was requested by the Minister of Agriculture, Mr. P. Josie, to explore the feasibility of financing this project. All substantive discussions, however, have been conducted with Mr. Peter Stone, General Manager, and Mr. Brian Crosby, Horticulturist, both of Dennery Farmco Ltd.

III. PROJECT DESCRIPTION

A. PURPOSE

The purpose of this project is to increase the volume of selected vegetables produced in St. Lucia. In particular, this project will increase the proportion of vegetables sold in St. Lucia supplied by local production, while decreasing the proportion of imported vegetable sales.

B. COMMODITIES

The project proposes to concentrate on six vegetables as follows:

• Tomatoes	-	approximately	5,000 lbs/week
• Lettuce	-	"	1,800 heads/week
• Cabbage	-	"	550 lbs/week
• Carrots	-	"	230 lbs/week
• Green Onions	-	"	230 lbs/week
• Green Beans	-	"	350 lbs/week

C. PRODUCTION TECHNIQUES AND AREA

Production of tomatoes and lettuce will be accomplished in covered growing chambers utilizing Nutrient Film Technique. (See Appendix A). The other vegetables will be grown in open sand-beds

under drip irrigation. The total production area is expected to use 79,200 sq.ft. distributed as follows:

- Tomatoes - 43,200 sq.ft.
  (12 NFT growing chambers of 3,600 sq.ft. each)
- Lettuce - 7,200 sq.ft.
  (2 NFT growing chambers of 3,600 sq.ft. each)
- Cabbage - 7,200 sq.ft.
  (12 sand-beds of 600 sq.ft. each)
- Carrots - 7,200 sq.ft.
  (12 sand-beds of 600 sq.ft. each)
- Green Onions - 7,200 sq.ft.
  (12 sand-beds of 600 sq.ft. each)
- Green Beans - 7,200 sq.ft.
  (12 sand-beds of 600 sq.ft. each)

D. MANAGEMENT

The vegetable production project proposed here will constitute a major enterprise of Dennery Farmco Ltd. operations. Overall responsibility will rest with the resident general farm manager; and immediate production supervision will be attended by the resident farm horticulturist. Each of these individuals has more than 25 years of experience in managing tropical farming operations. In addition to the resident management team, the technical services of the Bookers-McConnel Firm are available to Dennery Farmco. Indeed, Bookers has actively assisted in the project design thus far and will continue to do so.

E. PHASING

There are several alternatives regarding the phasing of project implementation. Since the production units are modular, and to some degree independent one from another, they lend themselves to incremental expansion. Thus, the project could be designed to begin with a few units, and expand as more on-site experience is gained. The client has not yet determined the design alternative with regard to implementation phasing. However, four different alternatives have been "costed-out", using different implementation assumptions. Each of these alternatives is presented in the following section, along with the explanatory notes of the client.

F. PROJECT COST

On the following pages, cost and return projections for four alternative designs are presented. These calculations and notes were developed by the client, and are reproduced here without modification.

DENNERY FARMCO LIMITED

Notes on Projections for Soilless Culture

Alternatives. 4 different alternatives have been calculated.

A. Nutrient Film in Covered Growing Chambers

An 18 month pilot project is costed. The full scale commercial project of 14 chambers of 3,600 sq.ft each is programmed to be implemented in the 2nd half of year 2. 12 houses are assumed to be for tomatoes and 2 chambers for lettuce. In the longer term other crops may be grown by this technique but for the purposes of this exercise only tomatoes and lettuce are considered. Net return less interest is $2,582,200 at year 12 for an initial invesument of $894,000 i.e. a ratio of 2.89 to 1.

B. Nutrient Film in Covered Growing Chambers

This alternative assumes the immediate introduction of a full scale unit of 14 growing chambers. As may be expected in view of the higher risk, the net return less interest is higher at $2,841,000 at year 12 for an initial investment of $721,000 i.e. a ratio of 3.94 to 1.

C. Nutrient Film and Sand Culture

This provides for a pilot project as in alternative A but crops more suited to sand culture are assumed to be implemented together with the 14 commercial scale growing chambers in the 2nd half of year 2. The sand culture will consist of 48 600 sq.foot beds which are equally divided at 12 beds each to cabbage, carrots, salad onions and green beans. The return from sand culture is lower than those for nutrient film due to the longer term and lower yield weight per plant grown. This alternative gives a net return less interest of $2,701,200 at year 12 for an initial investment of $1,147,000 i.e. a ratio of 2.36 to 1.

D. Nutrient Film and Sand Culture

Similar to alternative C but without the pilot project. In this instance the net return less interest is lower at $2,308,000 due to the loss of income over the 12 years from the pilot project house. The investment is $951,000 but the ratio of yield to investment is 2.42 to 1.

Summary of ratio of net returns less interest to initial investment is below

Alternative A $2,582,200 = 2.89 to 1
B $2,841,000 = 3.94 to 1
C $2,701.200 = 2.36 to 1
D $2,308,000 = 2.42 to 1

It is suggested that return is not necessarily the most important criteria and the value of the various options in terms of contribution to national self sufficiency needs to be considered.

2. Capital Costs

2.1. The initial costs have been based on up to date quotations and prevailing prices.

2.2. Capital replacements of roofing for nutrient film chambers have been allowed at 5½ year intervals. Provision for replacement of 33% of growing equipment has been made each year.

2.3. Replacement of 5% of sand culture equipment has been provided for each year.

2.4. Costs have been inflated at 10% compound interest per annum.

3. Operating Costs

3.1. These have been based on up to date quotations prevailing labour rates and the best information obtainable.

3.2. Costs have been inflated at 10% per annum.

3.3. General charges of the Company have been apportioned to the project at 15% of 1980/81 estimates inflated at the standard 10%.

4. Yields

These have been conservatively estrapolated from results obtained by growers using similar techniques elsewhere and modified by "in house" experience.

4.1. <u>Tomatoes</u> Each house is expected to yield 10 tonnes per annum from 2 crops i.e. approx 9 lbs per plant per crop. Commercial results elsewhere range up to 30 lbs per plant per crop and higher. Yield has been escalated at 1 % compound per annum to allow for improved techniques and varieties.

4.2. Lettuce Each house is expected to yield 3,750 ½ lb heads per month. Other results show higher weight per head for a growth period of 21 days. 12 crops per annum are expected from each growing point.

4.3. Cabbage 12 sand beds each of 600 sq.ft will be devoted to this crop. 2 crops per year are expected from each bed with an average weight of 2 lbs per plant.

4.4. Carrots 12 600 sq foot sand beds will be devoted to this crop yielding, 2 crops per bed per annum. Each bed yielding 500 lbs per crop - an average weight of approx 1¼ ozs per plant.

4.5. Spring Onions 12 600 sq ft sand beds will each yield 2 crops per annum with an average weight per bed of 500 lbs per crop - approx 32 plants per lb.

4.6. Green Beans 12 600 sq ft sand beds will be devoted to this crop. 1500 lbs per bed per annum are expected.

5. Prices Current average wholesale prices have been used for the basis of the projected income. Selling prices have been - escalated at 9% per annum i.e. 11% slower rise per annum than for costs.

5.1.	Tomatoes	Average current wholesale price $1.80 per lb.
5.2.	Lettuce	As for tomatoes.
5.3.	Cabbage	Average current wholesale price of %1.50 per lb.
5.4.	Carrots	As for cabbage.
5.5.	Spring Onions	As for cabbage.
5.6.	Green Beans	Average current wholesale price of $1.00 per lb.

6. Market Capacity The St. Lucia Marketing Board is prepared to guarantee a market for 10 tons of tomatoes per month. The projected production sales of the other crops is small in relation to current demand and given the high quality produce expected, there is a potential for project expansion within current demands. Demands are expected to rise with the continuing development of the tourist trade and the rise in the stand of living.

Information on market prices and demands has been obtained from the St. Lucia Marketing Board, The Department of Statistics, Hotels, Supermarkets and wholesalers.

7. Government Policy The avowed and widely publicised policy is to stimulate local vegetable production but expansion in production by conventional means is not considered a threat to this project which will provide a consistent and reliable source of supply of quality produce the year round.

8. Other Crops There is great scope for experimenting in the growth and production of a/ wide range of other crops such as melons, lettuce, herbs etc'.

14/3/80

(1)

DENNERY FARMCO LIMITED
Soil less Culture Projections - Alternative A (EC$ 000)

		Total	1	2	3	4	5	6	7	8	9	10	11	12
1.	CAPITAL ITEMS													
1.1	Fixed Assets													
1.1.1	Land			-										
1.1.2	Site works	92		92										
1.1.3	Buildings	376		130					65	71				110
1.2	Equipment													
1.2.1	Nutrient film	1097	100	483	32	36	39	43	47	52	57	63	69	76
1.2.2	Sand Culture													
1.3	Ancillary Equipment													
1.3.1	Mains connection	28		28										
1.3.2	Water Supply	28		28										
1.3.3	Standby power	33		33										
	SUB TOTAL	1654	100	794	32	36	39	43	112	123	57	63	69	186
2	OPERATING COSTS													
2.1	Salaries & Wages													
2.1.1	Supervisory		-	7	14									
2.1.2	Labour		4	35	73									
2.2.	Nutrients		-	25	54									
2.3.	Pesticides		-	9	20									
2.4.	Crop Establishment													
	C/F		4	76	161									

Escalated @ 10% per annum

(2)

DENNERY FARMCO LIMITED

Soilless Culture Projections - Alternative A (EC$ 000)

		Total	1	2	3	4	5	6	7	8	9	10	11	12
	B/F		4	76	161									
2.4.1	Seed		-	3	6									
2.4.2	Other Materials		-	3	6									
2.5	Electricity		2	19	42									
2.6	Insurance		1	5	10									
2.7	Distribution													
2.7.1	Packaging		-	20	39									
2.7.2	Transport		-	3	7									
2.8	Maintenance		1	4	6									
2.9	General charges		180	198	218									
2.10	SUB TOTAL	8408	187	331	495	545	599	659	725	797	877	965	1061	1167
2.11	TOTAL ANNUAL COSTS	10062	287	1125	527	581	638	702	837	920	934	1028	1130	1353
3.	REVENUE													
3.1	Production (000 lbs)	4212	15	204	385	388	391	394	397	400	404	408	412	414
3.2	Price per 000 lbs (EC$)		1800	1962	2139	2331	2541	2770	3019	3290	3587	3909	4261	4645
3.3	Gross Revenue (EC$000)	13478	27	400	824	904	994	1091	1199	1316	1449	1595	1756	1923

Escalated @ 10% Compound p.a.

(3)

DENNERY FAIMCO LIMITED

Soilless Culture Projections - Alternative A (EC$ 000)

	Total	1	2	3	4	5	6	7	8	9	10	11	12
CASH FLOW													
4.1. Income less annual costs (3.3. less 2.11.)	3416	(260)	(725)	297	323	356	389	362	396	515	567	626	570
4.2. Cumulative net return		(260)	(985)	(688)	(365)	(9)	380	742	1138	1653	2220	2846	3416
4.3 Finance Required	1100	300	800										
5. SOURCES OF FINANCE													
5.1. Equity		-	-										
5.2 Loan Capital	1000	300	800										
6. REPAYMENT SCH													
6.1 Interest	833.9	31.5	73.5	115.5	108.4	100.6	92.0	82.4	71.9	60.2	47.3	33.1	17.4
6.2 Principal	1100			67.4	74.5	82.3	90.9	100.5	111.0	122.7	135.5	149.8	165.5

DENNERY FARMCO LIMITED

Soil less Culture Projections - Alternative B (EC$ 000)

		Total	1	2	3	4	5	6	7	8	9	10	11	12
1.	CAPITAL ITEMS													
1.1.	Fixed Assets													
1.1.1	Land		-											
1.1.2	Site Works	84	84											
1.1.3	Buildings	452	118					59	65				100	110
1.2.	Equipment													
1.2.1	Nutrient Film	886	439	24	26	29	32	35	39	43	47	52	57	63
1.2.2	Sand Culture	-	-	-										
1.3	Ancillary Eqpt.													
1.3.1	Mains connection	25	25											
1.3.2	Water Supply	25	25											
1.3.3	Standby Power	30	30											
	SUB TOTAL	1502	721	24	26	29	32	94	104	43	47	52	157	173
2.	OPERATING COSTS													
2.1	Salaries & Wages													
2.1.1	Supervisory		6	13										
2.1.2	Labour		28	62										
2.2.	Nutrients		20	44										
2.3.	Pesticides		7	15										
2.4.	Crop Establishment													
	C/F		61	134										

Inflated at 10% per annum

(2)

DENNERY FARMCO LIMITED

Soil less Culture Projections - Alternative B (EC$ 000)

		Total	1	2	3	4	5	6	7	8	9	10	11	12
B/F			61	134										
2.4.1	Seed		2	4										
2.4.2	Other Materials		2	4										
2.5	Electricity		15	33										
2.6	Insurance		4	8										
2.7	Distribution													
2.7.1	Packaging		18	36										
2.7.2	Transport		3	6										
2.8	Maintenance		3	6										
2.9	General Charges		90	198										
2.10	Sub Total	8147	198	429	472	519	571	628	691	760	834	920	1012	1113
2.11	Total Annual Costs	9649	919	453	498	548	603	722	795	803	881	972	1169	1286
3.	Revenue													
3.1	Production (000 lbs)	4252	177	357	359	362	365	367	370	373	376	379	382	385
3.2	Price per 000 lb (EC$)	3096	1800	1962	2139	2331	2541	2770	3019	3290	3587	3909	4261	4645
3.3	Gross Revenue (EC$ 000)	13166	319	700	768	844	927	1017	1117	1227	1349	1482	1628	1788

Inflated @ 10% per annum

(3)

DENNERY FARMCO LIMITED
Soil less Culture Projections - Alternative B (EC$ 000)

	Total	1	2	3	4	5	6	7	8	9	10	11	1[illegible]
4. Cash Flow													
4.1 Income less annual costs (3.3 less 2.11)	3497	(600)	247	270	296	324	295	322	424	468	510	459	502
4.2. Cumulative net return		(600)	(353)	(83)	213	517	812	1134	1558	2026	2536	2995	3497
4.3 Finance Required	800	800											
5. Sources of Finance													
5.1 Equity	-	-											
5.2 Loan Capital	800	800											
6. Repayment Sch													
6.1 Interest	530	42	84	840	78.9	73.2	66.9	59.9	52.3	43.8	34.4	24.1	12.6
6.2 Principal	800	-	-	49.0	54.2	59.8	66.1	73.1	80.7	89.2	98.6	108.9	120.4

(1)

DENNERY FARMCO LIMITED

Soilless Culture Projections - Alternative C (EC$ 000)

	Total	1	2	3	4	5	6	7	8	9	10	11	12
1. CAPITAL ITEMS													
1.1. Fixed Assets													
1.1.1 Land													
1.1.2 Site works	92		92										
1.1.3 Buildings	376		130					65	71				110
1.2 Equipment													
1.2.1 Nutrient Film	1097	100	483	32	36	39	43	47	52	57	63	69	76
1.2.2 Sand Culture	414		220	12	13	15	16	18	20	21	24	26	29
1.3 Ancillary Equipment													
1.3.1 Mains Connection	28		28										
1.3.2 Water Supply	28		28										
1.3.3 Standby power	66		66										
SUB TOTAL	2101	100	1047	44	49	54	59	130	143	78	87	95	215
2. OPERATING COSTS													
2.1 Salaries & Wages													
2.1.1 Supervisory			8	15)									
2.1.2 Labour		4	37	82)									
2.2 Nutrients		-	25	54)									
2.3 Pesticides		-	9	20)									
2.4 Crop Establishment				)									
C/F		4	79	171)									

Escalate 10% compound per annum

(2)

DENNERY FARMCO LIMITED

Soilless Culture Projections - Alternative (EC$ 000)

		Total	1	2	3	4	5	6	7	8	9	10	11	12
	B/F		4	79	171									
2.4.1	Seed		-	3	6									
2.4.2	Other Materials		-	3	6									
2.5	Electricity		2	21	47									
2.6	Insurance		1	5	11									
2.7	Distribution													
2.7.1	Packaging		-	22	48									
2.7.2	Transport		-	3	6	Escalate 10% compound per annum								
2.8	Maintenance		-	4	9									
2.9	General charges		180	198	218									
2.10	SUB TOTAL	8845	187	338	522	574	632	695	764	841	925	1017	1119	1231
2.11	TOTAL ANNUAL COSTS	10946	287	1385	566	623	686	754	894	984	1003	1104	1214	1446
REVENUE														
3.1	Production (000 lbs)	4731	15	229	435	438	441	444	447	450	453	456	460	463
3.2	Price per 000 lbs (EC$)	3091	1800	1897	2067	2253	2456	2677	2918	3181	3467	3779	4119	4490
3.3	Gross Revenue (EC$000)	14622	27	434	899	987	1083	1189	1304	1431	1571	1723	1895	2079

(3)

DENNERY FAIRCO LIMITED

Soilless Culture Projections - Alternative C (EC$ 000)

	Total	1	2	3	4	5	6	7	8	9	10	11	12
CASH FLOW													
4.1. Income less annual costs (3.3. less 2.11.)	3678	(260)	(951)	333	364	397	435	410	447	568	619	681	633
4.2. Cumulative net return		(260)	(1211)	(878)	(514)	(117)	318	728	1175	1743	2362	3042	3675
4.3 Finance Required	1300	300	1000	-	-	-	-	-	-	-	-	-	-
5. SOURCES OF FINANCE													
5.1. Equity	-	-	-										
5.2 Loan Capital	1300	300	1000										
6. REPAYMENT SCH													
6.1 Interest	976.8	31.5	84.0	136.5	128.1	118.9	108.7	97.4	84.9	71.1	55.9	39.1	20.5
6.2 Principal	1300	-	-	79.6	88.0	97.2	107.4	118.7	131.2	145.0	160.2	177.0	195.6

(1)

DENNERY FARMCO LIMITED

Soilless Culture Projections - AlternativeD(EC$ 000)

	Total	1	2	3	4	5	6	7	8	9	10	11	12
CAPITAL ITEMS													
1.1. Fixed Assets													
1.1.1 Land		-											
1.1.2 Site works	84	84											
1.1.3 Buildings	452	118					59	65				100	110
1.2 Equipment													
1.2.1 Nutrient Film	886	439	24	26	29	32	35	39	43	47	52	57	63
1.2.2 Sand Culture	403	200	11	12	13	15	16	18	19	21	24	26	28
1.3 Ancillary Equipment													
1.3.1 Mains Connection	25	25											
1.3.2 Water Supply	25	25											
1.3.3 Standby power	60	60											
SUB TOTAL	1935	951	35	38	42	47	110	122	62	68	76	183	201
2. OPERATING COSTS													
2.1 Salaries & Wages													
2.1.1 Supervisory		6	13										
2.1.2 Labour		32	70										
2.2 Nutrients		23	50										
2.3 Pesticides		8	18										
2.4 Crop Establishment													
C/F		69	151										

Escalated 10% per annum

②

Soilless Culture Projections - Alternative 1 (EC$ 000)

		Total	1	2	3	4	5	6	7	8	9	10	11	12
	B/F		69	151										
2.4.1	Seed		·3	·6										
2.4.2	Other Materials		3	6										
2.5	Electricity		20	43										
2.6	Insurance		5	10										
2.7	Distribution													
2.7.1	Packaging		20	44	Escalated 10% per annum									
2.7.2	Transport		3	6										
2.8	Maintenance		5	11										
2.9	General charges		90	198										
2.10	SUB TOTAL	9372	218	475	545	599	659	725	797	877	965	1061	1167	1284
2.11	TOTAL ANNUAL COSTS	11307	1169	510	583	641	706	835	919	939	1033	1137	1350	1485
3.	REVENUE													
3.1	Production (000 lbs)	4827	202	407	409	412	415	417	420	423	426	429	432	435
3.2	Price per 000 lbs (EC$)	2990	1740	1897	2067	2253	2456	2677	2918	3181	3467	3779	4119	4490
3.3	Gross Revenue (EC$000)	14433	351	772	845	928	1019	1116	1226	1346	1477	1621	1779	1953

(3)

DENNERY FAISCO LIMITED

Soilless Culture Projections - Alternative (EC$ 000)

		Total	1	2	3	4	5	6	7	8	9	10	11	12
CASH FLOW														
4.1.	Income less annual costs (3.3. less 2.11.)	3126	(818)	262	262	287	313	281	307	407	444	484	429	468
4.2.	Cumulative net return		(818)	(556)	(294)	(7)	306	587	894	1301	1745	2229	2658	3126
4.3	Finance Required	1000	1000											
SOURCES OF FINANCE														
5.1.	Equity	-	-	-	-	-	-	-	-	-	-	-	-	-
5.2	Loan Capital	1000	1000	-	-	-	-	-	-	-	-	-	-	-
REPAYMENT SCH														
6.1	Interest	818.1	50.5	105	105	98.6	91.5	83.6	74.9	65.3	54.7	43.0	30.1	15.8
6.2	Principal	1000	-	-	61.3	67.7	74.8	82.7	91.3	100.9	115.5	123.2	136.2	150.5

IV. ISSUES

A. SECURITY

Dennery Farmco Ltd. is essentially a farm management enterprise that engages in agricultural production using leased land and equipment. The tangible assets of this firm are apparently very limited, and in any case not appropriate in kind or value to secure large loans. A major issue then will be the willingness of a third party to secure the loan requested. It is possible that the Government of St. Lucia (a major shareholder of Dennery Farmco Ltd.) may be willing to provide the required loan guarantee, although this possibility has not been explored with any Government official.

B. DEBIT/EQUITY RATIO

Dennery Farmco Ltd. is apparently not in a position to invest any capital in the proposed project at this time due to cash requirements in other farm enterprises. Thus, the CDB may be requested to extend 100% (or nearly 100%) loan financing for this project. The issue here will involve the justification to make an exception of bank policy to loan such a high proportion of the project cost to a private sector client.

C. EFFECT ON MARKET STRUCTURE

The project description suggests that the proposed vegetable production will only displace imports and not materially effect the market supplied by traditional vegetable growers. While this may be true, especially during certain seasons when local

supplies are short, it seems that the project may compete directly with traditional producers during other seasons. The CDB should further evaluate the probable impact on the local market structure to determine the negative consequences, if any.

D. SELECTED TECHNOLOGY

The project proposed to utilize a capital intensive and relatively new type of soilless culture technology. The need and appropriateness of this technology in St. Lucia (or the Caribbean) is an issue that cannot be ignored. While the client is convinced that NFT is indeed appropriate, the CDB should consult a wider range of opinion. In particular, the potential for replication should be assessed; along with the probable impacts (both positive and negative) on the traditional farming sector.

GROWERS' BULLETIN No. 5

NUTRIENT FILM TECHNIQUE

by
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Glasshouse Crops Research Institute
1979

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INTRODUCTION

The early years of development of nutrient film culture passed relatively unnoticed. A description by Cooper (1973) of an experimental system for growing plants in a shallow layer of nutrient solution soon attracted considerable publicity, however. The first account of the system in a scientific journal followed in 1975. Originally the plants had been grown with their roots in nutrient solution circulating between two layers of polythene sheet. Lay-flat tubing, with holes cut at suitable intervals, at first appeared to be a very convenient and inexpensive way of achieving the required film of solution, but various difficulties were soon encountered. With the transition from lay-flat tubing to open gullies, thus improving aeration, the system gained support both from progressive growers and from research workers. It was soon apparent that basic research on plant growth in shallow, re-circulating nutrient culture was urgently required to support the developmental work on commercial nurseries and Experimental Horticulture Stations. A Nutrient Film Working Party was therefore set up at the Glasshouse Crops Research Institute to co-ordinate research by specialists drawn from many Departments of the Institute. Close collaboration is maintained with the South East Region Nutrient Film Study Group (Chairman: Mr. P. Lowater), this consisting of growers and ADAS staff, and, more recently, with a similar Study Group based on the Lee Valley Experimental Horticulture Station.

There have been many requests in recent years for an authentic guide to the techniques of nutrient film culture. Members of the Working Party fully appreciated the need for such a guide, but the basic information was, at first, simply not available; research inevitably progresses more slowly than technical innovation, and techniques were changing rapidly. We still cannot claim to have answers to all the questions arising in nutrient film culture. Enough is now known, however, for a preliminary publication to be produced.

The present manual is based primarily on experience of growing glasshouse tomatoes, this being the crop which has received most attention in the U.K. from commercial growers and research workers alike. The general principles involved, however, other than the type and spacing of the gullies, should prove relevant to a wide range of crops.

Nutrient film culture has many advantages over other systems of crop production. In particular it gives control of the root environment, using modern, automated methods. Watering is greatly simplified; it is no longer necessary to make day-to-day assessments of water requirement, and the tedious task of clearing blocked irrigation nozzles is eliminated. Uniformity of nutrient supply is ensured, and nutrient concentrations can be matched to the varying needs of the crop throughout its growth. Root temperature may be raised whenever required, and suitable chemicals for crop protection may be dispersed uniformly at low concentrations throughout the system as necessary. The crop is isolated from the underlying soil with all its problems of disease, salinity, poor structure or drainage. The costly and time-consuming tasks of regular soil sterilization and cultivation are thus avoided, and rapid

'turn-round' of crops is readily achieved.

On the basis of results obtained, particularly by commercial growers, nutrient film culture must now be regarded as a very promising alternative to other systems of tomato and lettuce production under glass. An interim appraisal of the progress and prospects of nutrient film culture for crop production under glass was given by Winsor (1978). Highly successful results have been reported by the ICI Plant Protection Division, Fernhurst (see Spensley, Winsor & Cooper, 1978), and also at the Efford Experimental Horticulture Station. There are currently some 25 hectares (61 acres) of glasshouse crops grown in nutrient film in the British Isles, including 17 ha of tomatoes and 6 ha of lettuce, and the production area continues to increase both at home and abroad.

Nutrient film culture has still not reached the peak of its development, however, and the system requires highly proficient technical management. Tomato growers wishing to try the technique for the first time would be wise to devote only part of their area to solution culture in the first season, thus gaining experience without total commitment of their resources. Very promising results have been obtained with other crops such as lettuce, strawberries and sweet peppers. Owing to problems of disease it is still too early to recommend the technique for commercial production of cucumbers and carnations. This assessment could, however, change rapidly as our experience of using fungicides in the gullies increases.

NUTRIENT FILM LAYOUT

For those not already familiar with the layout of a commercial system for nutrient film culture the basic features are as follows:

(i) a catchment tank containing nutrient solution
(ii) a pump which delivers the solution to the upper ends of the gullies (troughs)
(iii) parallel gullies in which the crop is grown, laid on a slope down which the circulating solution flows
(iv) a catchment pipe, into which the gullies discharge, to conduct the solution back to the catchment tank
(v) monitoring and control systems to maintain overall nutrient concentrations (salinity), pH and water level.

The general layout is illustrated diagramatically in Fig. 1, and the main features of the catchment tank and its control systems are shown in Fig. 2. Examples of commercial installations are shown in Plates 1 and 2, and part of a research installation at the Glasshouse Crops Research Institute is seen in Plate 3.

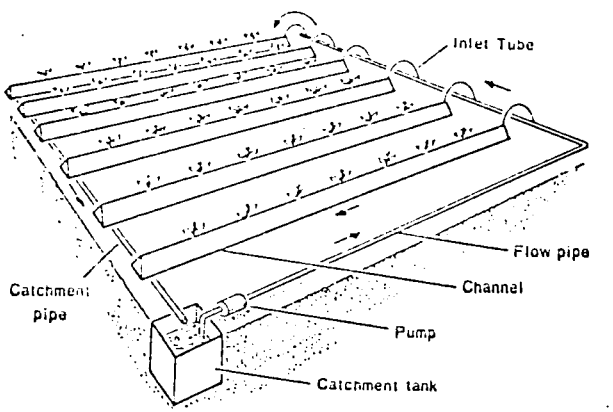
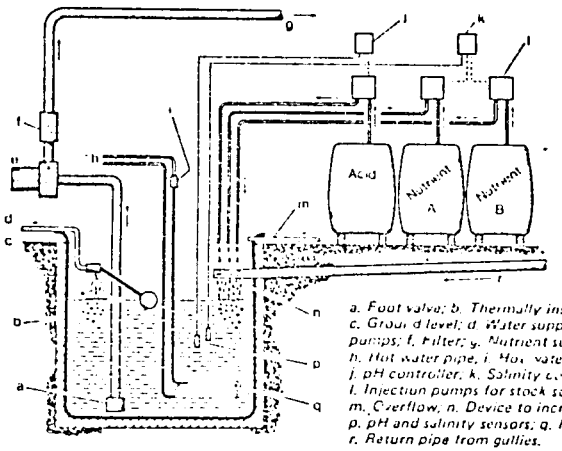


Figure 1. The main features of a nutrient film system.



a. Foot valve; b. Thermally insulated tank; c. Ground level; d. Water supply; e. Circulating pumps; f. Filter; g. Nutrient supply to gullies; h. Hot water pipe; i. Hot water control valve; j. pH controller; k. Salinity controller; l. Injection pumps for stock solutions; m. Overflow; n. Device to increase aeration; p. pH and salinity sensors; q. Heating coil; r. Return pipe from gullies.

Figure 2. Diagram of the catchment tank and nutrient supply system in an automated nutrient film installation.

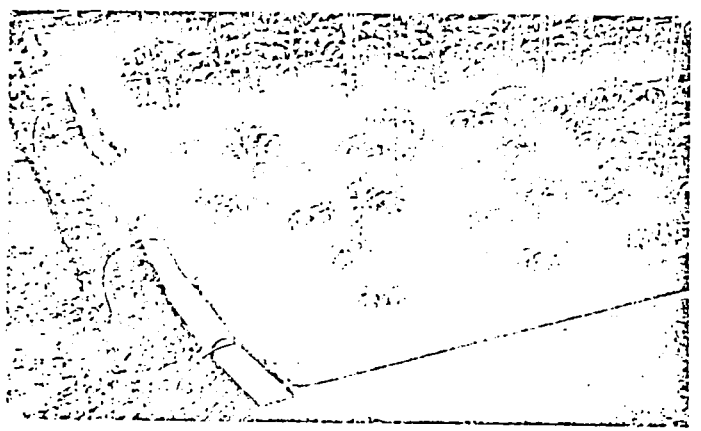


Plate 1. Young tomato plants growing in a nutrient film system, showing the entry of the nutrient solution through flexible pipes at the upper ends of the gullies. The gullies are of the pre-formed type, arranged in pairs between the heating pipes.

Plate 2. Tomato plants in a 'raised' nutrient film system. The gullies, made of stout black plastic, are supported on galvanised iron platforms. The photograph shows the upper ends of the rows, where the nutrient solution enters via pairs of small-bore tubes.

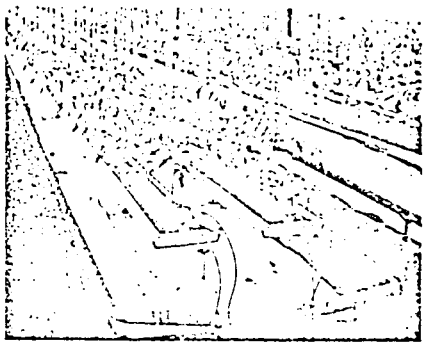
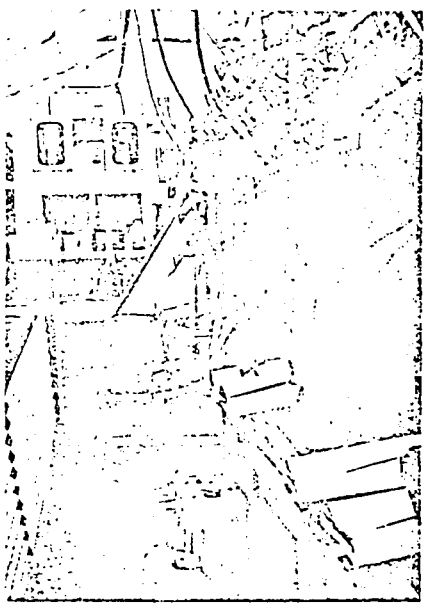


Plate 3. Part of a system used for research on nutrient film culture at the Glasshouse Crops Research Institute. Nutrient solution from the lower ends of pre-formed gullies, here seen planted with cucumbers, is led back to two catchment tanks. The tanks are part of a batch of sixteen, set in a trench to allow ready access. Twin pumps for injection of nutrient concentrates in one of the systems are shown in the foreground.



GULLIES

Various forms of gullies (troughs) are in use, ranging from those made up of plastic film 'on site' to pre-formed products.

Many nurseries have used 'white-on-black' polythene of 600–1000 gauge, purchased in widths of 650–700mm for tomatoes. The heavier gauge of polythene gives a smoother base for even spread of solution, whilst the thinner materials, being cheaper, would normally be discarded rather than re-used. The sheeting is laid in position, black side uppermost, on the prepared supporting surface; the sides are raised and ultimately stapled together between the plants to form a gully of triangular cross-section. The width of the base should be about 250–280 mm for tomatoes, and slightly wider (300 mm) for cucumbers. The ends of the gully are folded and stapled together to complete the construction (Plate 4). The nutrient solution is usually introduced by a small flexible pipe (a 'pipette'), sometimes provided in duplicate as a protection against blockage, at the top of the gullies (see Plates 1 and 2).

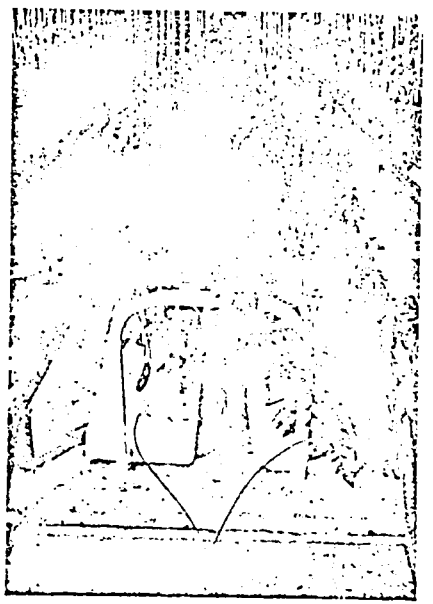


Plate 4. Gullies formed of white-on-black polythene sheeting, with the ends folded and stapled. The metal tubing at the ends of the rows carries horizontal wires for layering the tomato plants.

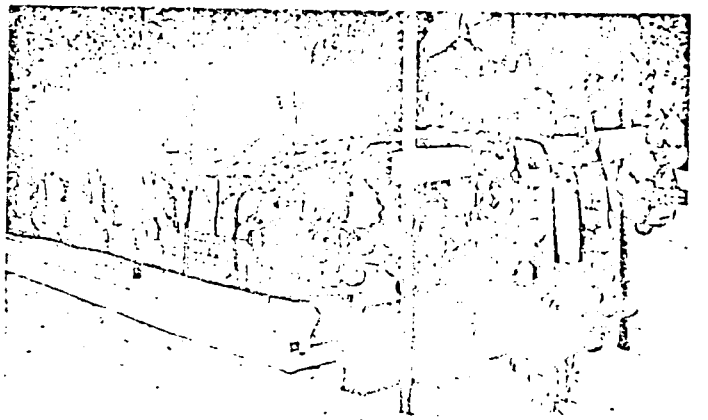


Plate 5. Pre formed white-on black plastic gullies in use with a layered tomato crop.

Alternately, a pre-shaped form of gully may be purchased, made of heavier gauge white-on black plastic and clipped together at the top with removable clips (see Plate 5).

Where possible the layout of the gullies should be such as to avoid unduly long runs; a maximum of 20 m is suggested. Whilst longer gullies have been used commercially, these could accentuate any problems of poor aeration which may arise. Alternatively, it may be helpful to introduce the nutrient solution into the gullies at 2–3 points along their length as well as at the top; this practice has been adopted by ICI Plant Protection Division at Fernhurst.

Nutrient film culture was originally developed as a low-cost system using lightweight, disposable, gullies, and it is in this form that it is currently being studied at the Glasshouse Crops Research Institute. The principle of crop production in a thin layer of flowing solution has also been extended commercially, however, to include shallow gullies formed in the sloping concrete floor of the glasshouse. This concept is particularly suitable for the production of small plants at close spacing (e.g., lettuce), and allows the movement of staff and rubber-tyred vehicles over the surface during planting and harvesting. An illustrated description of this system, developed by Mr. L. Dingeman, was given in a supplement to the Grower dated February 24, 1977; see also the issue dated May 3, 1979.

SLOPE AND FLOW RATE

As noted in the preceding section, the nutrient solutions flow down the gullies to the catchment tank under gravity, providing a shallow layer of moisture around the roots. In order to ensure good aeration it is important that the flow rates should be adequate and that the depth of the solution should not be excessive — preferably less than 10 mm even when the root mat is well developed.

To ensure suitable conditions in the root zone it is necessary to provide sufficient slope to give adequate movement of solution along the gully. Since other factors such as width of gully, size of plant container, extent of root development and rate of supply of solution to the gullies also affect the depth of the solution layer, no precise recommendation on slope can be given to meet all situations. In general, however, a slope of 1 in 75 appears suitable for most purposes, and slopes of less than 1 in 100 should be avoided.

The evidence for these recommendations came partly from observation and general experience and partly from direct trials. Data obtained by Spensley (Spensley, Winsor & Cooper, 1979) showed no significant differences in the cumulative yield of tomatoes grown at slopes of 1 in 25 and 1 in 100 from May onwards. The steeper slope was beneficial to early fruit production (March), but this may have been due to a higher temperature rather than to the slope itself, the 1 in 25 slope was provided by means of a raised platform whereas the 1 in 100 slope was on the soil surface.

In addition to providing a suitable overall slope, it is important that the surface be carefully graded to avoid localised regions of deeper solution. In planning the layout, advantage will of course be taken of any natural slopes in the glasshouse. The soil surface should be well compacted initially, and some localised adjustment of the surface may become necessary between crops or even during cropping. In some cases (Plate 4) a very uniform slope has been provided by concreting the floor of the house. In one such instance a second slope at right angles to the flow in the gullies facilitates the return flow to the catchment tank, sited at the lowest corner of the glasshouse block. Air temperatures tend to be lower at the bottom of the slope, and additional heating pipes may be required to overcome this problem.

Although nutrient film culture on a commercial scale at first relied on sloping soil surfaces, there has recently been increased interest in raised systems using rigid platforms and adjustable stands (Plate 2). Such systems, fabricated in galvanised iron, are widely used in Jersey, for example, to support polythene gullies. Pockets of deeper solution due to poor levelling or soil settlement are eliminated by such systems. Furthermore, slopes of 1 in 75 or 1 in 100 can readily be provided in glasshouses where grading the soil would be difficult. Adjustable supports should be provided on both sides of the double rows in order to ensure maximum stability. Care must be taken to prevent any condensate or spillage on the galvanised iron surfaces of the platforms from running back into the catchment system, since this would raise the zinc concentration and damage the plants.

A flow rate of 2 litres per minute per gully would normally be regarded as fully adequate. Higher flow rates (>4 litres per minute) have been suggested for long gullies, provided that the slope is sufficient to ensure that the solution remains shallow.

CAPILLARY MATTING

With the introduction of wide, flat-bottomed, gullies it was at first thought essential to stand the plant pots on capillary matting so as to ensure uniform wetting across the root zone. The matting simplified crop management during the early weeks of plant growth, since none of the young plants could be 'by passed' by the flow of solution. Once the root systems have become established in the gullies, however, there is no longer any need for the capillary matting. Furthermore, since the roots grow downwards through the matting, most of the root system develops underneath where it is likely to be less well aerated.

As a compromise, it was later suggested that a narrow (e.g., 50 mm) strip of capillary matting should be placed across the gully beneath each plant container. This ensured that no plant dried out in the early stages of growth yet left most of the root uncovered, thus combining good aeration with economy. Some growers dispensed with capillary matting entirely; its use is not essential provided that, during the early stages of root development, the pots are moved laterally within the gullies to ensure that all are kept moist by the flow of solution.

Cases of phytotoxicity occurred during the early years of nutrient film culture, attributed to the use of unsuitable or contaminated capillary matting. Only proven non-phytotoxic mattings should be used.

CATCHMENT TANKS

The catchment tank, being the lowest point in the system, is sited below ground level. Fibreglass tanks have proved highly suitable for trial purposes. Pits lined with polythene film have been used for larger installations. More permanent concrete tanks, suitably sealed with resins, are now proving popular. The tank should be covered to exclude light, thus preventing the growth of algae. Enclosure of the tank also helps to limit contamination by soil organisms.

In major installations the tank capacity often represents only some 10–15% of the total volume of solution in the system, the greater part being in circulation in the gullies. It has been estimated that a nutrient film system supporting a mature tomato crop contains up to 50,000 litres of nutrient solution per hectare (Spensley, Winsor & Cooper, 1978). The level of solution in the tank can be controlled by a float valve connected to the main water supply. Alternatively, an electrical system of depth control can be used to operate a solenoid valve in the water supply line; this system is preferable if water usage is to be recorded by a meter.

The design of catchment tanks is still developing by practical experience, the object being to improve mixing of the nutrient solution and thus to ensure reliable control of salinity and pH. Circular tanks, and also rectangular tanks with sloping bases, are being tried commercially. Where two separate return pipes enter the same tank, it is possible to arrange for these to be sited at right angles to each other, the streams thus converging well above the level of solution in the tank to improve aeration. As an alternative to discharging solution into the catchment tank via an open-ended pipe, the use of a short length of slatted plastic piping to increase foaming and dispersion merits further attention.

Some growers of early tomatoes have begun to experiment with intermittent water supply in the very early stages of growth in the gullies, the object being to restrict growth and improve fruit setting and quality under conditions of poor light. If this practice proves beneficial, a considerable increase in tank capacity will be necessary to accommodate solution draining back from the gullies when the pumps are stopped. Restriction of the water supply by delaying the start of continuous circulation of the nutrient solution undoubtedly 'hardens' the plants, but several aspects of the matter still require investigation.

SALINITY CONTROLLERS

Measurement of electrical conductivity provides the only practical method for control of total salt concentration at present available for nutrient film culture. The method is based on the passage of electricity between two or more electrodes immersed in the solution, the conductance increasing with salt concentration. The salinity controller monitors and displays the conductivity, and operates the injection pumps when the measured conductivity falls below the pre-set value. Various types of controller are available, one of which is shown in Plate 6 (right-hand side).

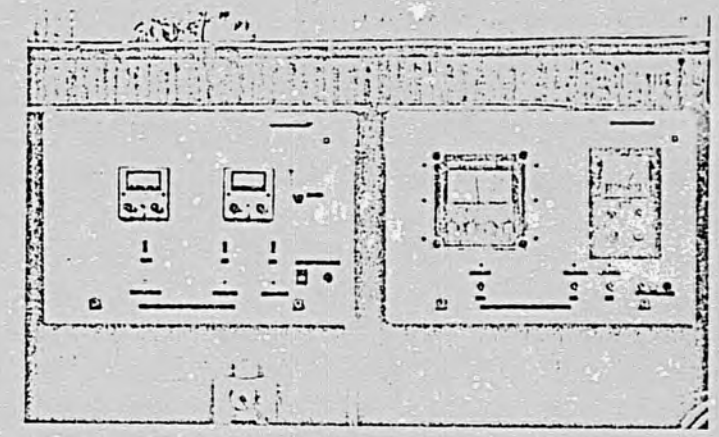


Plate 6. Control panels for nutrient film culture. The unit on the right houses the pH and conductivity controllers. Safety monitors to sound an alarm in the event of malfunction of the primary controllers are mounted in the left-hand unit.

The units of electrical conductivity usually reported for nutrient solutions are micromhos per centimetre (μmhos/cm), more recently quoted as microsiemens/cm; the unit is commonly abbreviated by omitting the reference to centimetres. Other units, e.g. millimhos and 'CF' units, are also in use; the relation between these is as follows:–

1 millimho = 10 CF units = 1000 μmhos

Use of the term 'CF' to describe the electrical conductivity of a solution is undesirable unless the values quoted are in CF units.

The cells now available for conductivity measurements are of robust pattern, usually with carbon electrodes set in a plastic matrix. Such cells require only minimal maintenance. Two main types are available, one being a dip cell suspended in the solution and the other a flow-type cell for incorporation into a pipeline. In the latter case a sampling 'loop' is arranged from the delivery side of the circulating pump; the nutrient solution flows through the conductivity cell before returning to the catchment tank.

Since the electrical conductivity of a salt solution rises with temperature it is usual to provide temperature compensation in the measuring system. The average change in conductivity with temperature is generally taken as about 2% per degree centigrade, and this factor can be used when necessary for approximate conversion of readings from one temperature to another. Several popular conductivity controllers give automatic correction to 25°C, whereas laboratory measurements of salinity in the U.K. are commonly reported as measured at 20°C.

It is not easy to generalise concerning salinity settings for nutrient film culture, since these will vary according to the stage of growth, time of year and the quality of the water. Commercial growers in south-east England, where the water is fairly 'hard', have frequently started with settings of 2500–3000 μmhos in the early stages of tomato growth. Some growers have favoured still higher salinity levels in the hope that growth will be restricted and the setting of the first truss improved, though this concept still awaits verification. Somewhat lower conductivities, 2000–2500 μmhos for tomatoes and 2000 μmhos or less for lettuce seem preferable in mid-summer, when transpiration rates are higher.

Since the salinity of water supplies varies widely in different parts of the country, this factor must be taken into account when setting the controller. A useful, empirical, method for doing this has been adopted at the ICI Plant Protection Division, Fernhurst; see Spensley, Winsor & Cooper, 1978. The electrical conductivity of the water is first measured (reading, say, x μmhos). To this is added the conductivity of a balanced solution of plant nutrients suitable for plant growth, this being taken as 1500 μmhos. The required salinity setting is thus x + 1500 μmhos.

In practice, where the water supply contains appreciable amounts of minerals in excess of plant requirement or where the fertilizers supplied do not match the ratio of nutrient uptake by the crop, a build up of certain nutrients will invariably result. Examples of ions which sometimes accumulate include calcium (from 'hard' water supplies), sulphate (usually when the fertilizer supplies more than the crop requires), together with sodium and chloride (mainly derived from the water supply). Under these circumstances the 'background' conductivity will rise progressively, and proportionate increases in the setting of the salinity controller will be necessary periodically in order to maintain adequate nutrient levels. When the conductivity becomes unduly high for the crop, the nutrient solution should be discarded and the tanks refilled. The salinity levels at which such action becomes justified have not yet been established with any degree of certainty; the adverse effects of salinity are progressive, and will vary according to crop, time of year and stage of growth. As a provisional guide, however, conductivities in excess of 4000–4500 μmhos for

tomatoes or 3000–3500 μmhos for lettuce would seem excessive during the summer months. When refilling the tanks, the water should be heated if necessary to avoid thermal shock to the plants.

Although salinity controllers can maintain the total salt concentration with considerable precision and reliability, they provide no information about the individual nutrients involved. Periodic chemical analyses are therefore required; it is suggested that major nutrients (N, P, K, Mg and Ca) should be determined at 10–14 day intervals, and that the trace elements should be monitored at least once a month. As experience of the system increases, however, less frequent sampling will undoubtedly suffice.

INJECTION PUMPS FOR NUTRIENT CONCENTRATES AND ACIDS

The pumps used to inject nutrients or acids into the catchment tank need to be chemically resistant in all parts which come into contact with the relatively concentrated solutions; several types are available. Electrically driven pumps with plastic diaphragms and with capacities of up to 10 litres per hour have proved popular. Impulse-type injection pumps are also available, delivering a fixed volume (e.g., 0.5–1 ml) of concentrate or acid per stroke. The pumps are activated by their respective controllers, and draw nutrient concentrates and acids from plastic containers for injection into the catchment tank; see Plate 7. Since certain constituents of the nutrient solution must not be mixed in concentrated form (see p. 24), it is usually necessary to provide two pumps for nutrients, working in parallel, in addition to one for acids. The nutrient pumps should be adjusted to give equal outputs, otherwise the composition of the diluted nutrient solution will be affected.

The most favourable position for siting the injection pump outlets may require some preliminary trial; it should not be near the inlet of the main circulating pump, but a quicker response and less danger of overrun will result if the point of injection is not too far from the sensors.

Some large installations use solenoid valves operating on the principle of gravity feed rather than pumps to supply the nutrient concentrates.

Plate 7. Automated control system for a large nutrient film installation. Twin circulating pumps are shown in the left foreground. The three plastic tanks contain the two nutrient concentrates and the diluted acid for pH-control. Three injection pumps are shown immediately above the concentrate tanks. Controllers for salinity and pH are mounted at the top of the panel, above the central tank.

pH CONTROLLERS

The pH of the nutrient solution is usually maintained within the range 5.5–6.5 by a pH-controller (Plate 6, second instrument from the right) linked to a glass electrode in the catchment tank. Where the nitrogen is supplied mainly or entirely as potassium or calcium nitrate the pH of the solution rises during cropping, and the control system operates a pump to inject acid. Values below pH 5.0 may prove unfavourable to the crop and will be corrosive to the circulating pump; most crops will be damaged at pH values of 4 or below. At the other end of the range the availability of trace elements (other than molybdenum) will be decreased as the pH rises above about 6.5.

The pH sensor consists of a glass electrode and a reference electrode, the former in particular being somewhat fragile and normally mounted in a protective casing. Temperature compensation is sometimes also provided

Some controllers incorporate two separate control points (high and low pH). The higher setting can be used as previously described to operate an acid injection pump, switching off when the pH falls to the required value. The lower setting may be used as a safety device to switch off the pump in the event of failure at the higher setting point. Since the pH-electrode itself is the most vulnerable part of the system, however, it now seems preferable to include two separate circuits and pairs of electrodes for pH-control. Of these, one unit functions as the day-to-day pH-controller whilst the other, the 'pH monitor', is available to prevent further injection of acid if the pH falls too low. As noted in the section on Safety Devices, no major nutrient film system should be operated without some form of safety precaution to guard against overdosing; excessive acidity will damage or kill the plants.

The acids chosen for control of pH are nitric and phosphoric, often used in combination so as to reduce the resultant changes in concentration of these nutrients; see section on Nutrient Concentrates. The concentrated acids as purchased should be diluted 1:10 or preferably 1:20 before use; the precise concentration is unimportant since the controller will activate the injection pump until the required pH is reached. Where solenoid valves are used instead of injection pumps, still further dilution may help to avoid undue fluctuations in pH, since delivery into the catchment tank is more rapid.

The procedure followed for handling the acids will vary according to the scale of operations. For small systems a suitable storage cupboard for acids should be provided below bench level; never store acids on a sunny window ledge or close to a radiator or steam-pipe. When diluting the concentrated acids, always add the acid to the water, never add water to a concentrated acid. Avoid spilling acids on your skin or on your clothing, and always wash your hands afterwards. For large installations it is advisable to use an acid-resistant carboy pump, electrically operated, to transfer the concentrated acid to a tank of water. When designing equipment on this scale the advice of a chemical engineer should be sought. The operator should wear a protective eye-shield and the building should be well ventilated and equipped with 'wash-down' facilities.

SAFETY DEVICES

The larger the system, the more essential it is to make adequate provision against electrical and mechanical failure. The consequences of interruption of the flow of nutrient solution could be extremely serious, particularly during bright, sunny weather. A spare pump should always be available, to be switched in either manually or automatically. Since none of the control devices or pumps would operate in the event of a power failure, a standby generator should be provided to cover periods of interrupted supply. A pressure sensor fitted in the flow line from the circulating pump may be used to give visible or audible alarm signals in the event of flow failure; the alarm system may be used to call out maintenance staff by telephone outside working hours.

Precautions should be taken against failure of the pH and conductivity controllers. Adjustable timers can readily be fitted to switch off the injection pumps if the normal period of continuous operation is exceeded, thus preventing the addition of damaging amounts of either acids or nutrients. Major installations should have a second pH-meter fitted, wired to switch off the acid-injection pump if the pH falls below the 'controlled' level by more than 0.2–0.3 pH units; see Plate 6.

An overflow system should be provided to carry excess solution to waste from the catchment tank in the event of pump failure, since the gullies contain solution far in excess of tank capacity.

Finally it should be emphasised that automatic safety devices such as those now mentioned are no substitute for regular checks on the pH and salinity levels achieved. The readings displayed on the pH and conductivity controllers should be recorded once or more each day in order that any progressive trends can be recognised and suitable adjustments made. The results should be checked periodically against samples taken for analysis in the laboratory.

All connections in the flow and return systems should be inspected periodically to eliminate leaks. Whilst leakages are readily detected when the gullies are laid directly on the soil of the glasshouse, they can be difficult to trace where the soil is covered with white polythene sheeting, and sometimes remain undetected for considerable periods. Filters in the system should be cleaned at intervals as necessary to maintain flow rates.

PLASTICS AND PHYTOTOXICITY

Nutrient film culture involves the continuous re-circulation of nutrient solution over the surface of the gullies, matting (where used), flow and return pipes, pumps and control devices. Unlike the irrigation systems developed for watering and feeding crops in soils or other substrates, any substances dissolved from the equipment will remain within the system instead of draining away into the soil. It is, therefore, vitally important to use only such materials as are known to be free from extractable chemical components which could damage the plants. Many of the plastics available meet this criterion, especially if they comply with British Standards or Food Grade requirements. In 1978 the British Agricultural and Horticultural Plastics Association (BAHPA) set up a working party on 'Plastics for Hydroponic Systems' to consider such matters, leading to the publication of BAHPA Code of Practice 0002, 1979, on 'Non Phytotoxic Equipment'. The report notes that some of the additives incorporated in flexible PVC, particularly migratory plasticisers, can cause phytotoxic effects. The use of flexible hose pipes made of plasticised polyvinyl chloride should therefore be avoided. Calendered PVC sheet, sometimes used in the fabrication of catchment tanks, should be of Approved Food Grade; some other grades may cause toxicity. There have been instances in which butyl rubber sheet, used as a liner for catchment tanks, has been suspected of causing phytotoxity. The BAHPA Code of Practice suggests that the supplier's assurance should be obtained that butyl rubber sheet is fully cured and free from harmful migratory compounding ingredients. Epoxy resins, used to seal concrete gullies and catchment tanks, should be fully cured before hydroponic systems are operated.

The likelihood of injury to plants where unsuitable plastics are used is obviously greatest where materials are new. It is a wise precaution, therefore, to fill any new installation with clean water and to circulate it for a day or so; the system is then drained and refilled with nutrient solution before the plants are introduced.

NUTRIENT CONCENTRATION

Typical nutrient concentrations recommended by Stoughton (1969) for general use in hydroponic systems include 100 300 ppm nitrogen and 120 250 ppm potassium. The 'standard' Long Ashton nutrient solution (Hewitt, 1966) contains 168 ppm nitrogen and 156 ppm potassium. Such concentrations, which have proved highly satisfactory for conventional solution culture, are far higher than those suggested by research workers using flowing nutrient solutions. Thus Asher and Ozanne (1967) reported that of 14 plant species tested, eight reached maximum yield in flowing culture at 0.9 ppm K and the remaining six at 3.7 ppm K. Similarly, Clement *et al.* (1974) showed that plants could be grown satisfactorily at maintained concentrations as low as 0.1 ppm NO_3–N in a re-circulating system. The contrast between flowing and static systems is thus very striking. Nutrient film culture, a re-circulating system, started at the concentrations typical of static systems. Plants appear to grow well in nutrient film at such concentrations, but it remained to be shown whether these concentrations were optimal and how far the concentrations could be varied without restricting growth and yield.

Experiments at the G.C.R.I. have shown that neither growth nor yield of tomatoes differed significantly over the range 10–320 ppm NO_3–N (Winsor & Massey, 1978); concentrations as low as 10 ppm N and 20 ppm K did not reduce yields. In practice, however, it seems desirable to work at considerably higher concentrations in order to ensure a reserve of nutrients within the system. Some growers also favour the use of more concentrated solutions in order to exert some degree of osmotic stress upon the plants; this topic still requires investigation.

As a general guide to nutrient concentrations for tomatoes, some data compiled by ADAS on the basis of research, development and experience on commercial nurseries are given in Table 1. Whilst the recommendations in Table 1 provide a useful basis for control of nutrient concentrations in NFT, minor changes will doubtless arise in the light of further research and development. In particular, there is as yet little experimental evidence concerning the toxicity levels for the trace elements in nutrient film culture. The effect of high levels of zinc require further study, since this element often accumulates owing to the use of galvanised iron piping in the nursery water supply. Recommendations for iron concentration will ultimately have to take into account the choice of chelating agent, and current research at the G.C.R.I. suggests that increased concentrations of iron are beneficial in the vegetative and early fruiting stages.

Table 1 Nutrient concentrations for tomatoes in nutrient film culture*

Element	Concentration (mg/litre)		
	Minimum	Optimum	Maximum
NO_3–N	50	150–200	300
P	20	50	200
K	50	300–500	600
Ca	125	150–300	400
Mg	25	50	150
Fe	1.5	3	6
Mn	0.25	1	5
Cu	0.01	0.1	1
Zn	0.05	0.1	5
B	0.1	0.2	2
Mo	0.01	0.05	0.1
Na	–	–	250
Cl	–	–	400

*From 'Nutrient Film Technique : ADAS 1979 Blueprint for Tomatoes'.

NUTRIENT CONCENTRATES

EARLY FORMULATIONS

The nutrient solutions used during the early years of development of nutrient film culture were based on published formulations for other hydroponic systems. Since tomatoes were the main crop studied in nutrient film, however, the ratio of potassium to nitrogen was increased in order to improve fruit quality. An example of an early formulation used at the Glasshouse Crops Research Institute was published by Cooper (1975). Separate stock solutions of calcium nitrate, potassium nitrate, magnesium sulphate, potassium phosphate and the various trace elements were first prepared. The complete nutrient solution as used for plant growth was then made up by adding the required volumes of each stock solution to a known volume of water. The nutrient concentrations suggested (in mg/litre) were nitrogen 208, potassium 332, phosphorus 62 (with additional P from phosphoric acid used for adjustment of pH), magnesium 49, calcium 168, iron 5.6 (later raised to 12), manganese 2.2, boron 0.32, copper 0.065 and molybdenum 0.007.

A more dilute 'topping up' solution with the potassium phosphate omitted was added subsequently whenever the electrical conductivity of the solution in the system fell to 2000 μmhos, and phosphoric acid was added when the pH rose to 7.3.

FORMULATIONS FOR AUTOMATED SYSTEMS

The automated systems of nutrient control developed for commercial crop production require a somewhat different approach. Instead of adding measured volumes of the stock solution of each salt to a known volume of water in the system, mixed stock solutions are pumped in according to the setting of a salinity controller (see p. 15). If all the constituents required in the nutrient solution were mixed together in concentrated form, however, precipitation of sparingly soluble salts such as calcium phosphate or calcium sulphate would occur. In order to avoid this, two separate plastic tanks are normally used to hold the concentrated stock solutions. One such tank (Solution I) is usually reserved for calcium nitrate and the other (Solution II) for most of the remaining ingredients of the complete nutrient solution. Additional nutrients (nitrogen and phosphorus) are supplied as acids.

As an example of such formulations, the concentrates recommended by ADAS soil scientists for evaluation at the Experimental Horticulture Stations during 1978 are shown in Table 2. A second formulation, adopted by ADAS for use in the Experimental Horticultural Stations during 1979, is shown in Table 3.

Table 2 Nutrient solutions formulated for use at Experimental Horticulture Stations (1978)

Solution I

2.5 kg calcium nitrate (hydrated) per 25 litres

Solution II

3.5 kg potassium nitrate

2.5 kg magnesium sulphate (Epsom Salts)

250 g iron sequestrene (may be reduced to half rate from May onwards)

30 g manganese sulphate

10 g boric acid

2 g copper sulphate

2.5 g zinc sulphate

0.5 g ammonium molybdate

These eight ingredients (Solution II) are dissolved in 25 litres of water

Solution III

A mixture of three parts (by volume) of dilute nitric acid with one part dilute phosphoric acid.

This solution is prepared by putting 22 litres of water into a 25 litre container, adding 1.8 litres of concentrated nitric acid and mixing. Then add 0.6 litres of concentrated phosphoric acid and mix again.

Table 3	Nutrient solutions formulated for use at Experimental Horticulture Stations (1979)
Solution I	1.2 kg calcium nitrate per 25 litres
Solution II	1.7 kg potassium nitrate
	1.6 kg potassium sulphate
	300 g ammonium nitrate
	2 kg magnesium sulphate (Epsom Salts)
	75 g iron sequesterene (EDTA)
	10 g manganese sulphate
	3 g boric acid
	1 g copper sulphate
	1 g zinc sulphate
	0.25 g ammonium molybdate
	These 10 ingredients (Solution II) are dissolved in 25 litres of water.
Solution III	A mixture of equal parts (by volume) of nitric and phosphoric acids (each previously diluted either 1+9 or 1+19)

Formulations such as these should be regarded as a general guide to the preparation of nutrient concentrates, to be varied in the light of crop development, the nature of water supply and the fertilisers already added to the system. For example, neither of these ADAS formulae supplies phosphate other than that provided by the mixed acids (Solution III) required for adjustment of pH. This limits the amount of phosphorus available to the plants when the tanks are first filled, particularly in areas with 'soft' water supplies of low acid requirement. It is therefore suggested that, during the first few weeks of cropping, the formulation in Table 2 would benefit from inclusion of 400 g ammonium dihydrogen phosphate in Solution II; the amount of calcium nitrate in Solution I should be decreased to 2.09 kg in 25 litres in order not to change the nitrogen concentration. The ammonium phosphate would be reduced in concentration or omitted altogether as the phosphorus concentration of the nutrient solution rose above about 50 ppm by the use of Solution III to control the pH. Inclusion of ammonium dihydrogen phosphate may similarly be recommended for the first few weeks when using the formulation shown in Table 3, during which time the ammonium nitrate should be halved in concentration.

As noted in the ADAS recommendations, calcium nitrate (Solution I) may be omitted if the water supply contains 100-150 ppm or more of calcium. At intermediate calcium concentrations in the water supply it will be necessary to decrease the concentration of calcium nitrate in Solution I in order to prevent accumulation of calcium in the system. Since this will also reduce the nitrogen supply, a corresponding increase in nitrogen level in Solution II will be required. Whilst this requirement could be met by adding ammonium nitrate, for the formulation shown in Table 3 it is suggested that the amount of potassium nitrate be increased, and that of potassium sulphate be decreased, so as to maintain the nitrogen level without increasing potassium. For every 100 g of calcium nitrate ($Ca(NO_3)_2.4H_2O$) omitted from Solution I the amount of potassium nitrate per 25 litres of concentrate should be increased by 86 g, and that of potassium sulphate reduced by 74 g, thus maintaining the concentrations of nitrogen and potassium whilst decreasing the levels of calcium and sulphate.

ALTERNATIVE FORMULATIONS

Some G.C.R.I. formulations for nutrient concentrates are shown in Table 4, the purpose of which is to show how the qualities and choice of fertilisers may be varied to achieve different K/N ratios, with and without phosphate and at different levels of calcium. In addition to the salts listed in the Table supplying the major nutrients N, P, K, Mg and Ca, all formulations would also receive trace elements as follows (g salt for 25 litres of Solution II) :- 80 g iron EDTA, 5-10 g manganese sulphate, 4 g boric acid, 0.8 copper sulphate, 0.8 g zinc sulphate and 0.2 g ammonium molybdate. The zinc would be omitted if the water supply contained more than about 0.1 ppm Zn. Although in practice the resultant nutrient concentrations would be governed by the setting of the salinity controller, the theoretical concentrations of nutrients achieved by diluting the concentrates 1:100 are also shown in Table 4 in order to facilitate comparison.

Table 4 GCRI formulations for nutrient concentrates at different K/N ratios, with and without phosphate in Solution II. The weights of salts in Solutions I and II are given in kilograms (kg) for 25 litres of concentrate. For trace elements, see text.

		A	B	C	D	E	F	G
	K/N	1.5	1.5	1.5	2.0	2.0	2.0	2.5
SOLUTION I (kg/25 litres)								
Calcium nitrate		2.42	1.45	1.94	1 67	1.20	1.77	0.44
SOLUTION II (kg/25 litres)								
Potassium nitrate		1.53	1.94	1.94	2.18	2.59	2.09	3.23
Potassium sulphate		-	-	-	-	-	0.42	-
Potassium dihydrogen phosphate		0.55	-	-	0.55	-	-	-
Ammonium dihydrogen phosphate		-	0.46	-	-	-	-	-
Magnesium sulphate		1.27	1.27	1.27	1.27	1.27	1.27	1.27
Theoretical concentration (mg/litre) if diluted 1:100 (see text)	N	200	200	200	200	200	200	200
	P	50	50	-	50	-	-	-
	K	300	300	300	400	400	400	500
	Mg	50	50	50	50	50	50	50
Resultant Ca level derived from the fertilisers* (except in formula F; see footnotes)	Ca	164	99	131	113	81	120**	30

* Additional calcium will come from the water supply.

** For solution F the calcium level was raised as for soft water areas, necessitating the inclusion of additional K from potassium sulphate.

Formulation A has a K/N ratio of 1.5, includes phosphorus as potassium dihydrogen phosphate and would be suitable for early growth. The resultant concentration of calcium is high for use in regions of hard water, however, and in such areas formula B, using ammonium dihydrogen phosphate, would be more appropriate. Thus in formula B the additional nitrogen supplied as ammonium dihydrogen phosphate allows the amount of calcium nitrate to be reduced, whilst extra potassium nitrate maintains the levels of N and K. Formula C gives the same K/N ratio as A and B, but without phosphate in Solution II, this assumes some build-up of phosphate from the feeds used to control the pH.

Formula D in Table 4 supplies phosphate at a K/N ratio of 2.0, the increase in potassium level allows more potassium nitrate to be included and hence the calcium nitrate to be decreased as compared with A. Omission of phosphate (potassium dihydrogen phosphate) at a K/N ratio of 2.0, as in formula E, allows a still further decrease in calcium nitrate and increase in potassium nitrate. If, in areas of soft water, the calcium content of formula E failed to maintain an adequate level of calcium, potassium sulphate could be included as in formula F. In this formulation the amount of calcium nitrate has been increased to supply a chosen level of calcium, in this instance 120 mg/litre; the additional nitrogen from this salt limits the amount of potassium nitrate which can be used at K/N = 2 and hence potassium sulphate is also included. Where a still higher K/N ratio is required, as at times during the fruiting phase of a tomato crop, formulations such as G in Table 4 may be used. However, this formula, using as much potassium nitrate as possible, assumes that the water supply is such that large quantities of calcium are not required to maintain an adequate Ca level in the system. In soft water areas a different approach would be used; the level of calcium would first be fixed, the balance of the nitrogen would be given as potassium nitrate and additional potassium supplied as potassium sulphate.

As stated previously the formulations in Table 4 have been used primarily to illustrate some of the ways in which the composition of the nutrient concentrates may be varied for particular purposes. Once cropping has started and analyses of the solution become available, a sequence of changes will normally be made to maintain nutrient concentrations appropriate to the crop. The general principles remain as follows, however. As much as possible of the K and N are included as potassium nitrate, since this avoids undue accumulation of ions such as sulphate or, in areas with hard water, calcium. Where the water supply is low in calcium, however, priority is given to maintaining adequate calcium as calcium nitrate. Potassium nitrate is then included up to the limits set by N or K requirement, and potassium sulphate is introduced only if still further K is required. When in doubt, consult your local Horticultural Advisory Officer who, in turn, has access to ADAS Soil Scientists specialising in the formulation of nutrient concentrates for hydroponic systems.

For those not wishing to prepare their own stock solutions, various commercial nutrient formulations are available; advice on their use in relation to the local water supply should be obtained from the manufacturers.

AIDS TO CALCULATION FOR THOSE WISHING TO PREPARE THEIR OWN NUTRIENT FORMULATIONS.

Some basic knowledge of inorganic chemistry is required by those wishing to formulate nutrient solutions for their own purposes. Such calculations lie beyond the scope of this Bulletin, but, for those already familiar with the principles involved, three Tables have been included as an Appendix. Table 5 lists the atomic weights of the elements present in salts used in hydroponic systems. Table 6 shows the formulae of the various salts, together with their molecular weights. Table 7 records the nutrient content (%) of the salts in Table 6, together with the weights of each salt required to supply unit weight of the essential nutrients; the factors shown in this Table are independent of the units of weight chosen, provided that the same units (e.g., g, kg, lb or oz) are used for both the salt and the nutrient concerned.

PROPAGATION AND VARIETIES FOR NUTRIENT FILM CULTURE

Since nutrient film culture does not rely on the use of any solid substrate such as soil or peat for crop growth, it would, at first sight, seem to be a retrograde step to propagate the plants in conventional substrates. Soil, and even peat, must be regarded as potential sources of infection in a hydroponic system, and the development of alternative propagating media would have obvious attractions. Cooper (1978) compared a range of methods of establishing tomato seedlings in a nutrient film system; the treatments included propagation in rockwool cubes, expanded clay granules ('Leca') in lattice pots, compressed peat blocks ('Jiffy 7') and John Innes Compost (7:3:2 loam: peat: sand) in 11 cm paper ('whalehide') pots. Bare-rooted seedlings were also placed in the gullies with their roots in the flowing solution. The effects of these treatments were largely confined to the early stages of growth and cropping. After one month of cropping the highest yields were obtained from plants established in loam-based compost, compressed peat blocks and in clay granules. The early yields were lower where rockwool cubes or bare-rooted seedlings were used. After cropping for two months, however, the method of establishment had little or no effect on the yield.

Rockwool cubes (5 cm) have been used extensively for nutritional research in nutrient film culture since they avoid the complication of extra nutrients added during the propagating stage. Problems have occurred with rockwool, however, including a chlorosis of the tiny seedlings before they are stood out in the gullies. The symptoms suggest iron deficiency, but the cause is thought to be poor aeration in the blocks; once the roots emerge into the gullies, growth and colour improve. Despite the early interest in bare-rooted seedlings, introduced into the gullies after germination, this concept is not attractive commercially. The soil-based compost produced the best results in Cooper's trials.

In practice, conventional propagation in whalehide pots filled with fertilised peat is generally preferred by tomato growers. Propagation then follows established practice, and growth of the plants can be restricted by controlled watering on the propagating benches. Even when the plants have been set out in the gullies, the equipment is sometimes used initially as an intermittent watering device rather than as a continuously operating hydroponic system, in order to restrict growth and hence improve fruit setting under conditions of poor light. Where intermittent watering is practised in the early stages of growth it is important to control it in such a way as not to encourage the development of roots outside the pots; such roots may be killed during the alternating periods of dryness, thus producing a substrate for saphrophytic micro-organisms and increasing the biological oxygen demand in the nutrient solution.

Where plant pots are used, it is important that these should allow ready penetration of the sides by the plant roots. Conventional plastic pots are unsuitable, since the roots can only emerge into the gullies at the base, where oxygenation is poorest. The

choice at present thus lies between pots made of paper, compressed peat or slatted plastic.

Vigorous strong-rooted varieties are preferred for nutrient film culture. Modern TMV-resistant cultivars are favoured; cv. Sonato was used in much of the past research and development work, though cv. Sonatine has since proved popular. As nutrient film culture increases in importance in years to come, plant breeders will doubtless produce varieties particularly suited to growth in hydroponic systems. The factors to be taken into account include not only TMV-resistance but also root-vigour, susceptibility to iron and manganese deficiencies and resistance to disease.

SOLUTION HEATING

It has long been realised that increasing the temperature of the root zone could, under certain circumstances, be beneficial to plant growth. In practice, however, the application of this concept has shown only limited success, mainly associated with plant propagation on raised benches. Attempts to heat the soil *in situ* by buried pipes or cables under growing crops have generally proved unrewarding or uneconomic, due to major heat losses into the surrounding soil. However, systems with a strictly limited rooting zone such as rockwool or nutrient film culture offer greater opportunities at realistic costs.

Experiments on the heating of solutions for nutrient film culture have often given conflicting results. Trials at the Glasshouse Crops Research Institute during 1978 suggested that heating the solution to 23°C was beneficial for tomatoes but that the use of higher temperatures (26°–32°C) gave little or no further gain. For much of the season, the fact that the solution temperature tends to follow the air temperature appears to ensure adequate warmth in the root zone. There are, however, conditions under which the ability to heat the nutrient solution is virtually essential. Thus, when tomato plants are first set out in the gullies early in the year, the temperature of the solution may be several degrees below that of the surrounding air owing to evaporative cooling. Since air temperature rises more rapidly than solution temperature during morning sunshine, there could also well be some benefit from warming the solution early in the day. Certainly, whenever circumstances necessitate replacing the nutrient solution, then some form of solution heating seems essential; refilling a tank with cold water when the sun is shining and air temperatures have risen can lead to wilting. Most commercial growers have therefore installed a stainless steel heating coil in the catchment tank, connected to the main glasshouse heating system and controlled thermostatically. Recent investigations at the Glasshouse Crops Research Institute (Moorby & Graves, unpublished) include a study of the interactions between root zone temperature (20, 23 and 26°C) and night air-thermostat settings (8°, 12° and 16°C), thus examining the possibilities for energy saving by reducing the air temperature at night whilst maintaining the temperature of the roots. Techniques such as this are unlikely to lead to increased yields, but it may be possible to maintain yields at reduced fuel costs.

THE MICROBIOLOGY OF ROOT SYSTEMS IN NUTRIENT FILM CULTURE

When the nutrient film technique was first developed it seemed to many people that the roots of the plants growing in this system would be more likely to be attacked by root-invading organisms than those of plants growing in soil. The same nutrient solution is kept circulating day after day, and a pathogen in the system could conceivably multiply and spread very quickly. Yet after several seasons of NFT culture, both on an experimental and commercial scale, reports of disease have been relatively few.

Healthy roots exude many substances and some of these, together with the constituents of the nutrient solution, form a good growth medium for bacteria and fungi. Rather than being detrimental, however, the majority of these organisms are beneficial. Roots formed in the solution age and die and, if they were not broken down, would block the gullies. It is also possible, though not yet proven, that the natural root flora may exclude pathogens. There is, however, another more soundly based reason for the absence of disease. The source of these root pathogens is most likely to be the soil within the glasshouses, and these pathogens would be excluded by the plastic sheeting which most growers lay over the floor.

Most of the experimental pathology up to now has been done on tomatoes. At G.C.R.I. the work was begun by a study of the natural flora that developed in the gullies. Over a period of three seasons, thirty-five well known species from two dozen genera were found, but none of them were tomato pathogens. During this period, five species of fungi were found regularly: *Chaetomium olivaceum, Fusarium oxysporum, Penicillium brevicompactum, P. nigricans and Trichoderma koningi.* The *Fusarium oxysporum* was found to be a non-pathogenic form. A more important discovery was that of a species of *Pythium* which, though apparently harmless in NFT, severely attacked the roots of seedling tomatoes when introduced into the soil.

DISEASE AND NFT

The main diseases of plants grown in NFT or soil can be divided broadly into two groups: those affecting shoots and those associated with roots.

DISEASE OF SHOOTS AND LEAVES

No matter by which method tomatoes are grown, *Didymella lycopersicae* is the most serious pathogen. Control measures in NFT systems are no different to those elsewhere, but care should be taken to avoid suspensions of fungicide running down the stems into the gullies. Although experience is limited, there seems to be less end-of-season foliar disease in large glasshouses containing only NFT plants than in plants grown in border soil or peat bags. This has been most noticeable with grey mould, caused by *Botrytis cinerea*, in NFT crops that have been kept in until late October and early November. Tomato leaf mould can be avoided by growing resistant cultivars.

ROOT DISEASES

In the few investigated cases in NFT systems it was found that the pathogens had got into the system before the 'normal' root flora had developed. This can happen in three ways:

- on contaminated seed
- in infested propagating compost
- on containers which have been stood on infested benches or soil

Of the types of disease most likely to be found entering via the roots are the wilts (caused by species of *Fusarium* and *Verticillium*). These diseases are usually avoided by using resistant cultivars.

A second group of disease-producing organisms, at present much less familiar to growers, contains species of *Pythium* and *Phytophthora*. These fungi need water in order to reproduce and spread by means of tiny zoospores. These spores, unlike those of many other fungi, are able to swim some distance and encyst (i.e., turn into conventional spores) before they attack the root at a new site. Four species of *Phytophthora (P. erythroseptica, P. infestans, P. parasitica* and *P. nicotianae*), as well as several species of *Pythium*, attack tomatoes. Usually, in an attack by these fungi, only the main roots are left unaffected; all the other roots disappear and no new roots are formed. It is this severe loss at any stage of the crop that distinguishes this from other forms of 'root death'. Plants attacked in this way will not recover, whereas plants with more common 'root death' show a transient wilt at mid-day, particularly in sunlight on warm days just before the first pick of fruit. We know little about the species *Pythium* found in NFT systems. There is evidence elsewhere that, in some ill-defined way, they affect growth without necessarily attacking the roots to cause death. Several investigations with soil-grown plants have shown that there are at least three species of *Pythium* which produce toxins or, in some way as yet unexplained, severely restrict growth (*P. butleri, P. myriotylum and P. irregulare*). Similarly some species of *Phytophthora* evidently differ considerably within themselves: one strain of a species will attack and kill a plant whilst another will only affect growth.

The other major root disease of tomatoes is brown root rot, caused by *Pyrenochaeta lycopersicae*. It is unlikely that this pathogen will cause a problem in NFT because it is very slow growing. In border soil it usually takes several seasons to increase sufficiently to cause crop loss.

There are two bacterial diseases of potential importance. The first, which occurs in the Channel Islands, is bacterial canker, a primarily seed-borne disease caused by *Corynebacterium michiganense*. Its most characteristic symptom is wilting along one side of a tomato leaf ('half leaf wilt'); when the leaves and stems are split, yellowish streaks may be seen in the vessels. Whilst *C. michiganense* might cause some loss in NFT, another bacterium, *Pseudomonas solanacearum*, can devastate a crop — as happened in New Zealand. This bacterium is also seed-borne, and causes a rapid wilt of plants. It is not established in the United Kingdom but is intercepted from time to time in some potato imports from outside the E.E.C. Because of the

risk from these seed-borne pathogens, only the very best young plants should be set out in NFT gullies.

Most cultivars of glasshouse crops grown today are genetically resistant to several pathogens. Where plants lack resistance to virus infection they may be at risk because it is possible for virus particles from a diseased plant to be recirculated within the NFT system and infect healthy plants via the roots. Although not proven experimentally, this was thought to have happened with cucumber mosaic virus in a crop of peppers in S.E. England.

A disease of lettuce called big vein is caused by an unknown agent transmitted by a small unicellular fungus, *Olpidium brassicae*. The fungus itself scarcely damages the plant since each spore damages only one cell, but big vein disease causes winter-grown lettuce to develop poorly, usually becoming unsaleable. The fungus produces minute spores similar to those of *Pythium* which, on release from infected cells, move freely about in the solution for a few minutes.

The novel root environment provided by NFT may mean new or previously unrecorded diseases being found. Consequently, all diseased and ailing plants should be examined carefully. An example of this is a wilt of carnations caused by *Phytophthora cryptogea*, which at first sight seemed similar to that caused by *Verticillum*.

CONTROL OF ROOT DISEASE IN NFT

No fungicides have been produced specifically for NFT, and most of those presently available have been made for use on the aerial part of plants. Leaves, shoots and branches are covered with a thick cuticle or bark which prevents most chemicals from entering the plant. The protectant chemicals are redistributed over a considerable period of time by rain and dew out of doors, or by damping down in glasshouses, and kill fungi and bacteria living on the plant surface. Tenacity, persistance and low solubility are thus essential qualities for protectant fungicides.

It is not easy to control root diseases in nutrient film systems; the roots do not have a protective cuticle, and most fungicides have an immediate, usually harmful, effect on the root cells. Many fungicides have been screened at the G.C.R.I. for use in NFT systems, but most have proved phytotoxic. Even the carbendazim types of systemic fungicide are harmful at concentrations as low as 80 p.p.m. Yet their systemic properties, so useful in soil, operate against them in NFT because they disappear rapidly from the solution, moving through the roots to the shoot. Thus the examination by UV spectrophotometry of nutrient solution originally containing 50 p.p.m. of the active ingredient carbendazim showed that the compound had become undetectable after three days. However, experience over the past few years has shown that the threat of root disease and/or loss of yield comes from species of *Phytophthora* and *Pythium*, against which the carbendazim fungicides are ineffective. Etridiazole is commonly used to control these two pathogens in border soil or for container-grown plants, but the comparatively high doses used in these conditions are toxic in NFT solution. Tomato plants, for example, are killed by 50 p.p.m. etridiazole, but concentrations below this supressed growth of the fungi and an exposure of as little as one hour will prevent zoospores being formed. Recent work

at this Institute has shown that, using the wettable powder formulation of etridiazole, a dosage of 30 p.p.m. of the active ingredient every four weeks will control species of *Phytophthora* and prevent reproduction as well as limit growth of several species of *Pythium*. Other fungicides are being tried for their usefulness, and furalaxyl, which has similar effects to those obtained with etridiazole, is being used in commercial NFT systems.

ROOT GROWTH AND ACTIVITY

It is an incidental feature of NFT that the roots are at all times visible, and in consequence the grower is much more aware of their existence, and their condition, than when they are in the soil. For the tomato grower this can be at first a stimulating and then an alarming experience as the roots first grow rapidly to produce a dense white mat and then start to brown and die just as the plant starts to bear fruit. In the first part of this section the normal pattern of root growth for a tomato crop is described in order to clarify these changes with time; see also Hurd, Gay and Mountifield (1979). Much the same pattern of root growth can be expected in other long-term glasshouse crops, and it is important to recognise that this sequence of growth is the same regardless of growing medium. The remainder of the section deals briefly with those attributes of the technique which can influence the efficient functioning of the root system and which should be optimised for maximum benefits from this method.

Figure 3. Relative growth rates of the shoot and root of a November-sown tomato plant, expressed on the basis of fresh weight.

ROOT GROWTH

Two days after a seedling is pricked off into nutrient solution it is growing again normally and the weight of both the root and shoot increases each day by about 20-30% of the weight already present. This rate of growth diminishes with time (Figure 3), and depends on temperature and light. The root of the seedling is smaller than the shoot and inevitably remains so, becoming a progressively smaller part of the plant. Even so, by the time the plant is about to flower, a substantial volume of white and clearly healthy roots is seen, representing about 15% of the

total fresh weight of the plant (Plate 8). The root at this stage consists of 15-25 first-order (primary) roots approximately 2 mm thick and 2-3 m in length, from which extend in a regular sequence a vast number of second-order (secondary) roots of indefinite length and 0.2-0.5 mm diameter.

From first flowering onwards the rate of root growth diminishes until it stops about four weeks later. This may be 130 days from sowing (the end of March from a November sowing), by which time the oldest roots have turned light brown. Indeed, at this stage, dead roots (mid brown in colour and disintegrating to the touch) are often seen in the oldest part of the root system. This is perhaps not surprising since, by this time, the cotyledons and oldest leaves will also have died. The time at which root growth ceases coincides with the time when maximum fruit load is developing on the plant. One possible explanation for this reduction in root growth is that the roots fail to compete with the developing fruit for the available products of photosynthesis produced by the leaves.

There follows a quiescent period of about one month, during which there is little or no new root growth. If the plants are grown in deep nutrient solution it can be seen by this time that some second-order roots are dying and falling away, starting at the top of the root system and leaving 'strings' of first order roots running down to the main root mat (Plate 9).

Subsequently, new white roots emerge at the top of the root system, replacing the original dead roots. In nutrient film gullies, some of the new roots grow under and over the existing root mat, but most are found along the sides of the gully where the flow of solution is greatest (Plate 10). Since these roots tend to replace

Plate 8. Tomato roots removed from the nutrient film gully into which they have spread from the original paper pot.

those which have died and been washed away, the gross weight of the root remains relatively constant. This is why, on the basis of overall changes in weight, there is apparently no further growth of the root once fruiting starts (Fig. 3). As a result of this process of root renewal, the root system may be seen throughout fruiting as a mixture of new white roots, light brown roots and older roots in varying stages of decomposition.

The number of roots which are seen to die during fruiting varies considerably. In extreme cases root death is severe, most of the second-order roots turn dark brown, the plant wilts and is unable to set fruit and may lose leaves. Eventually, however, after much of the existing fruit load has been harvested, a substantial new flush of white roots is produced and the plant recovers. Although this severe loss of roots suggests attack by a root pathogen, none has been consistently isolated (see page 34) Luckily this extreme situation is uncommon in tomatoes and, when it has ocurred, it has not affected the whole crop.

Plate 9. Tomato roots in deep water culture at the early fruiting stage (April). The oldest second-order roots at the top of the root system have been lost, exposing the first-order roots.

Plate 10. Tomato roots in the gully at mid-fruiting stage (June). By this time a zone of new white roots has grown on either side of the older roots, which are now light brown in colour. The rockwool propagating blocks of two plants in the row are visible at the top and bottom of the photograph.

The tendency for new roots to supplant the old dead roots has already been noted to lead to a relatively constant root weight. The vegetative shoot also stays relatively constant in size once fruiting commences, since young leaves replace the old ones removed as part of normal cultural practice. This observation is consistent with the important concept that the plant tries to maintain a balance between the activities of the shoot and the root. It follows that deliberate defoliating should not be excessive at the stage when the roots are dying. It also implies that the considerable amount of root often produced in water culture should not be considered as surplus to the plant's needs. In general a vigorous shoot produces a large root and, equally, a small shoot will often have a poorly developed roots system.

FACTORS AFFECTING ROOT ACTIVITY

We are concerned here with the influence on the physiology of the root and the plant of an aqueous rooting medium circulating in a closed system.

The most obvious attribute of NFT is the continuous presence of water around the majority of the roots. On a commercial scale the resulting consistency in watering cannot be matched by any irrigation system operating on solid media, and this has been claimed to be one reason for the increased yields in NFT. Another feature of such a flowing solution is the consistent availability of nutrients at the surface of the roots in a soluble form suitable for immediate uptake by the plant. This contrasts with the slow processes in solid media of root growth up to the nutrient and diffusion of nutrient down concentration gradients to the root.

One disadvantage of the continuous water supply normally associated with nutrient film culture is that control of growth by restricted watering is excluded. However, some degree of control may be obtained by circulating the nutrient solution intermittently during the early stages of growth, assuming that adequate tank capacity is available to accommodate all the solution draining back from the gullies. Whilst experiments in growth cabinets using this technique failed to improve flowering under conditions of low light, there is no doubt that a smaller, harder plant is produced and there is the possibility of improved fruit quality.

There is one further disadvantage in having the roots submerged in water. Roots require oxygen to perform their several functions, and oxygen has a low solubility in water (approximately 9 ppm at saturation, depending on temperature). However, this low level is found to be adequate for normal functioning even with the roots completely submerged, and experience suggests that concentrations down to about 5 ppm have little effect on yield. Even so, with such a low concentration of available oxygen, it is advisable to encourage maximum aeration throughout the system (see, for example, p 14). The deeper the nutrient, the more root is submerged and the greater the problem. It follows that the best NFT conditions should be those in which fast, shallow-flowing nutrient solutions ensure maximum exposure to the air and maximum surface turbulence, thereby improving uptake of oxygen as the solution passes down the gully. Without this source of oxygen a rough calculation shows that, for mature tomato plants, oxygen depletion would be complete in a row about 20 plants long (given a flow rate of one litre per minute and complete root submersion).

Raising the temperature of the nutrient solution is very simple in nutrient film culture. This may increase not only the rate of growth of the root and the rate of nutrient and water uptake but also the root's production of growth substances affecting the growth of the rest of the plant. In general, temperatures between 20 and 25°C appear optimal, although this is under active experimentation, especially in relation to air temperature (p.33).

A further important attribute of NFT is that the nutrient film flows round in a closed system. This leads to economy in the use of nutrient chemicals but may also result in the build up of undesirable substances such as the sodium chloride, sometimes found in the water supply (p.16). Another source of impurities comes from the plant's roots. Trace quantities of a wide range of substances are exuded by roots, and most are probably broken down rapidly by bacterial action. However, following severe root death there is a build up, and subsequent disappearance, of relatively large amounts of growth substances at about the time of early fruiting (Fig. 4). Such concentrations of growth substances are known to be biologically active, and it is quite possible that they affect growth in closed systems. Their production may have accounted for the lack of root growth at this time, although it is always difficult to distinguish this sequence of events from the opposite one in which the dying roots released the growth substances into the solution.

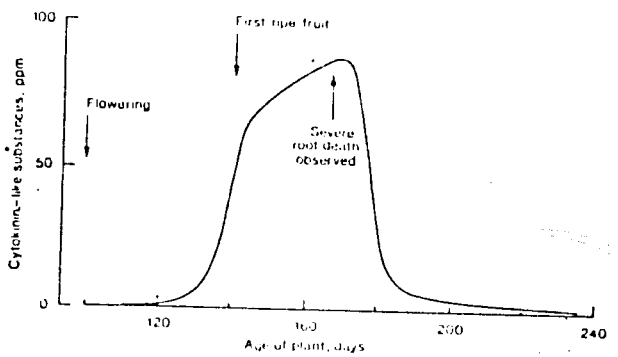


Figure 4. The concentration of cytokinin like growth substances in the nutrient solution of tomatoes showing severe root death at fruiting (after Tucker, 1977).

A second consequence of the closed system in NFT, with its relatively small volume of circulating solution, is the speed with which the nutrient solution is changed. A mature tomato plant takes up a maximum of about 1 litre of nutrient

a day (Fig. 5). On a commercial scale this is about the amount of solution in the system per plant and hence the nutrient solution will be renewed about once a day under the highest light conditions. In such a dynamic system it becomes important to have good control of nutrient conditions and to avoid the use of impure chemicals, since the build up of undesirable substances would be rapid. At the same time there is the advantage that nutrient conditions can be changed rapidly in accordance with the needs of the plant.

Figure 5. Water consumption by a December-sown tomato plant (Note: day 198 is midsummer's day).

APPENDIX

The Tables which follow are included for the convenience of those wishing to formulate their own nutrient solutions. Table 5 gives the chemical symbols and atomic weights of the elements. Table 6 gives the formulae and molecular weights of the salts normally used in nutrient solutions. Table 7 lists the percentages of the various elements in the pure salts, together with the weights of salt required to supply unit weight of nutrient.

Table 5 Atomic weights of the elements

Element	Symbol	Atomic Weight
Boron	B	10.8
Calcium	Ca	40.1
Carbon	C	12.0
Chlorine	Cl	35.5
Copper	Cu	63.5
Hydrogen	H	1.0
Iron	Fe	55.9
Magnesium	Mg	24.3
Manganese	Mn	54.9
Molybdenum	Mo	96.0
Nitrogen	N	14.0
Oxygen	O	16.0
Phosphorus	P	31.0
Potassium	K	39.1
Sodium	Na	23.0
Sulphur	S	32.1
Zinc	Zn	65.4

Table 6 Some salts used in the preparation of nutrient concentrates

Salt	Formula	Molecular weight
Calcium nitrate	$Ca(NO_3)_2.4H_2O$	236.2
Potassium nitrate	KNO_3	101.1
Ammonium nitrate	NH_4NO_3	80.0
Potassium sulphate	K_2SO_4	174.3
Potassium dihydrogen phosphate	KH_2PO_4	136.1
Ammonium dihydrogen phosphate	$NH_4H_2PO_4$	115.0
Magnesium sulphate	$MgSO_4.7H_2O$	246.5
Manganese sulphate	$MnSO_4.4H_2O$	223.1
Boric acid	H_3BO_3	61.8
Copper sulphate	$CuSO_4.5H_2O$	249.7
Zinc sulphate	$ZnSO_4.7H_2O$	287.6
Ammonium molybdate	$(NH_4)_6Mo_7O_{24}.4H_2O$	1235.9

Table 7 The nutrient content (%) of some salts used in hydroponic systems, together with the weight of each salt required to supply unit weight of nutrient*

Salt	Element	% nutrient	Weight of salt per unit weight of nutrient
Calcium nitrate	Ca	17.0	5.89
Calcium nitrate	N	11.9	8.44
Ammonium nitrate	N	35.0	2.86
Potassium nitrate	K	38.7	2.59
Potassium nitrate	N	13.8	7.22
Potassium sulphate	K	44.9	2.23
Potassium sulphate	S	18.4	5.43
Potassium dihydrogen phosphate	K	28.7	3.45
Potassium dihydrogen phosphate	P	22.8	4.39
Ammonium dihydrogen phosphate	N	12.2	8.21
Ammonium dihydrogen phosphate	P	27.0	3.71
Magnesium sulphate	Mg	9.9	10.14
Magnesium sulphate	S	13.0	7.68
Manganese sulphate	Mn	24.6	4.06
Boric acid	B	17.5	5.72
Copper sulphate	Cu	25.5	3.93
Zinc sulphate	Zn	22.7	4.40
Ammonium molybdate	Mo	54.4	1.84
Iron EDTA	Fe	15.2	6.58

*i.e:, g salt required to supply 1g nutrient, or lb salt required to supply 1 lb nutrient.

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Finally, we wish to acknowledge the help which we have received from members of the Agricultural Development and Advisory Service, and also from members of the South East Region Nutrient Film Study Group.

FRUIT JUICE CANNERY

An

AGRI-BUSINESS PROJECT PROFILE

Prepared by:

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For

THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

And

THE CARIBBEAN DEVELOPMENT BANK

March 1980

This document does not assume the approval (nor imply such) of the United States Agency for International Development, the Caribbean Development Bank or any of their officers.

AGRI-BUSINESS PROJECT PROFILE

DATE:	MARCH 20, 1980
PROJECT:	FRUIT JUICE CANNERY
LOCATION:	ST. LUCIA
CLIENT:	PHEONIX FOODS LIMITED
LOAN REQUIRED:	EC$200,000

I. BACKGROUND

Almost 2 million 12 oz. cans of fruit juice is reported to be imported into St. Lucia each year. There are currently no fruit juice canning operations in St. Lucia, although several individuals are reported to be considering such an operation.

The principals of Pheonix Foods Ltd. (which is a new firm without established facilities as yet) intend to process locally grown fruits and imported concentrates into juices. At first, the canning operations would be very dependent on imported concentrates to provide sufficient throughput of the factory. Gradually, as the supply and assembly of local fruits is reliably established, the proportion of juice products made from locally grown fruits would increase.

The clients report that capital cost will be kept to a minimum by: 1) avoiding elaborate building construction; 2) utilizing re-conditioned (used) equipment with low volume throughput; and 3) substituting manual labour for machines where feasible.

During a recent trip to St. Lucia, a principal of Pheonix Foods Ltd., Mr. Robert Walters, discussed this cannery proposal with CDB Loan Officers and shared the estimated cost/revenue projections he had developed. Mr. Walters indicated that the firm was prepared to stand the cost of capital investment, and would be interested in securing loan financing for working capital.

II. PROJECT DESIGN

A. PURPOSE

The purpose of this project is to establish a cannery in St. Lucia to annually produce and market the equivalent of about 2 million 10 oz. cans of fruit juice, fruit pieces and tomato juice.

B. PRODUCT LINES

The project proposes to engage in three principal products:

1. Citrus juice from concentrate - 45% of 4th year output.
2. Tropical fruit juices and fruit pieces - 42% of 4th year output.
3. Tomato juice from paste - 13% of 4th year output.

C. MARKETS

All production is aimed at the national St. Lucian market. The project would function as a manufacturer/wholesale supplier to supermarkets, institutions and distributors. Based on current apparent demand, this project would necessarily dominate the

St. Lucian market.

D. PROCESSING

No details of processing facilities or operations were discussed.

E. RAW MATERIAL SUPPLY

The citrus juice concentrate will be purchased abroad, probably in the U.S.A. The same is true of tomato paste. With regard to supply of local fresh fruit, Pheonix Foods Ltd. plans to actively promote fruit production by providing suitable root stock and planting material to selected farmers at no charge, and otherwise assisting these farmers to participate in Government subsidy schemes for fruit production. In addition, an associated firm, Pheonix Estate Ltd., will produce a significiant proportion of fruit required within the next three years.

F. MANAGEMENT

The proposed project will be managed by one of the principals of the firm, Mr. Peter Herd. Mr. Herd is a chemical engineer with experience in food processing. In addition, Mrs Anne Walters, who has a B.S.C. in Food Science and Nutrition, will be employed by the firm to oversee the day-to-day technical operations, ensure quality control, and manage new product development.

III. PROJECT COST & REVENUE

On the following pages, the cost and returns for the

proposed project are presented and summarized for a four year period. These data and projections were accomplished by the client, and are reproduced here without modification.

PHEONIX FOODS LIMITED

SUMMARY OF PROJECTED EXPENDITURE AND REVENUE FOR FOUR YEAR PERIOD

	Year 1 Prod.	EC$	Year 2 Prod.	EC$	Year 3 Prod.	EC$	Year 4 Prod.	EC$
EXPENDITURE								
Citrus from concentrate	440,000 cans	916,206	750,000 cans	1,610,681	1,050,000 cans	2,319,381	1,050,000 cans	2,292,741
Tomato from paste	-	-	55,200 cans	115,038	300,000 cans	624,656	300,000 cans	616,960
Fresh fruit juice & pieces	16,000 cans	22,432	97,300 cans	179,971	600,000 cans	1,110,421	1,000,000 cans	1,825,875
Total Expenditure		938,638		1,905,690		4,054,458		4,735,576
REVENUE								
Citrus		1,083,600		1,935,000		2,786,400		2,786,400
Tomato		-		138,000		750,000		750,000
Fresh fruit juice & pieces		26,964 (includes start-up prod.)		216,000		1,576,500		2,627,553
Total revenue (production value)		1,110,564		2,289,000		5,112,900		6,163,953
Actual balance (on production value)		171,926		383,310		1,058,442		1,428,377
C/o from previous year		-		39,472		21,586		80,028
Cum. balance at end year		171,926		422,782		1,080,028		1,508,405
Dividend		50,000		50,000		50,000		50,000
Planting material, etc. to farmers		20,000		50,000		50,000		50,000
Equipment expansion, maintenance, etc.		30,000		100,000		100,000		100,000
Reserve A/c		-		150,000		800,000		1,200,000
Carried to next year		39,472		21,586		80,028		108,405

Prices as follows

Citrus	works cost	0.481¢/fl.oz	i.e. 10 oz $1.48 + 20% = $1.78; 19 oz. $2.81 + 20% = $3.38
Tomato	" "	0.1437c./fl.oz.	i.e. 10 oz. $1.44 + 20% = $1.72; 19 oz. $2.73 + 20% = $3.28
Fresh Fruit	" "	0.125c./fl.oz.	i.e. 10 oz $1.12 + 20% = $1.34; 19 oz. $2.14 + 20% = $2.57

During year 1 Pheonix Estate will be engaged in the production of suitable plants for sale to Pheonix Foods who will then make them available to local farmers along with other subsidized inputs. This will be expanded in year 2 & continued, by year 3 enough fresh fruit should be available for the projected increase in that year.

If the projected sums can be placed in a reserve account and the planting scheme is successful, a major expansion into the export market could be scheduled for year 5 using reserve funds of $2,150,000.

Payment for citrus concentrate is scheduled for month received, but an irrevocable letter of credit will be required 4 months earlier. All costs and prices based on 1980 levels, it is assumed that increases in costs will be offset by equivalent price increase.

IV. ISSUES

A. MARKET PENETRATION

The project proposes an output which is very close to the current apparent demand for juice in St. Lucia. Is it realistic to assume that one firm could capture such a large share of this market? It is suggested that an evaluation of the likely competitive behaviour of current supply sources be undertaken to better judge how price competitive the proposed project will need to be in order to survive.

B. RAW MATERIAL SUPPLY

Input supply is known to be a major constraint to successful food processing operations in the region. The project is designed to reduce this risk by depending heavily on imported juice concentrate, especially during the early years of operation. Still, there is the issue of how secure the supply of imported concentrate is, at least on a timely basis when needed. The Project Committee should investigate the arrangements for insuring imported supplies, and review in detail the firm's plans for establishing local supply sources of fresh fruit.

C. LOAN SECURITY

Pheonix Foods Ltd. is a new firm with few tangible assets. Although this firm is not in operation, the St. Lucian Government has granted it certain privileges, including: 1) duty-free

import of equipment; 2) 75% relief from income taxes for 3 years; and 3) 40% relief from income taxes in year 4 and thereafter. Nonetheless, Pheonix Foods Ltd. has no "first class" security to offer for loan purposes. The possibility of using the equity of equipment and inventory should be explored. In addition, the assets of a third party may be a feasible alternative for loan security. In any case, the CDB will need to explore the question of security further.

AN OVERVIEW OF THE ARROWROOT INDUSTRY

IN ST. VINCENT, 1931 - 1980

PREPARED BY

REFUGIO I. ROCHIN

FOR THE

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

BARBADOS, W.I.

MARCH 1980

PREFACE

This report presents a summary of the St. Vincent arrowroot industry in terms of the historical development of the supply of and demand for arrowroot and its product since 1931. The report is based on selected reports and files provided by the Arrowroot Industry Association of St. Vincent in February 1980. We are indebted to Mr. Ormond J. Ollivierre, Association General Manager, Mr. H.B. Crichton, Association President and Mr. David Jack, former General Manager, for their cooperation in the preparation of this report.

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ORIGIN

The Co-operative Arrowroot Association of St. Vincent was established in 1931 to address a "state of chaos" facing the industry.. Prior to this year there was no quality control for starch and huge stocks were piling up in warehouses in the U.K. Producers were shipping on consignment and owing to a complete lack of co-operation were consistently underselling each other. As far back as 1911, efforts had been made to establish some sort of organization to stabilize prices, but all such attempts failed.

The Association was set-up under an ordinance framed on the basis of Canadian wheat pool laws and was initially financed by the U.K. Colonial Office with a grant of £3,000 and a loan of £30,000 which was satisfactorily repaid. Under the ordinance, the Association was empowered to lump together all arrowroot delivered of the same quality and to act as sole exporter of arrowroot from St. Vincent. The Association established more uniform quality and stable prices for the prime producers. Within ten years production had practically doubled and sales tripled. The net result was that the arrowroot industry became an even more important factor in the St. Vincent economy and was the number one foreign exchange earner among agricultural exports until 1957 when bananas earned more.

From Under-Production to Excess Supply: 1956-1964

Table 1 shows how production rose from nearly 25,000 (200 lbs) barrels of starch to 50,000 barrels in 1955. Beginning in 1956 production began gradually to decline, primarily for two reasons:

(i) the production of banana on suitable land proved a more lucrative crop;*/ and

(ii) the arrowroot growers had to wait for as long as 18 months before they were fully paid.

According to the system in effect, growers were paid an initial advance when the starch was delivered, an interim payment the following December and final payment the following June and often later. The long delay in receiving full payment made it difficult for growers to plan and to make ends meet for family consumption.

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*/ The success of banana cultivation provided alternative employment for workers and enabled demands for higher wages for field workers to be met, which, in turn raised the costs of producing arrowroot. There were, of course, planters and peasants who had land better suited for arrowroot than bananas and this is given as the principal reason why arrowroot was not ousted by bananas (or indeed other crops) completely.

Alarmed by the downward trend in production, the Board in 1958 changed its policies to include:

(i) full payment to growers at time of delivery;

(ii) easy credit for imported fertilizer; and

(iii) higher price.**/

The policies eventually paid off as production gradually turned around and rose from a 1961 low of 31,500 barrels to 37,500 barrels in 1962. It should be mentioned, however, that production would have been notably higher in 1961 except for the fact that many loads of rhizomes were used as planting material for new fields instead of being processed into starch. In addition to the new policies, the Board continued to improve quality standards and spent large sums of money on new milling and shifting machinery and on up-to-date laboratory equipment.

In 1962, the expected harvest for the 1962/63 crop was estimated at 45,000 barrels. Although some well-informed opinion considered this to be on the high side, the final result was in fact a fraction over 50,000 barrels. A major

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**/ It was pointed out in a 1958 report that any attempt to bring arrowroot on a par of profit with bananas by raising price would be "self-defeating , indeed disastrous. For such a rise in price would make arrowroot wholly uncompetitive with other starches." Hence, the main thrust of the Board was to improve the efficiency of the industry and develop the confidence of producers in maintaining a stable market.

cause of this quantum jump was the demise of the sugar industry in early 1962. Practically the entire acreage devoted to cane cultivation was diverted to arrowroot as the sugar industry fell victim to intense labor disputes.

The added arrowroot supply was a serious matter for the Board. Instead of an expected steady annual increase of 3,000 barrels and an eventual leveling-off of arrowroot to between 45,000 to 50,000 barrels in a few years, the Board found itself suddenly swamped. It had no time to find and promote new markets and faced problems in rationing its limited funds among growers.

An attempt was made in 1963 to have its traditional U.S. customer buy more. For 30 years the U.S. customer (a buyer for Kraft foods) had been the largest purchaser of arrowroot starch. From 1953 to 1962 it purchased from 80 to 60 percent of St. Vincent's total sales of starch but the total quantity purchased annually was on the decline as shown in Table 1. In addition to annual contracts for sales of arrowroot starch agreements were made to give U.S. representatives the right of first refusal of any surpluses of starch, a privilege they gladly accepted on previous occasions. Moreover, in the past, the U.S. customers repeatedly urged greater cultivation of arrowroot in St. Vincent and for their part the U.S. customers had done their best to eliminate competition from other starches. No time was lost therefore in advising the U.S. of a surplus and offering it to them. After two letters from the Board and

two and a half months later, a U.S. representative visited St. Vincent and to the Board's dismay refused to accept the surplus but would only promise to commit himself to do what he could to dispose of it. His chief reason was that on account of the Board being unable to fully meet his requirements in the past, particularly in 1961, he had lost many of his main customers and saw no possibility of regaining their business.

Apart from the U.S. market, efforts were made also in 1963 to increase sales in the U.K. through its representatives there and also on the Continent including Western Germany. In the U.K. however, it was also explained that customers had been lost through inability to keep supplied in the past years and that it was extremely difficult to regain this business, especially when they had changed their food formulae. In other parts of the world arrowroot starch was up against difficulties of either noncompetitive price, import duties against starches or being an unknown quantity, or a combination of all three.

Over 1963/64 crop year, the same story of supply and demand was to be retold. Supply jumped even more to approximately 60,000 barrels at 200 lbs. each and demand slumped some more, from 37,500 barrels in 1963 to 27,700 in 1964.

In the summer of 1963, the Arrowroot Association had an overdraft of EC$1,083,000 largely because of its new payment policies for its growers. The overdraft was covered by payments

due amounting to EC$140,590 and stock at cost, valued at EC$1,000,000. But of the stocks comprising 27,535 barrels, only 17,597 were contracted. Thus a surplus of nearly 10,000 barrels remained. The surplus of 1964 spelled an even greater crisis for the Association.

From Over-Production to Excess Demand: 1964-1971

To remedy this problem the Board lowered the price it paid growers, protracted payments and anticipated reduced acreage sown to arrowroot. In the meantime, the demand for arrowroot looked grim (see Table 1). No clear-cut reasons were given for the declining demand facing arrowroot producers. However, the Chairman's report covering the crop year ending 30th September, 1968 noted that: "There has been evidence of signs of overstocking by our North American buyers who largely [have] account[ed] for the increase". While the 1968 contract with the U.S. buyer was for 18,000 barrels firm, their contract for 1969 called for 13,000 barrels only, though with an option on an extra 5,000. There was also speculation at the time, noted in the Chairman's 1968 report, that Colombia would be producing a crop of some 3,000 tons of canna starch at a relatively lower price than arrowroot, and that U.S. buyers would substitute canna starch for arrowroot. However, in later years, this competition from Colombia did not materialize.[*/]

[*/] St. Vincent Arrowroot has properties far different from other types of starch derivatives. The principal varieties of arrowroot grown in St. Vincent are "creole" and "banana" varieties, both maranta arundinacea. The starch is eminently suitable for making high class pastries and cookies, ice cream, salad dressing, baby foods, "Miracle Whip" of Kraft Foods and biscuits. Further information on arrowroot plant and the properties of its starch are given in Appendix I.

Table 1

PRODUCTION: SALES AND RELATIVE PRICE OF ARROWROOT

Harvest Year	200 lb. BRL Production	200 Lb. BRL Total Sales	Pd. To Growers (EC$/200 lbs.)
1945	24700	25500	14.52
1946	32600	31600	14.80
1947	33800	33300	16.96
1948	34500	33400	20.26
1949	36250	-	21.70
1950	43500	-	25.72
1951	45500	-	27.06
1952	48600	-	29.58
1953	48700	43500	30.00
1954	50000	45000	28.30
1955	50000	49100	27.50
1956	47500	50600	28.75
1957	45300	46700	32.16
1958	37400	40600	32.40
1959	34400	41900	31.00
1960	32800	34500	34.00
1961	31800	32500	36.00
1962	37400	33600	40.00
1963	50000	37500	39.00
1964	60000	27700	34.00
1965	37000	29800	28.00
1966	23150	19000	28.00
1967	17870	20640	28.00
1968	14135	26812	28.00
1969	12750	23809	28.00
1970	8962	26000	32.00
1971	6546	10037	40.00
1972	8716	8000	45.00
1972/1973	10267	10000	57.00
1973/1974	8961	8500	70.00
1975	8725	-	85.00
1976	8227	-	85.00
1977	7438	-	125.00
1978	9192	-	145.00
1979	7466	-	145.00
1980 est.	7000	-	160.00
			180.00

In 1966, the Association had unsold stocks of over 55,000 barrels on hand. In the next 5 years, however, continuing low farm prices eventually resulted in a gradual decline in production and by 1971 all surplus stocks had been sold. The problem now was that the industry again faced the difficulty of producing enough starch to meet the demand.

In its 1969/70 Chairman's Report, the Arrowroot Association noted signs of improved market demand. U.S. research in starches found a new use for the product in paper, especially for the compater industry (in carbonless duplicating paper). A new two-year contract for 15,000 barrels, Grade 1, was signed with the Staley Manufacturing Co. of Decateur, Illinois in June 1970 for a higher price. But although this was good news for the Association, especially the promise of a higher market price, the resulting offer of a price incentive to the farmers came too late to influence adequate increased production.

The outcome was that while the Association was able to meet demand through 1970, it found itself in the unenviable position of having to inform its customers that it could not meet its commitments for 1971. In spite of all apparent efforts to stimulate production, only 700 acres of arrowroot were cultivated in 1970 and the crop yielded only 6,546 barrels as opposed to nearly 9,000 the previous year. This was at least 10,000 barrels short of the demand desired in 1971. Part of the shortfall was also attributed to the unavailability

of harvest labor. According to the Chairman's report of 1970/71, 150 acres went unharvested "for the want of labor".

In sum, during the period from 1961 to 1972 the Association faced a vicious cycle of problems; i.e. wide annual fluctuations between supply and demand, giving rise, alternately to policies which resulted in shortages and excess supplies. These policies and fluctuations caused serious instability for growers and buyers alike, and sapped the confidence of both in trusting the arrowroot market. In addition, the chaotic conditions of the late 1960's persuaded some politicians of the time that the industry would die.

Renewed Efforts to Stimulate Production: 1972-1974

In an attempt to augment supply to meet the demand faced in 1971, the Association put into effect new policies on four fronts:

(1) higher prices for growers;

(2) extensive repairs at processing plants;

(3) introduction of mechanised harvesting; and

(4) expansion of arrowroot acreage.

In 1962 the price paid to arrowroot growers was EC$40 per barrel of starch. But as supply far surpassed demand, the price was lowered to $39 in 1963, $34 in 1964 and $28 in 1965. The price remained at $28.00 per barrel until 1969.

It wasn't until 1971 that the price reached its former high of $40 per barrel. Then on the strength of an increased price contract in late 1970, the Association embarked on a "Back to Arrowroot Campaign". Big jumps in price began when in 1973 the price was set at $57 per barrel, then $70 in 1974 (see Table 1).

The second effort of the Association was to rent the Colonarie Factory and take over the government owned Biabou Factory (rent free) and put in extensive repairs to cope with the increased production. This was to ensure that the small growers would have adequate facilities to process their production. Altogether in the early 1970's, the Association could count on five processing plants:*/

(1) Biabou (3-4,000 barrel capacity);

(2) Colonarie (3,000);

(3) Sans Souci (6,000);

(4) Union (3,000); and

(5) Wallilabou (3,000)

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*/ This number is considerably reduced from prior times. In the 1930's there were from 30-35 processing plants without motorized and/or electrically operated parts. Sieving was performed by hand.

As a third measure, the Association considered the use of a mechanical harvester for the 1972/73 crops.**/ It was thought that large farmers would not return to arrowroot until a mechanical harvester was perfected and made available for reaping. Despite the failure to perfect a versatile and economic mechanical means for harvesting, especially for the marginal lands, the crop rebounded in output. From a low of 6,546 barrels in 1971, production rose to 8,716 barrels in 1972 and 10,267 in 1973. Part of this increase was due to the fact that the Association went directly into production by acquiring its own acreage. In June 1971, the Association leased the 360 acre Langley Park Estate for a period of three years from Mr. Basil Balcombe. At the time he had threatened to go out of production due to labor problems. In turn, the Association sublet around 200 acres of the estate to tenants in order to ensure that arrowroot was grown. Whereas Balcombe had sown around 50 acres to arrowroot, the Association's tenants tripled the amount.

During 1971/72, the Association made a further effort to purchase the Langley Park Estate but the scheme fell through "when the Minister of Agriculture informed the Board that he

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**/ The Association has considered mechanical harvesting since 1959. A list of related reports is shown in Appendix II.

would not recommend to Government to guarantee the loans as (1) he did not want to see the Association become a land owner: (2) should the Association buy the lands all arrowroot growers would repay the loan while only those directly connected with the estate would benefit."*/

Due to the new attempts to revive supply and a stronger demand for arrowroot starch starting in 1971, production increased and stabilized. Between 700 to 800 acres of arrowroot were planted by 1972 and the number of growers rounded out to approximately 230. (Numbers of both are given in Table 2)**/

Table 2

Approximate Number and Distribution of Growers and Acreage in Arrowroot, 1972

Area	Number of Growers	Number of Acres Ratoon	Plant
Sandy Bay/Owia	85	140	47
Chester Cottage - Rabacca	50	90	3
Biabou Area	35	50	7
New ground to P. Hill	20	80	6
Escape to Belmont	15	25	10
Layou to Wallilabou	25	60	33
	230	445	106
Langley Park Estate	-	200	4
Basil Balcombe	-	25	-
		660	110
Total	230 Growers	770 Acres	

*/ This was not the first interest of the Association in purchasing land. In a 1971/72 "Memorandum" the Association indicated a desire to purchase the Mt. Bentick Estate, comprising about 600 acres. No more is said of this in later reports. However, with both the Bentick and Langley Park Estates, the Association envisioned owning and operating at least 600 acres of arrowroot for regular production.

**/ The number of growers is considerably lower than the 852 counted in 1962/63 but much higher than the 164 growers counted for the 1968/69 crop (from Memorandum dated circa 1971-72).

Together, the policies resulted in increased production; i.e. increased by 1,500 barrels from 8,716 in 1971/72 to 10,207 in 1972/73, while there was an increase of still another 100 acres, making a total of around 900 acres under cultivation at the end of 1973. The number of growers increased still further to about 350.

It should be noted that the interest in the mechanical reaper faded out of the picture as workers were paid more and "the attitude of workers towards reaping manually continued to improve during the year". (1972/73 Chairman's Report).

In addition to the set of policies described above, 1973 marked the first year the Association decided to pay the cost of trucking the roots to the factory. The trucking cost was substantial, amounting to nearly 9 percent of the cost of delivering roots to the processing plants, as indicated in Table 3. In short, there was a form of subsidy to the growers, as reflected in the figures. The Association continues the policy (in 1980) of paying the trucking fees for producers to this day.

Table 3

Statement on Purchase of Roots Crop by the Arrowroot Association, 1972-73

Total roots purchased, 2,871,128 lbs @ $2.65 per 100 lbs.		$ 76,084
Trucking		6,885
Starch purchased - 2,000 barrels Valued at $86,657	$86,657	$ 82,969
Less manufacturing cost of $10.00 per barrel	20,000	66,657
Net loss on operations		$ 16,312

All in all 1972/1973 turned out to be a good year for marketed starch and the arrowroot industry. Ten thousand barrels of starch were sold, production continued to increase, wages and workers increased as well as prices and net income to growers. The Association estimated a good potential market for some 25,000 barrels and projected that within three years (by 1975) it could catch-up with the expected demand.

Loss of Processing Capacity: 1974-1976*/

However, the beginning of 1974 did not continue this happy trend. On February 6, 1974, the Sans Souci factory was destroyed by fire. The destruction of the factory had an immediate impact on reaping, manufacturing, starch yields and the attitude of the growers. The main adverse effects were listed by the Association as:

(1) the loss of the most efficient factory;

(2) the estimated loss of about 3,000 barrels in the 1973/74 crop - resulting in an annual output of 8,961 barrels as compared to 10,267 in the previous year; and

(3) the reduction in acreage of about 100 acres in the 1974/75 crop due to the loss of processing facilities in the region covered by Sans Souci.

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*/ A detailed description on the processing of arrowroot is provided in Appendix III.

In response, the Association made "every effort to renovate/remodel the Belle Vue Central Factory at the earliest possible time" to replace the processing capacity lost at Sans Souci.

The Belle Vue factory was built in the early 1950s for processing purposes but remained idle from 1958 because the equipment and layout were considered unsuitable for arrowroot.*/

In 1974, the Premier, Mr. Mitchell, appealed to the Caribbean Development Bank C.D.B. for assistance. "Discussions were held between the St. Vincent Government, the C.D.B. and the Association. It was agreed:

(a) that the Government would convey the Belle Vue Central Factory premises to the Association;

(b) the Association would apply to the Bank for the loan necessary to install a modern factory.

The Association prepared the Belle Vue building for inspection and survey which was carried out by C.D.B. personnel. (However, to the Association's surprise, despite the initial interest of the Premier), the premises were never conveyed to the Association and therefore the loan could not be applied for." (1973/74 Chairman's Report).

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*/ Donated by the German Government the equipment was essentially used for processing potatoes and utilized electric power. In contrast, the locally built plants relied on diesel power and were designed differently.

Although the negotiation with the C.D.B. fell through, the Association went ahead with its own funds to adapt the processing plant in Belle Vue for arrowroot starch production. The work proceeded under the direction of Mr. Benedict Balcombe and in a matter of two years, with EC$200,000 from the Association, the plant was in operation.

Once again, the purchase of the Langley Park Estate again took up the active attention of the Association in 1974 when the Premier, Mr. Mitchell, reversed an earlier decision and invited the Association to purchase the estate. Although the Caribbean Investment Corporation approved a loan in November 1974 for $245,000, to be applied towards the purchase price of $490,000, a new Government came to power in December 1974 and let the offer of the C.I.C. loan lapse (on April 30, 1975) without backing the purchase.

During the crop year 1974/75, 8,725 barrels of starch were delivered to the Association, compared with 8,960 barrels the previous year. The adverse effects of the loss of the San Souci factory were still being experienced in the length of time between reaping and processing at the remaining factories. And despite earlier problems with labor, the good will among workers continued. In fact, manual reaping "was always ahead of the capacity of the factories to process and that also created a problem. Only in two instances was the mechanical harvester used." (1974/75 Report).

With better prospects in sight and the Belle Vue plant near completion, 1974/75 marked the first time the Association paid a bonus to growers. A bonus of EC$5.00 per barrel was paid in the hope that the incentive would result in greater production. The bonus was also an indication of the continuing strong demand for arrowroot, especially from the U.K., which took over the position of the U.S. as the leading buyer of arrowroot starch in 1972 (see Table 1). It should also be noted that the U.K. buyers were relatively more generous in meeting the Association's requests for higher payment. For the 1974/75 crop alone, the Board was able to increase the price to growers from $57 to $70 per barrel and also to credit fertilizer to growers at $4.50 per sack below cost.

Arrowroot Versus Sugar Cane: 1975 St. Vincent National Agricultural Program

As world demand continued to look good and the bonus was paid to growers, (December 1975), the Association pressed further "not only to maintain production but to reach at least a target of 1,500 acres by 1980," up from the 750 acres in 1975. However, two new developments were at foot. One, the government announced its decision to re-introduce sugar cane cultivation and, two, the government "strongly recommended that arrowroot be phased out in the Leeward coast, and the existing factory at Wallilabou be resited at Owia", (to cover an area stretching from Peruvian Vale to Fancy into what is

commonly called "Carib Country"). The Government's main policy is stated in the 1975 St. Vincent National Agricultural Program (S.N.A.P.); and although pointing out "a great world demand for arrowroot starch", indicated the following advantage to be gained for sugar production. To quote:

(1) The creation of a higher level of employment because of the labour intensive nature of the sugar cane industry;

(2) The utilization of sugar by-products in the domestic production of livestock feed;

(3) Considerable saving in foreign exchange by eliminating sugar imports which now [in 1975] total over $2.5 million.

However, the re-introduction of sugar cane not only meant the relocation of arrowroot production to an area without developed, paved roads or a functioning processing plant, but also meant the exclusion of arrowroot from Langley Park. In particular, the Association was directed by the Government to vacate 100 acres of the Estate to be used for sugar cane.

To counter some of the negative effects facing the industry, the Government of St.Vincent and the Association signed an agreement with the Caribbean Development Bank for a loan of EC$314,000 to build an arrowroot factory at Owia. The work was to be carried out by the Association and the Association would be responsible for the management of the

factory and the repayment of the loan. In its appraisal report of September 1975, the C.D.B. noted that the "factory at Owia would bring an additional 100 or more acres into arrowroot production, thus providing considerable benefits to the population of this isolated area". The factory was also to have a processing capacity of about 5,000 x 200 lb. barrels of starch per season. In addition, the report went on to note that "the cost of the project is estimated at $437,877 of which the borrower would contribute $43,877. The DCF [discounted future] rate of return has been estimated at 22.3 percent and the economic rate of return 43.9 percent."

At last word, the management of the Arrowroot Association expected the plant to be in operation for 1980/81 crop year.

On March 18, 1976 the Belle Vue Arrowroot factory began operation, with encouraging results. With a capacity of about 50 barrels (200 lbs.) per 8 hour shift, it relieved some of the pressure faced with the loss of Sans Souci.

International Demand for Arrowroot: 1975-80

Although the capacity to process starch had visibly improved, the market situation for increased exports was less clear. In October 1975, the Association's delegation to the U.S., Canada and U.K., composed of Mr. Julian Boyea - Chairman and Mr. David Jack - General Manager, reported that "over the past three years business has been generally slower in the

capitals we visited. This was very noticeable in Barbados and in New York compared with even a year ago. In London there is an inescapable feeling of depression all around. Canada seems to be the exception. As far as our arrowroot market is concerned it might be advisable to be on the look out for new outlets rather than relying too heavily on our traditional buyers". (Delegation report dated October 16-29, 1975).

It is important to examine this outlook more closely. For several years the Association had predicted an optimistic demand and had attributed most of its problems to limited supply. Now, the prospects for expanded sales looked less favourable than ever before. While many reports dating back to 1945 */ have mentioned the possibility of cheaper starches taking the place of arrowroot, and the need to expand markets, the Association never promoted a big list of buyers. This was understandable in light of the fact that the Association had rarely created (save for the period between 1963-1969) a large stock to trade. The result has been only three or four main buyers to deal with by the Association.**/ The principals

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*/ See "The Arrowroot Association of St. Vincent" by A.R. Williamson, Report in Association files, dated August 1945.

**/ A former buyer between 1930-1970 was Morningstar Nicol of New York City. Poons, who was a buyer for Morningstar, continued to purchase arrowroot starch beginning about 1970. E.M. Staley has not purchased arrowroot starch since about 1974.

includes:

(1) Graham and Michael Starke
Bruce Starke & Co. Ltd. (Oldest buyers dating back
Hatton Gardens to 1930's)
London

(2) Melvin C. and Ronald Poons
Poons Co. Inc.
45 Great Neck
Long Island, N.Y.

(3) E.J. Donovan
Ontario Merchandisers Co.
Toronto, Canada

(4) E.A. Staley Manufacturing Co.
C/o Gilbert Myers, E. Scheiter or Wayne Martin
Decater, Illinois, U.S.A.

Two problems have recently become more critical for the Association:

(1) the need to identify more potential buyers, and

(2) the need to engage in market research to expand the possible uses of arrowroot starch.

With regard to the latter, it is apparent that the St. Vincent Association does not know how arrowroot starch is currently marketed by the principal buyers, or what the ultimate uses of arrowroot starch are, or for that matter, what competition they really face in the market for starch. Caught in this bind, the Association is not in a favourable position to bargain for better prices or to consider marketing "directly" by bypassing current intermediaries.

The Arrowroot Industry Act of 1976

On November 2, 1976 a Government policy was enacted which had major effects on the Arrowroot Association. It was "The Arrowroot Industry Act, 1976" which was enacted to "provide for the establishment, constitution, functions, powers, and duties of the Arrowroot Industry Association and for purposes therewith and incidental thereto". The Act put into effect the following measures:

(1) The Act repealed the Arrowroot Ordinance, 1954 and the Arrowroot (Control) Ordinance, 1966.

(2) It terminated the "St. Vincent Co-operative Arrowroot Association" and put in its place the "Arrowroot Industry Association," a corporate body with power to sue and be sued in its corporate name

(3) It established the eligibility provisos for membership to include:

(a) Any person who produces and delivers annually to the Association not less than two thousand pounds of arrowroot product;

(b) Any person who grows and delivers annually to the Association not less than twelve thousand five hundred pounds of arrowroot plant.

(4) It defined the functions of the Association to be:

(a) to promote and encourage the growing of arrowroot and the development of the Arrowroot Industry;

(b) to supervise the production and processing of arrowroot plant;

(c) to erect and operate factories for the processing of arrowroot plant;

(d) to control the export marketing of arrowroot product;

(e) to buy, sell or deal in fertilizer, agricultural implements and agricultural supplies for the benefit of the arrowroot industry;

(f) to undertake or to promote research in the cultivation of arrowroot plant.

(5) It empowered the Association to make loans to growers of the arrowroot plant and to furnish technical advice to growers;

(6) It established the Arrowroot Industry Board, the executive body of the Association.

The last point of the Act in effect removed control of the Industry from the growers to the Government. This is evident in the composition of the Board, which now consists of eleven members:

(1) The Financial Secretary or deputed representative;

(2) The Permanent Secretary, Minister of Trade and Agriculture, or deputed representative;

(3) The Chief Agricultural Officer or deputed representative;

(4) Five eligible members of the Association appointed by the Governor for one year; and

(5) Three persons appointed by the Governor for one year.

In addition, the Governor appoints a Chairman and Deputy Chairman from among the members of the Board.

Chief among the functions of the Board are to regulate and control the export of arrowroot product, fix the price of arrowroot plant and product, specify the grades of arrowroot and appoint and employ staff.*/

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*/ Any post paying a salary in excess of six thousand dollars per annum is approved by the Cabinet.

Besides a significant change in the means of appointing members to the Board, the Act also affected membership. To quote from the Chairman's Report for 1976-77: "One of its immediate effects was on the membership of the Association which automatically increased from 32 to 174 in respect of the 1975/76 crop. At the same time, out of a total of 374 growers, 200 whose individual deliveries were less than 2000 lbs. starch or 12,500 lbs. roots were deprived of any representation on the Arrowroot Board or at General Meetings.

Of a more recent note, and also a delayed result of the Act, was the change in the Association's management. In late 1979, Mr. D.E. Jack was eased out of his long term position as General Manager, after serving for more than 25 years with the Association in responsible leadership roles. He was replaced by Mr. Ormond J. Ollivierre, a former loan officer of the co-operative Agricultural Bank. In addition, a new Association President was named, Mr. H.B. Crichton, to serve with Mr. Ollivierre. Both Mr. Ollivierre and Mr. Crichton took their first sales mission on behalf of the Association in September 1979 and contracted 7,500 barrels of starch for the 1979/80 crop with buyers in the U.S., Canada and the U.K. They also negotiated an increase in the price of starch from EC$1.05 per lb. in 1978/79 to EC$1.20/lb in 1979/80 (f.o.b.). It is too early to predict what the initial results of their performance will be.

The Current Situation: 1977-1980

From 1976 through crop year 1979, arrowroot production fluctuated around 8000 (200 lb.) barrels of starch per year: 8,227 in 1976, 7,438 in 1977, 9,192 in 1978 and 7,466 in 1979. The yield would probably have been higher in Spring 1979 except for the eruption of volcano Sufriere on April 13, which retarded processing activities for the remainder of the crop year and lowered the quantity of Grade 1 (export) starch, as illustrated in Table 4.

From 1976 through 1979, the demand for starch appeared to level-off, to include: around 4,000 barrels to the U.K., 3,500 barrels to the U.S. and 1,000 barrels to Canada. In addition, small 4 oz. packages of arrowroot starch were again distributed by the Association to markets in the West Indies in 1977/78.

The price of arrowroot starch gradually improved as well as the price paid by the Association to arrowroot producers. Table 5 shows the level of total payments made to growers achieving a high of EC$1 million in 1978 as the price paid for starch climbed. Table 5 also shows how the payments were distributed among different size farm groups for the 2 main grades of starch processed by the Association. With rising price and a regular demand for arrowroot starch, the prospects for the arrowroot industry appear to be reasonably good.

Table 4

Annual Summary Statistics on Production

lbs. and Barrels of Starch Received
by Association in Kingstown by Grade and Crop Year

		----------lbs of starch----------			
Crop Year	Number of Barrels	Grade 1	Grade 2	Ungraded	Total
1978/79	7,466	914,189	480,421	98,706	1,493,316
1977/78	9,192	1,285,960	457,960	94,577	1,838,497
1976/77	7,438	1,184,259	251,344	52,156	1,487,759
1975/76	8,227	1,334,180	289,357	22,023	1,645,560
1974/75	8,725	1,205,296	476,173	63,560	1,745,029
1973/74	8,961	1,218,123	487,543	86,484	1,792,150
1972/73	10,267	1,695,328	229,592	101,871	2,026,791
1971/72	8,716	1,391,629	238,105	113,611	1,743,345

200 lb. Barrels delivered from factories to the Association in Kingstown.

Two additional points should be added with regard to the production of arrowroot. One, in the Chairman's Report for 1976-77, it was noted that the workers were able to raise their incomes by padding their harvested baskets. To wit: "workers appeared to be quite satisfied to charge as much as $1.25 per basket (in 1977) of about 75 lbs. instead of 100 lbs. [which is the normal weight of a load] while the growers accepted their fate." Second, the growers, in turn, appeared to pad their truck loads as indicated in the Chairman's Report for 1977-78. To quote: "It has become a matter of some concern the amount of foreign matter (including large stones) which find its way into loads of arrowroot delivered at the factories. This practice was one of the many factors contributing to the low starch return as experienced at most of the factories".

As of December 1979 the Association has experienced a poor liquidity position. It has an overdraft with the National Commercial Bank of approximately EC$500,000 at 8% per annum. This is due to: (1) compensation paid to farmers who lost harvested roots in the Spring of 1979 because of the volcanic eruption and the concomitant loss of unprocessed rhizomes from spoilage and roaming animals (cattle) and, (2) miscalculation in payment of a second bonus to growers in excess of the price obtained.

The overdraft is expected to grow to EC$1.5 million before payments are received for arrowroot sales in June 1980.

Table 5

Total Payments Made By Association
for Different Grades by "Farm Size Group"
for Arrowroot Starch by Crop Year*/

	Grade 1	Grade 2	Ungraded	Total
1979/80**	($90/100 lb)	($80/100 lb)	($60/100 lb)	
1978/79	($70/100 lb)	($60/100 lb)	($40/100 lb)	
Small	5,370.40	4,690.20	-	10,030.60
Large	624,392.30	292,309.20	39,482.40	956,183.90
Total	629,762.70	296,969.40	39,482.40	966,214.50
1977/78	($60/100 lb)	($50/100 lb)	($30/100 lb)	
Small	14,331.00	780.50	-	15,111.50
Large	757,245.00	228,199.50	28,373.10	1,013,817.60
Total	771,576.00	228,980.00	28,373.10	1,028,929.10
1976/77	($50/100 lb)	($45/100 lb)	($25/100 lb)	
Small	101,680.00	9,819.00	170.75	111,678.75
Large	490,449.50	103,285.80	12,868.25	606,594.55
Total	592,129.50	113,104.80	13,039.00	718,273.30
1975/76	($35/100 lb)	($32.50/100 lb)	($17.50/100 lb)	
Small	75,637.10	3,921.72	-	79,558.82
Large	399,382.90	82,639.05	3,854.02	485,875.97
Total	475,020.00	86,560.77	3,854.02	565,434.79
1974/79	($35/100 lb)	($32.50/100 lb)	($17.50/100 lb)	
Small	90,310.85	27,472.12	364.69	118,147.66
Large	331,543.75	127,283.93	10,758.30	469,585.98
Total	421,854.60	154,756.05	11,122.99	587,733.64

*/Farm size is determined by the amount of arrowroot purchased from growers. A large grower is one who delivers enough arrowroot to yield 2000 barrels of starch per year. In general, 12-14 baskets (100 lb) yield 1 barrel (200 lbs) of arrowroot starch. There are approx. 150 baskets/acre.

**/1978/79 Rhizomes (roots) = $8.00/100 lbs.

...Continued

Table 5 (Cont'd.)

	Grade 1	Grade 2	Ungraded	Total
1973/74*	($28.50)	($20.00)	($15.00)	
Small	112,827.51	24,886.42	47.70	
Large	234,337.54	101,874.76	12,924.90	
Total	347,165.05	126,761.18	12,972.60	486,898.42
1972/73	($23.75)	($21.25)	($12.50)	
Small	119,726.00	19,048.68	3,991.27	142,766.64
Large	282,675.02	29,739.29	18,428.59	330,842.90
Total	402,401.11	48,787.97	22,419.86	473,609.54
1971/72	($22.50)	($20.00)	($10.00)	
Small	134,086.18	28,845.40	12,017.14	174,948.72
Large	179,017.02	18,780.60	7,342.07	205,139.69
Total	313,103.20	47,626.00	19,359.21	380,088.41

*/ The "ungraded" column for these years includes Grade 3 Starch which was priced between the values of Grade 2 and Ungraded.

If production attains a level of 8,000-9,000 barrels of starch in 1980, the Association is expected to carry an overdraft of about $300,000 in 1981. If production levels are much lower, the overdraft will be large.

As far as the future is concerned, the Arrowroot Industry Association's management is encouraging expansion of arrowroot acreage in the Owia/Fancy area where the new factory financed by the C.D.B. is nearing completion. It hopes to undertake improvements in the Biabou factory which needs certain replacements in order to boast its efficiency.

Issues and Comments

The Arrowroot Industry Association is currently at the crossroads of either continued output and sales at the current level or renewed expansion and vigor. Whatever course the Industry takes will depend largely on the interest of the Government in developing three major areas:

(1) Production

Current levels of production still fall below the level of contracted demand. The Association has not built-up any reserves of starch from which it can supply other than three or four principal buyers. Before new markets can be considered and new sales arranged, the Association will have to develop its stock to better serve its customers on a consistent basis.

Before production levels can be augmented, the role of arrowroot in the St. Vincent economy should be clearly pronounced. Under the current situation,with new Board and Management at the helm, it is not readily apparent what the targets and goals of the Association are in terms of the national economy. Targets and goals can aid the Association in promoting its programs among its growers.

In order to sustain production, attention must be given to the situation facing workers and employers. While better wages may help remove labor shortages in certain areas, the real problem of labor may merely be the absence of a labor-use coordination scheme. The Association may want to experiment with ways of coordinating labor harvest crews across various farms and at the same time experiment with ways of improving the quality and timely delivery of rhizomes to processing plants.

(2) Processing

Current processing facilities are inadequate, outdated, poorly maintained and dangerous. Steps must be taken to improve the operation and efficiency of dilapidated plants like the one at Biabou. In some cases the marginal returns to modest improvements may be high. In one or two cases it may be most cost efficient to raise the entire plant and build anew. In either case the conditions of all processing facilities should be studied.

(3) Marketing

For years there has been a notable absence of sales promotion and market research. Relatively few people in St. Vincent have a vague idea of where arrowroot starch is ultimately consumed. Few ideas are extant on the potential uses of arrowroot. It may well-serve the computer industry. But who knows?

Furthermore, major customers have been willing to accept price increases of 25%. Does this mean that the selling prices may have been unnecessarily low? With a little marketing research, the answer could be known.

Appendix I Arrowroot and Its Properties

I. Arrowroot Plant

Arrowroot - maranta arundinacea - is a plant which grows to a height of two to five feet and bears large green leaves shaped like arrow heads. The roots divide just below the surface of the soil and send down several rhizomes, nine to eighteen inches in length and about an inch in diameter, depending on the variety. Ten to twelve months are required for the rhizomes to attain their maximum starch content of about 17 to 22 percent. The peak harvest period is February - March with the harvest season running from December to May. Best planting results are obtained from good loamy soil, free of stumps and stones. The plant does well on hillsides and is grown extensively by small farmers.

The two varieties used are the Creole and Banana. The Creole is a bigger plant with longer rhizomes. The internodes are longer, more fibrous, less compact, hardier and the rhizomes can remain in the field longer than the second variety before processing. The Banana variety is generally preferred on a flat land. The rhizomes bunch and do not grow as deeply in the soil as the Creole type. It is therefore easier to harvest, both manually and mechanically.

2. Technical Features [1/]

St. Vincent Arrowroot is a powdered, unmodified food grade arrowroot starch. (It is refined from the tuberous roots of a plant similar to tapioca and native to the British West Indies.)

St. Vincent Arrowroot flour, imparts a soft tender gel and a short texture to food products. It is both heat and acid stable, and its bland taste does not mask natural or added food flavours.

Typical Chemical and Physical Properties

Moisture, %	18.0
Ash, %	0.3
pH	6.0
Screen Analysis:	
Through U.S. No. 100, %	98.0
Through U.S. No. 200 %	85.0

Viscosity (Brookfield)*

At 80° C., Cps	1550
At 60° C., Cps	1625
At 40° C., Cps	1800
At 25° C., Cps.	2175

*(No. 3 spindle, 20 rpm, 4½% cooked to 92½°C, and held 20 min.)

1/ Source: Staley Manufacturing Co
Decater, Illinois, U.S.A. (1974)

Application

St. Vincent arrowroot flour is recommended for infant and invalid foods because it is especially easily digested. It is preferred as a constituent of low pH foods, such as salad dressing or cooked fruits, because its hydrogel structure resists acid-hydrolysis breakdown. It is also useful in icings and desserts, such as puddings and pie fillings.

St. Vincent arrowroot flour complies with the requirements of "Food Starch-Modified" as recorded in Food Additives Regulation 121.1031. It meets National Canners Association's standards for canner's starches.

Availability

St. Vincent arrowroot flour is available in commercial quantities packed in 100 or 50 pound multiwall paper bags. It is put up into corrugated cardboard cartons of 56 lbs. or 28 lbs. net containing packets of either 2 oz, 4 oz, 8 oz or 1 lb.

Appendix II: Studies of Mechanical Harvesting of Arrowroot

(1)	April 1959	by P.H. Rosher "Report to the St. Vincent Arrowroot Association on Mechanical Harvesting of Arrowroot".
(2)	March 1960	by J.C. Hawkins, "Report on The Mechanization of Arrowroot Cultivation in St. Vincent".
(3)	December 1970 & September 1971	by British Development Division in the Caribbean, "St. Vincent - Arrowroot Mechanization Preliminary Field Trials". - Two Reports.

Appendix III: The Processing of Arrowroot in St. Vincent [1/]

The processing of arrowroot may be classified as follows:

1. Washing
2. Maceration or grinding
3. Mixture with water
4. Straining - Fibre Elimination
5. Subsidation - Settling
6. Air Drying

Washing

This is aimed chiefly at taking off pieces of soil that have adhered to the rhizomes, when they reach the factory. It also assists in getting rid of fibres, rootlets, scales etc.

The first washing consists of dumping roots in a suitable container with water. The roots are put in and turned well so that they can be washed in this first container. A lot of soil is removed from the roots during this process. The next washing which takes place after this is mainly to remove scales, rootlets etc. The cleaner the water and the utensils, the higher will be the starch quality.

After these stages of washing, a revolving washer is used which consists of a barrel turned by mechanical means. Some of these barrels have an arrangement like water wheels which keep the whole barrel moving. The roots are thrown in at one end and come out the other. Inside the barrel is mesh wire

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1/ Source: Internal Document of St. Vincent AIA (Not Dated)

which allows the water to flow out easily. Water is continually thrown into the barrel to wash the roots. The rolling of this barrel gets rid of other fibrous matter and leaves the rhizomes in a cleaner condition. In some factories a 'german' washer is used which has compartments. This 'german' washer has a propeller-like part which is so made that it will pass the roots from one end to the other. This process also removes stones, which being heavy sink to the bottom. The roots continue to be agitated from one propeller to another in different sections. After this no more washing is necessary.

Grinding

This is the first essential point of the processing, as in this the roots are ground or torn up so that the cells which contain the starch are ruptured and broken to allow starch to be released. The implement which tears up the roots is known as a drum or barrel. It is about 8 inches wide, 18 inches in diameter and contain saws.

The bed of this implement has a series of wooden slats packed in grooves and the saws are fitted in the spaces between the grooves.

One barrel, depending on its size, may carry about 300-400 saws the fineness of the teeth of which varies. Some have fine teeth and others coarse. One edge of the fine saw has 90 teeth and the coarse saw 40 teeth. Saws with coarse teeth

are used for the first tearing of the roots and those which have fine teeth are used for the second tearing.

In some factories there are more than 2 barrels for this process.

Every saw has 4 positions in which it can be used. The barrel revolves 4000-5000 times per minute. The faster the speed the greater the tear and the quicker the starch is extracted.

In the primitive type of factory the roots are pushed into the barrel by hand. The closer the feeding board is to the barrel the better.

If there are lots of cigar-type rhizomes the feeding board has to be put closer because they are small in diameter and the starch content is low. In modern factories hand feeding is not used. Extraction depends on speed of the barrel etc.

Mixture with Water

This has to be done before straining and from here onwards the water must be very clean. For this purpose all factories have a process of filtering so as to cleanse all impure water. The water after first straining is known as 'coarse bitty'. After the first washing subsequent washings are done in a series of containers which are lined with very

fine mesh wire, and these are linked up with each other so that drainage from one passes into the other, in a continuous flow.

The wire which is used for straining the residue gets finer and finer in each subsequent container (60-120 mesh). 120 mesh is extremely fine and in practice it is found that 80 mesh wire can do the job just as well. The residue from the strainer is known as fine bitty. The finer the wire used the finer would be the residue. The residue is taken off by hand and discarded but in some factories there are automatic strainers which move mechanically. The bitty is mechanically thrown into waste. The material which is left in the strainer then goes another stage which is known as Subsidation. Care should be exercised to see that no bitty goes into the Table of Settling and this is the advantage of using a finer strainer. The disadvantage is that the presence on the table of some fine parts of bitty has a slight tendency to delay the speed with which the starch should settle out on the table, because the starch water will be so dispersed finally and that will delay settling. Large particles of bitty are allowed to pass on to the table and the presence of these in the starch will encourage flocculence and will allow for more rapid settling.

Subsidation

This consists of settling on long concrete table --

1. The water at the intake should enter with the minimum splash and --

2. The water which leaves the end of the table should be free of starch. In some factories it is run on to another table.

The tables are made of concrete varying in width from 4 ft to 5 ft and from 80-100 ft. The shape if taken in two forms -

1. A straight table
2. A table with curves

At the intake the depth of the table varies from 1 ft - 2 ft. The intake depth is usually greater than the outlet. The outlet varies from 1 - 2 inches in depth.

Certain checks are placed along the table length. These checks are put in to allow starch to settle in these pockets. The floors of the checks must not slope towards the intake, the reason being that when the starch begins to harden a plug is opened to allow the water to drain off. If the floors of the checks slope in this direction the water will not drain off properly. These checks can be put in whether the table has curves or not, but the starch having less corners to turn will be less agitated. In a curved table there is the tendency of agitation. The floor on the table should be as smooth as possible allowing for no agitation. There should be no starch at the end of the table -- if this happens the remedy is to slow down the water and so give the starch a longer time to settle.

Second stage of Settling: This consists of draining the water off the table and no more washing of bitty. The water should remain on the table first to make sure that the starch is settled out. After the water is drained off, it is wiped off with a lean piece of cloth, properly soaked up and after this the cloth wrung out. When this is done the starch is in a semi-dry nature. It is then put into big lumps and placed in another container where it is again mixed with clean water, properly stirred up and the starch is allowed to dissolve again. Too much water is not necessary at this stage for it is not to wash the starch but just to melt it up. After it leaves the box it runs through a strainer into a trough and from there into circular pans. The trough is so regulated that the starch can be removed to any circular pan. These pans are about 3 ft in diameter and 3 ft high. There is a slight sink in the pan about 6 inches in diameter. When the mixture is put into any of these pans, it is stirred regularly in a circular motion until a vortex is formed at the top. It is stirred about 3-4 minutes until the vortex is formed and left to stand overnight. All pans are treated in a similar way.

Similarly, all the pans have holes somewhere in the middle which are plugged up when the pan is in use. Early in the morning the water which will now be standing at the top will run off through the taps. Below the water, there

will be a layer of scum deposited which consists of starch which takes a brownish colour caused by the presence of fine grain impurities, the chief of which is very fine bitty to which is added certain gums which were present in the rhizomes. Because the impurities are lighter than the grain of the starch, they float to the top and remain on top. Sometimes the layer is up to 4 inches in thickness. That is the reason why the starch in the pan has to be stirred so vigorously.

If it is just run off from the trough to the pans without stirring the starch, the scum layer is separated from the true starch and in the depression at the bottom there is another set of impurities heavier than starch so it is settled at the bottom. This usually consists of grains of sand and stones which by chance have found themselves in the starch. After the water is run off, the 'madungo' is properly scraped until the whole of it is taken off and there is no more brown. If the pan is not properly stirred, madungo would not come to the top, therefore, it is important to have all the pans stirred.

When the madungo is properly taken off the clean pure starch is left behind, and it is dried in a similar way in which the starch which was left on the table was. Towels are then used to soak up the water. This process takes about 1 hour allowing the starch to be appraently free from water. After it is sufficiently dried, the starch is then dug up and taken out to go to the last stage which is Air Drying.

The heavy impurities will not be seen until all the true starch is taken off and they should be looked for somewhere in the exact centre of the pans. That section of settling is the most technical part of the whole process for the quality of the starch depends on it.

Clean water, clean table, proper stirring, taking off all the madungo, taking off surplus water from the body of the real starch, all these points contribute to the success of good quality starch.

Air Drying

This consists of exposing the starch in such a manner as to get rid of all moisture, and the time taken varies from 5-7 days depending mostly on weather conditions. The wet starch is taken from vats, is broken up into small pieces about the size of an egg and those lumps are put on racks made of chicken wire arranged in layers about 18" apart, using up as much space as possible.

To prevent any wastage of starch the small crumbs which escape are squeezed together by hand into balls and are put on the wire to be dried also.

Drying Shed

There should be a lot of windows to ensure good ventilation. The openings should be so protected as to keep out birds

which can be a nuisance to the drying house. The location of the house is also important. It should be exposed to air preferably on an elevated spot and there should be no possibility of dust entering the house as this would give discoloured starch.

The speed of drying depends on the weather largely, but it also depends on the size of the pieces of starch. The smaller the lumps of starch the easier they would dry.

The weather has direct bearing on the speed of drying and the aspect of weather which influences drying most is humidity. (The less breeze the more humid the air tends to be and vice-versa).

Damp weather sometimes gives starch a set back and can also cause starch to be discoloured because dust can enter the starch more readily. Starch is discoloured when it has a yellowish or brownish taint. Pure white starch tends to have a bluish look to the reflection of light, but is not really blue.

When the starch is thoroughly dried it can be tested on the wire by shaking it. It can also be tested by taking small quantities of starch in hand, squeeze it and after releasing it, if it remains in a lump the starch is not dry, but if it breaks into particles it is dry.

When the starch is dried it is shaken off from the wire frames, bagged and taken away.

The racks have a tray at the bottom to collect starch.